Resource assessment of *Daphne bholua* in Bhujung VDC of Annapurna Conservation Area, Central Nepal

A dissertation carried out in the partial fulfillment for the requirement of
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This is to certify that **Ms. Nirina Khadgi** has prepared this Master's thesis entitled "**Resource assessment of *Daphne bholua*, in Bhujung VDC of Annapurna Conservation Area, Central Nepal**" for partial fulfillment of the requirements for the completion of Master's Degree in Environmental Science majoring in Mountain Environment. She has worked sufficiently well under my supervision and guidance. This study work embodies candidate's own work and original. To the best of my knowledge this report has not been submitted for the any other degree.

I recommend this dissertation to be accepted and approved for the partial fulfillment of the requirements for Master's Degree in Environmental Science.

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DECLARATION

I, **Nirina Khadgi**, hereby declare that the piece of work entitled **"Resource assessment of *Daphne bholua*, in Bhujung VDC of Annapurna Conservation Area, Central Nepal"** presented herein is genuine work based in primary field work for the requirements of the Masters degree program and has not been published or submitted elsewhere. Any literature data works done by other and cited within this Dissertation has been given due acknowledgement and listed in the references.

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LETTER OF APPROVAL

This dissertation entitled **"Resource assessment of *Daphne bholua*, in Bhujung VDC of Annapurna Conservation Area, Central Nepal"** conducted and submitted by **Ms. Nirina Khadgi** has been accepted as a partial fulfillment of the requirements for the completion of Master's Degree in Environmental Science (Mountain Environment).

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Nirina Khadgi

Abstract

Daphne bholua (locally known as Lokta) is one of the NTFPs which occur naturally in Bhujung VDC, it is raw material for making Nepali Paper. Until now the locals have not used the locally available *D. bholua*. Due to the increasing demand of Nepali Paper there is a good possibility of income generation by harvesting the resource. Subsistence as well as commercial use, demands more careful assessment of resource base and application of sustainable harvesting techniques to ensure the sustainability of both local people and hand made paper enterprises. For the sustainable management of the species it is very important to know the present stock of the species.

This study is an attempt to estimate the present stock, the potential yield of bark from *Daphne bholua*, its distribution, population status, and to find if there is any relation between the environmental variables and attributes of *Daphne bholua*. For the study, the two sites were selected namely Surno Kharka and Wijung Ban. In each site, 3 plots were laid along the elevation gradient and in each plot 17 quadrats were randomly laid. In total the study was carried out in 102 quadrats and 102 soil samples were collected and analyzed to study the species.

The average density of *D. bholua* were determined to be 5231 and 6925 ind/ha respectively and harvestable dry inner bark mass to be 288 and 391 kg/ha respectively. The density of *D. bholua* decreased with the increase in potassium content and soil pH, but increased with elevation. Maximum girth of *D. bholua* and total bark mass also increased with elevation. Tree cover and litter index had negative relation with height of *D. bholua* and harvestable bark mass. Both density and harvestable bark mass of *D. bholua* were found to be higher in Wijung Ban suggesting it to be more favourable for harvesting *D. bholua*. If financial and technical assistance are provided to the local people, for harvesting bark and paper making then this could be an attractive source of income to the people. But the study showed that regeneration was very low due to disturbances like grazing, harvesting and trampling which could lead the species to vulnerability in near future demanding for serious steps to be taken.

Key words: NTFPs, Daphne, Lokta, Resource assessment, Bhujung VDC

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ACRONYMS

ANSAB	Asian Networks for Small Scale Agriculture and Bio-resources
ACAP	Annapurna conservation Area Project
CAMC	Conservation Area Management Committee
CF	Community Forest
DOF	Department of Forestry
FAO	Food and Agriculture Organization
FRSO	Forest Study and Research Office
FSC	Forest Stewardship Council
GON	Government of Nepal
ICIMOD	International Center for Integrated Mountain Development
IUCN	The World Conservation Union
KCA	Kanchanjunga Conservation Area
MAPs	Medicinal and Aromatic Plants
m asl	Meter above sea level
MFSC	Ministry of Forest and Soil Conservation
MPFSN	Master Plan for Forest Sector Nepal
NPC	National Planning Commission
NSCFP	Nepal Swiss Community Forestry Project
NTFPs	Non-Timber Forest Products
NTNC	National Trust for Nature Conservation
NE	North East
NW	North West
NWFPs	Non Wood Forest Product
SDC	Swiss agency for Development and Cooperation
SME	Small and Medium Enterprises
TUCH	Tribhuvan University Central Herbarium
VDC	Village development committee
WWF	World Wildlife Fund
Stem/ha	Stem per Hectare
Kg/ ha	Kilogram per hectare

1. INTRODUCTION

1.1 Background

1.1.1 Non-Timber Forest Products (NTFPs)

The Non-Timber Forest Products (NTFPs) are defined as all kinds of goods derived from forests, of both plant and animal origin, other than timber, fodder and fuel wood (Hammett 1993). Other terms used for a similar meaning are Non-Wood Forest Products (NWFPs) and Minor forest Products (MFP). For the past few decades, there has been a growing awareness of the importance of NTFPs especially for food and medicinal uses. This growing awareness is not only for the role they play in the subsistence economy, but also for their potential and real contribution to the economies of many developing countries (FAO 1998). Similarly, NTFPs are important forest products especially in dry land areas where they form alternative sources of livelihoods. They also contribute to poverty alleviation through generation of income providing food and improved nutrition, medicine and foreign exchange earnings (Chikamai and Kagombe 2002). Harvesting of NTFPs usually has a lower impact on the forest ecosystem than timber harvesting and can provide an array of social and economic benefits particularly to community operations and can therefore be an important component of forest ecosystem management (Duong 2008).

1.1.2 Status of NTFPs in Nepal

The diversity of NTFPs in Nepal is very high. According to an estimate, nearly 2000 species of plants are considered to be potentially useful, including medicinal and food plants (Ghimire et al. 2008). Some of these plants have been traded while others have been used for subsistence livelihood by local people. According to Subedi (2006), about 161 plant-based NTFP species have been harvested from wild for trade in Nepal. The Master Plan for Forestry sector of Nepal identified the sustainable harvesting of NTFPs as an important component of forestry sector development programs (HMGN/ADB/FINNIDA 1988). The forestry sector in Nepal contributes about 15% of the national GDP, of which about 5% is contributed by NTFPs. The volume of trade of NTFPs from Nepal Himalaya is not clearly known, and is estimated between 10-15 thousand tons of raw NTFPs annually. Annual export of NTFPs from Nepal is estimated worth US $ 8.6 million by Edwards (1996); US $ 16 million in 1997-1998 by Olsen

(2005); NRs. 2.5 billion (US $ over 35 million) by Subedi (2006). An increasing harvesting trend has given rise to greater pressure for long time on selected species since almost all medicinal plants and NTFPs in trade are harvested from wild population.

1.1.3 Importance of NTFPs in Nepal

According to Human Development Report of 2007, Nepal falls at 144th position in the world and more than 31 percent of the population was below poverty line (CBS 2004). Incidence of poverty is more severe in rural areas, owing to very limited non-farming employment opportunities and very small landholdings. By ecological region poverty has been more serious problem in the hills. Nepal is facing land degradation problem and declining agricultural productivity in mountainous terrain, which has broadened urban-rural economic gaps. To fill this economic gap there should be the creation of new economic opportunities together with improved access to resources, markets, services and sustainable utilization of natural resources which will contribute to improve rural livelihood.

A large proportion of rural population depend on NTFPs for livelihoods such as food, nutrition, medicine, fodder, fibre, condiment, dye and other useful materials. In the mountains of Nepal, 10-100% of households are involved in the collection of medicinal plants and other NTFPs; and in certain rural areas this contributes up to 50% of the family income (Edwards 1996; Olsen and Larsen 2003). NTFPs are relatively abundant in rural areas where other income generating opportunities are limited (USAID 2006). In those areas, NTFPs-based SMEs (Small and Medium Enterprises) offer good prospects for enhancing the livelihood and income of local communities (Subedi 2006). Thus, NTFP in Nepal is one of the major sources of nutrition, healthcare, raw material and cash income to people of rural areas. It is further critical to the poor as they are the one mostly involved in the collection of NTFPs.

NTFPs are harvested and collected from all ecological regions and collected, which almost all are sold in India. These natural products that originate from forests and pasture ecosystems are being increasingly recognized for their role in rural livelihoods, biodiversity conservation and export values. In recent years, the demand of herbal product is increasing in the global market and many forest related stakeholders have shown interest to work for the development of this sector and help poverty reduction. Global market for Nepal's NTFPs has been large and the demand trend of these products

is increasing as more and more people from developed country are attracted to these products. This is an opportunity as well as a challenge for a more sustainable, efficient and equitable management of NTFPs resources (Subedi 1997, Ojha et. al 2001).

1.1.4 *Daphne* species (*Lokta)*

Daphne spp., locally known as '*Kagaje'* or 'Nepali paper plant', is a shrub species, found in the hills of Nepal from east to west. Two species of the genus *Daphne* are common in Nepal they are *D. bholua* Ham ex. D.Don and *D. papyracea*. They grow gregariously and abundantly in Himalayan forests between 1,600 and 4,000 masl (Biggs and Messerschmidt 2003). The species found in the present study area has been identified as *Daphne bholua* Buch-Ham.ex. D. Don. They prefer medium to light crown cover and usually avoid sites with dense crown cover not more than 70 percent (Dhungana and Khatri-Chhetri 1995) or large open areas. Plants are found in lesser densities in areas of intense or haphazard exploitation of the forest resources, and areas with frequent fires and heavy grazing. They appear to thrive on a wide range of soil types but generally favour moist sites with rich organic humus layer overlying well-drained sandy loam or Brown earth.

Daphne spp. is one of the major incomes generating NTFPs of Nepal. *Daphne* has been used since ages in Nepal for making ropes and various forms of paper, which is widely known as Nepali *Kagaj* (Nepali paper). The hand-made papers are used to make various products in Nepal which find good market in Europe, the USA and Japan. They are popular and have high demand in international markets (Banjara 2007).

Daphne spp. is available in 2,910,848 hectares of forests in 55 districts of Nepal, of which 25 districts witness its abundant supply. The total stock of bark of *Daphne* spp. has been estimated to be 110,481 metric ton, which can support sustainable production of paper over 950 metric ton every year (FSRO 1984).

1.2 Justification

The study was performed in order to assess resources availability to meet the purpose of uplifting rural livelihood of poor people in Bhujung VDC of Annapurna Conservation Area, Central Nepal. Agricultural yield in the Bhujung VDC is very low and not enough even for six months despite the hardships because of its cool climate. *Daphne bholua*

occurs naturally in the forests of Bhujung VDC. Since the demand of Nepali hand-made paper prepared from the bark of *Daphne bholua* is increasing in national and international market, it could be a good source of income for the local people by increasing employment opportunities and income generation activities if we can use this resource sustainably. For sustainable harvesting of plant resources such as *Daphne bholua,* a sound ecological knowledge is essential. A systematic inventory of *Daphne bholua* in the region is necessary to know the population structure, present stock and the quantity of sustainable yield that can be prescribed for harvesting and area specific sustainable harvesting techniques in terms of seasons, methods and tools while planning for the sustainable management. Sustainable harvesting of *Daphne bholua* can in turn ensure the sustainability of the enterprises that relies on the supply of bark of *Daphne bholua*.

1.3 Objectives

Main objective of the study is to assess the availability and utilization of *Daphne bholua* in protected forests of Bhujung VDC of ACA region. The specific objectives of the study are:

- To study the distribution and population status of *Daphne bholua* in the forest of Bhujung VDC.
- To understand the relationship between environmental variables and the abundance of Daphne *bholua* in the study area.
- To estimate the potential yield of bark from *Daphne bholua.*

1.4 Scope and limitations of the study

The study was carried out in the elevation range between 2000 to 2500 masl at two sites namely Surno Kharka and Wijung Ban of Bhujung village area. It did not cover entire VDC area in terms of resource assessment. However, it gives the indication of the availability and utilization of this plant in that area. In Nepal *Daphne* spp. is found between 1,600 and 4,000 masl (Biggs and Messerschmidt 2003). But the study area lies between 2000 and 2500 masl. Therefore, the present study represents only the lower belt of altitudinal distribution range of *Daphne* species in Nepal.

2. Literature Review

2.1 What is NTFP?

What is a Non-Timber Forest Product (NTFP)? This debate has raged since the term was coined by de Beer and McDermott (1989). The problems begin with the term itself. 'Non-timber forest products' is a negative term. It includes, literally, all products other than timber that come from forests. In their ground-breaking publication on the economic value of NTFPs in South East Asia, de Beer and McDermott (1989) used the term 'Non-Timber Forest Products' as an alternative to the "dismissive epithet 'minor forest products' and proposed the following definition: "*Non-Timber Forest Products' (NTFPs) encompasses all biological materials other than timber, which are extracted from forests for human use.*" The authors clearly recognized problems with the definition. They addressed them by setting out what they saw as the key point of distinction between timber and non-timber forest products: that timber is managed on an industrial scale for interests located outside the forest, while NTFPs 'are extracted using simple technologies by people living in or near forest.' They dismissed the alternative term 'non-wood forest products' as being too exclusive.

In early times the term for forest produce was defined as 'all material yielded by a forest estate". There produces were further classified into major forest products and minor forest produce. Timber and firewood were termed as major forest products while other items received from forests were called minor forest products, which gives the impression of low importance (Tewari 1993). With the time the value of these non-timber forest products has become increased. An increasing awareness of richness and diversity of these recourses has been observed.

Subedi (1999) defined NTFPs as all biological origin other than timber, fuel wood and fodder from forest, grasslands or any land under similar uses. The example of NTFPs includes medicinal aromatic plants, bamboo, rattans, nuts, fruits, tubers, berries, grasses, leaves, resins, insect and insect providers, wild animals and birds. Chandrasekharan (1998) presented a very similar definition, where she cited NTFPs as all goods and services for commercial, industrial, or subsistence use derived forests and allies land uses, other than timber, fuel wood and fodder.

2.2 Global Importance of NTFPs

At least 150 NTFPs are significant in terms of international trade (FAO 1997). The general direction of trade is from developing to developed countries, with about 60% being imported by countries of the European Union, Japan and USA. The export values of NTFPs were found to be approximately US$ 32 million in Thailand in 1987; US$ 238 million in Indonesia and Malaysia in 1986 not less than US$ 11 million (Beer and McDermott 1996). There is great employment opportunity for millions of people in Asia pacific people from NTFPs collection and processing. In India, about 7.5 million people are engaged as part time collector of Tendu (*Diospyrous melanoxylon*) leaves and another 3 millions process the leaves to Bidi (Mittelman et al. 1998).

For the poorest groups in a south west Province of Cameroon, the NTFPs did not present a significant component of their livelihood strategies, accounting for no more than 6% of their annual total income (Ambrose-Oji 2003). Poor groups are harvesting and utilizing small quantities of lower value NTFPs. It is the middle income groups that derive the greatest benefit from NTFP collection, use and sale, harvesting a greater volume or more valuable products. NTFPs were considered an insecure source of income that remained difficult to access whilst under the control of richer and other groups. In short, the prospects NTFPs hold for sustaining the livelihoods of people living close to forests in certain localities may be limited and should be subject to critical assessment.

NTFPs attracted early attention among practitioners and researchers alike, based on three largely untested assumptions: i) NTFPs are widely distributed, contributing more than timber to forest people's livelihoods; ii) their harvesting is ecologically more friendly than alternative forest or non-forest uses, and iii) increasing their commercial value will contribute to an increased appreciation of forests, therefore contributing both to poverty alleviation and to forest conservation (Belcher, 2003). The primary requirements to work with NTFPs are knowledge of products, their uses and locations (Panayotou and Glover 1994), and the time, energy and mobility to access (Pierce *et al*. 2002; Ruiz-Perezi 2005).

Many international development agenda promote NTFPs as tools for sustainable development (Shillington 2002). The promotion of gender equity materializes through NTFPs' ability to improve the economic situation of households by incorporating women as key actors, since they are recognized as the main extractors, processors, and

marketers. So NTFPs are viewed as a potential means to better the livelihood strategies of rural populations while simultaneously sustaining the biodiversity of forested areas. The purpose for NTFPs extraction also differs based on wealth class. For rich category of the households, income from NTFPs is mainly used for asset formation rather than allocated for household consumption. They are relatively self sufficient in food production, while for those middle wealthy category of the households income from NTFPs complement other livelihood activities mainly crop and animal husbandry, and to fill income gaps whenever there was shortfall in agricultural production. On the other hand, in case of the poor category of the household's income from NTFPs used for household consumption mainly it is allocated to buy food requirement (Feto 2009).

2.3 NTFPs in Nepal

The collection and trade of non-timber forest products (NTFPs) has played a key role in the economic development of the country (Maraseni 2002). Many people living in hills and remote villages are involved in the collection and trade of NTFPs for their livelihood. Because of inadequate domestic processing facilities, a large quantity of NTFP is exported both legally and illegally to India in raw form (Maraseni et al. 2006). This generates export revenue of about US$ 26.5 M a year (ANSAB 1998), or 4% of the national gross domestic product of Nepal (Kanel *et al*. 1999). About 100 species of NTFPs are currently used in trade and processing collected from different climatic zones of the country. Further, it has been experienced that out of 127 commercially important species (ANSAB, 2003a), about 20 major species constitute more than 80% of the volume and value of commercial NTFPs. Every year forty-two thousands tonnes of NTFPs have been harvested in Nepal with a trade value of 26.8 million US dollars (CECI, 1999). This sub-sector provides a 5% total GDP in the country. The increasing commercial demand for the NTFPs found in Nepal presents an economically and socially viable means of assisting mountain communities in controlling the transition from subsistence to a cash economy (Chandrashekharan 1998).

Edward (1996) has categorized Nepalese NTFPs into two groups, high valued products from high altitude (above 2000 m asl) and low valued products from lower altitude areas (below 2000 m asl). High valued products include medicinal and aromatic plants collected from high altitude pasture. Collection of NTFPs is an income generating

activity that contributes significantly to household budget in the northern and middle sectors of the Lamjung district (Olsen 1997).

Bhattarai and Croucher (1996) studied the impact of NTFPs harvesting on the biodiversity conservation. The paper identifies and examines the underlying causes for improper extraction of NTFPs and the resulting adverse impacts on biodiversity. It then proceeds to present a different scenario in which NTFPs, when properly harvested, managed, processed and marketed, can play a strategically positive role in the conservation of biodiversity as well as in the economic development of the region.

Sada (2007) studied the status and distribution of NTFPs in two community forests; one in Tukucha VDC of Kavrepalanchowk and another Sudal VDC of Bhaktapur districts. Altogether 56 species were identified as the sources of NTFPs (herbs and shrubs). Among these NTFPs species of *Rubia, Gaultheria, Arundinaria* and *Daphne* were found to be potential for enterprise development.

Thapa Magar (2008) reported that the Chepang community depends on forests for foods, medicines, fuel-woods, fodder and grasses, and income through selling NTFPs. Their reliance on the forest is considerable especially from February to July during which they suffer from chronic shortage of foods. Only very few options are left to them other than utilizing the NTFPs during food insecure conditions. Utilizing NTFPs as foods and medicines serve them as safety nets and help to cope up in the harsh and hostile situations. But such a valuable knowledge regarding use value of NTFPs seems to be disappearing into the younger generations.

The promotion of NTFPs can and should complement the objectives of rural development and appropriate forest management, as they are sources of alternative employment and income generation (Sharma, 1995). Sustainable reliance on NTFPs also creates the need to maintain and conserve biodiversity. Thus, management of NTFPs cannot be seen separately from general forest management, which, unlike forest plantation, affects vegetation and biodiversity in general.

2.4 Sustainability of NTFPs

NTFPs have attracted considerable interest as a component of sustainable development initiatives in recent years due to their ability to support and improve rural livelihoods while contributing to environmental objectives, including biodiversity conservation.

Sustainable harvesting of NTFP is an issue of concern to farmers, traders, middleman, planners and policy makers (Olsen 1997). However, systematic understanding of the role and potential of NTFPs in conservation and development remains weak and it has been realized that the utilization of NTFPs requires certain measures of planning and control to be sustainable. While domestication is one way to reduce pressure on the natural resource, certification may provide another option to ensure that wild collection is maintained at a sustainable level. Certification can offer collectors higher prices to compensate for lower harvest levels and help them to secure user rights (Stark et.al 2006)

The lack of NTFP management plan and increasing national and international market demand encouraging intensive harvesting are leading to a decrease in the diversity, quality and availability of the NTFPs. In turn, it affects seriously the plant biodiversity and local collectors, who depend heavily on NTFPs to meet their basic needs. According to the Charles (1994), for the sustainable use of NTFPs there are many things that should be considered; among them harvest assessment and harvest adjustment are important. Overharvesting and unscientific collection triggered by the de-facto property rights arrangement and other economic conditions led to the depletion of these resources even from the protected areas and national parks. (Yonzon 1993).

2.5 National Policy, Rules and Regulation on NTFPs

The policy and regulatory environment plays a very significant role in all aspects of trade of NTFPs. Government of Nepal had not regulated separate policy and legal framework relating the development, conservation and management of NTFPs. However, a number of national policy statements have emphasized the potential role of NTFPs resource base in controlling to poverty alleviation, economic growth and, occasionally, improved natural resources management (Olsen 1996). Several policies and legal provision had been included within the Forest Act (1993) and Forest Regulation (1995) for this sector on behalf of which their use and conservation are undertaken (GoN/MFSC 2007). The important ones are Master Plan for Forestry Sectors (MPFS), Tenth Five Year Plan, and NTFP policy (2004). The NTFPs regulation in Nepal emphasized on control in extraction, use, trade and marketing. Some species of NTFPs are banned for extraction, while other are banned for collection, while other are banned for export in crude form (HMG 1995).

National Parks and Wildlife Conservation Act (1973): Emphasizes conservation of biodiversity using protected area model, which usually restricts access of local people to NTFPs in the protected area, creating conflicts between local people and park authorities.

Master Plan for the Forestry Sector 1988 (MPFS): The MPFS highlights the need to increase the supply of medicinal and other minor forest products and to facilitate their conversion into useful commodities for local and foreign markets. The Forest Industrial Development Plan of MPFS emphasizes creation of jobs and processing facilities as well as cultivating wildly collected medicinal plants. NTFPs constitute one of six forestry programme in the MPFS, where seven marked NTFPs are signed out for promotion, including medicinal and aromatic plants, Lokta paper, pine resin, katha (*Acacia catechue*), Sabai grass, cane and bamboo.

Forest Act 1993 and Forest Rules 1995 (with subsequent amendments): The forest act has recognized the forest user groups (FUGs) as the self-governed organizations which can regulate and use NTFPs available in community forests. The Act and Regulations provide authority to Government to ban or restrict trade of specific NTFPs.

Tenth Five Year Plan (2003-2007): The 10^{th} five year plan has explicitly recognized the importance of the management and trade of NTFPs in poverty reduction, biodiversity conservation and ecotourism development. NTFPs production is the component of sustainable and broad economic development, which is the first strategy of 10^{th} five-year plan to reduce poverty. The NTFP sectoral strategies of 10^{th} five-year plan regarding poverty alleviation are sustainable management of NTFPs, promotion of investment at local level, and export promotion. It emphasized on the production, processing, and marketing of NTFPs in the private-public partnership basis, by establishing a national level Herbs and NTFP Co-ordinate Committee (HNCC) under the chairmanship of MFSC to help formulating appropriate national policy (NPC 2002; ANSAB 2003b).

NTFP Policy (2004): The long term vision of NTFP Policy (2004) is to boost the economics condition of the country by sustainable utilization of Medicinal Plants (MPs) and NTFPs by conserving and managing resources by 2020. Key objectives include sustainable development of MPs and NTFPs through infrastructure development, processing, and enterprise development, and assist in social transformation and earn foreign currency through competitive international marketing of these products.

2.6 Nepali Handmade Paper and *Daphne* species

Handmade paper making started in Nepal at least since 12th century AD and handmade paper was probably the only paper available that time, especially for the use in religious texts and government documents. With the introduction of modern paper that was imported from India since 1930s, the traditional handmade paper industry suffered for more than four decades. The industry started to revive in 1970s with tourists led demand. (Subedi et al. 2006)

Considering the growing demand of the bark of *Daphne* species as an important forest resource, FSRO (1984) conducted an extensive field survey to make a quick assessment of the *Daphne* species available in the country. The result of the survey provided some general information regarding the availability of *Daphne* species in each development region of the country. Controlled harvesting of *Daphne* species by management blocks, harvesting methods, allocating of harvesting rights, and monitoring *Daphne* species harvesting by Forest Department were some of the points listed to prepare management plan in order to ensure a continuous yield from the forest (Forest Service 1983b). Messerschmidt and Pandey (1983) proposed to mobilize local villagers for harvesting and marketing of *Daphne* bark to avoid destruction of *Daphne* species resources and to enhance the proper conservation and utilization of this forest resource for improving the economy of selected group of local people.

The biomass data and growth rate information have been interpreted to establish the productivity and annual availability of inner fibrous bark of *Daphne* species. Ghimire and Nepal (2008) have given the methods of sampling for *Daphne* species and also the equations to estimate the total dry mass of inner bark of *Daphne* species from the values of plant height and diameter. The study also has given the different management guidelines for sustainable harvest of *Daphne* species. Rasaily (2003) estimated the harvestable bark of *Daphne* species to be 8.4, 259.1 and 363.9 tones in Parvat, Myagdi and Baglung districts, respectively, for 8 years. He has also discussed about sustainable harvesting and value additions technology for *Daphne* species and other fibre yielding NTFPs like Lokta (*Daphne* species), Argeli *(Edgeworthia gardnerii)*, Allo (*Girardinia diversifolia*). An estimate by Forest Service (1983a) showed that a harvester could collect 6.5 kg of air dry *Daphne* species every day in a forest in Baglung district. *Daphne* species was one of the prominent NTFPs harvested in Sandhu Maruche of

Lamjung district; there was collection of about 700 kg/year and generated the income of NRs. 67500 (Gaire 2005).

Local hand-made paper has contributed significantly to the national economy as well. Total export of local hand-made paper in 2001/02 was worth about US$ 3.5 million (Biggs and Messerchmidt 2003). Handmade papers are made in remote hilly areas by the local farmers at a household level or made by entrepreneurs in a large scale, and then local level contractors buy the processed paper. These contractors either sell to regional contractors or sell directly to the processors in Kathmandu. In the domestic market, the paper products are mainly sold to tourists and for official government documents, primarily through handicraft retail shops and stationery shops. Kathmandu, from where almost all export of handmade paper originates, also consumes over 80% of domestic sales. Bulk of the products is exported to Europe (65%) and the US (23%), and in Europe mainly to the UK (28%), France (16%), Germany (7%), Japan (6%) and Belgium (5%) (Subedi et al. 2006). Nepali handmade paper products are sold to customers abroad mainly through specialized gift shops, fair-trade stores, variety stores, furniture and home interior stores, departmental stores, grocery multiples, and mail order houses.

Harvesting bark of *Daphne* species and paper making by local enterprises are important NTFPs based economic activities in Dolakha district. The social welfare and community development activities carried out by these Nepalese paper producers are remarkable (Biggs and Messerschmidt 2003). The hand made paper enterprises became aware of making substantial financial and other contribution in support of social inclusion and cohesion, cultural identity and poverty reduction. At the same time, employment opportunities are provided to low income and marginal producers mainly women and disadvantaged groups promoting safe working condition, respecting worker's culture and ethnic identities, health and quality of life and assure sustainable resource base and continued employment.

The study in Dolkha district has shown rapid decrease in the quantity of Lokta *(D. bholua* and *D. papyracea)* and Argeli *(Edgeworthia gardnerii)*bark from 17.40tons to 3.39 tons and 10.58 tons to 2.60 tons respectively during the year 2055/56 to 2059/60 B.S. in Dolkha district. (Poudyal, 2004). It is partly because of the situation of slack in the production of Lokta and Argeli and partly because of immature collection. However,

in the present situation of market, the demand of Lokta and Argeli bark is increasing, although supply is gradually decreasing. A systematic inventory of Lokta and Argeli would determine the resource availability and annual harvestable yield. There is increasing need for more careful assessment of resource base and application of sustainable harvesting techniques to ensure the sustainability of local hand made paper enterprises.

Sustainable harvesting of *Daphne* species is a complex issue requiring an analysis of multi-faceted dimensions of ecological, economical, and social aspects. Indigenous knowledge has to be incorporated to prepare the harvesting plan so that it could be easy to implement and understand. Methods of assessment and harvesting of *Daphne* species are site specific. However, both ecological and economic considerations must be taken into account while making any intervention for assessment, regeneration and harvesting of *Daphne* species. In designing the management and harvesting plan of these species community interests and the capacity of the enterprises must be considered. Ref??

The methods being used for harvesting, and season of collection has exerted threat to the very existence of the species. Enough support needs to be provided to the private farmers to increase the production of the bark of *Daphne* species. Nevertheless, if the production of the bark of these species could not be regulated to an increased level from the present status, sustainability of local hand made paper enterprises would be in crisis (Poudyal, 2004).

3 MATERIALS AND METHODS

3.1 Study area

3.1.1 Annapurna Conservation Area (ACA) Region

Annapurna Conservation Area (ACA) is situated in the central Nepal and has an area of 7629 km^2 at 28º12'48"-29º19'48" N and 83º28'48"-84º26'24" E. The Annapurna Conservation Area Project (ACAP) was initiated in 1986 in a single village, Ghandruk as a pilot phase. Now it encompasses 55 VDCs from Manang, Mustang, Kaski, Myagdi and Lamjung districts. It was gazetted in 1992 as the largest conservation area in Nepal, managed by National Trust for Nature Conservation (NTNC) (previously King Mahendra Trust for Nature Conservation, KMTNC). It is Nepal's most extensive protected area and the first conservation area consisting of the entire habitat gradient from subtropical Sal forest to perennial snow.

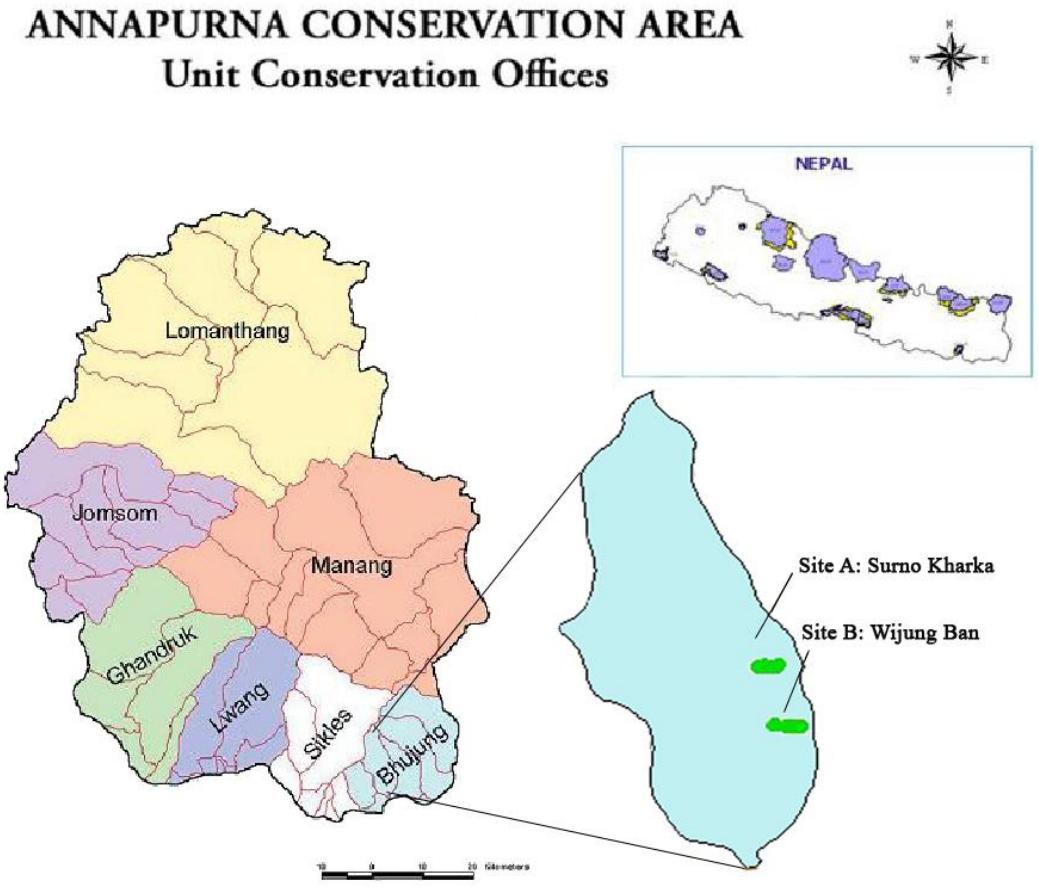


Fig 1: Annapurna Conservation Area, its sectors and Bhujung VDC

ACA is rich in biodiversity and is a treasure house for 1,226 species of plants, 38 species of orchids, 9 species of rhododendrons, 101 species of mammals, 474 species of birds,

39 species of reptiles and 22 species of amphibians. It harbours rare and endangered wildlife species such as the Snow Leopard, Musk Deer, Tibetan Argali, Impeyan Pheasant and
Tragopan Pheasant. (Tucker et al. 2005)

ACAP's principal is management of natural resource in very dynamic and effective way as it concerns people as the manager and project as a catalyst. The major objectives of ACAP are: conserve the natural resources for the benefit of present and future generation; bring sustainable social and economic development to the local people; and develop tourism in such a way that it will have minimum negative impact on the natural, socio-cultural and economic environments. In an effort to conserve the diversity of the ACA, area has sought the involvement of local people and emphasized the environmental education.

3.1.2 Bhujung VDC

Bhujung is a small and beautiful village that lies at the northwest part of Lamjung district on south facing slopes of Lamjung Himal It is also one of the 9 VDCs in the Bhujung sector of ACAP which is named as Bhujung sector. Bhujung contains the largest Gurung population in the area, with over 400 households that pride themselves on their rich cultural heritage. They have even generated their own electricity supply, and are considered pioneers in conservation and development in the area.

Physiographically, the village lies in middle mountains. It falls under Annapurna Conservation Area management system. Total area is 55 km^2, in which forest area covers 33.15 km^2, grass land 7.54 km^2 and shrubland 7.89 km^2. The human population is nearly 2100 with 400 households (approx.) (Field survey)

3.1.2.1 Climate

Bhujung is at an altitude 1570 m and falls under the warm temperate zone with a mean annual temperature of 22 degree Celsius. The maximum temperature has been recorded 32 degree Celsius during the summer. The annual rainfall was 2641.6 mm, about 71% of annual rainfall occurs in summer months (July- September) for the year 2009 (DHM, 2009). There are marked variations in temperature and precipitation influenced by

altitude and seasons. The climate of the forest ranges from lower to upper temperate. The northern areas of forest fall under sub alpine and alpine climate.

3.1.2.2 Environmental Features

The forest type in the region is categorized as hardwood forest with oak and laurels as dominant species. The vegetation comprises Alder (*Alnus nepalensis*), *Rhododendron* species, *Quercus*, Bamboo species and various mixed species. Major wild animals include Barking deer, Musk deer, Wolf, Langoor Monkey. Likewise bird species like Kalij, Danfe, Monal and other several bird species are found in forest. The area is popular for wild bee. The upper part of the forest comprises rangeland. The forest comprises varieties of orchid species

3.1.2.3 Social and Cultural Features

Bhujung is considered to be the largest Gurung settlement in ACA with a few other ethnic groups such as Bishwakarma, Chhetri and Brahmin. Majority of people in Bhujung are engaged in agriculture. They grow rice, wheat, maize, millet and potatoes. Apart from the agriculture, they also keep sheep and cattle as an alternative source of income and food. The people are still involved in traditional activities like weaving the clothes, making butter from milk, using indigenous tools for farming, playing local music, cooking meals in a typical kitchen. The beautiful carved windows, wooden and stone roofed houses, typical round shaped houses are some representative socio-cultural features of the village.

3.2 Study method

3.2.1 Reconnaissance

The reconnaissance of the site was undertaken in the month of February. During this period, informal group discussions were carried out and thorough observation of the area were carried out to access the suitability of the study. Information on availability, distribution, importance, harvesting and use of NTFPs were collected through informal discussions with local inhabitants. *Daphne bholua* was commonly observed in the forest but it was not harvested for its bark. Considering the contribution of *Daphne bholua* to local livelihood and national economy, the species was selected for ecological study and resource assessment. This could be a new source of income to local people in the study area. The species found in the study area was identified as *Daphne bholua*.

3.2.2 Study Species

Daphne bholua is an erect or spreading evergreen or deciduous flowering shrub, on 1-3 meter tall, but less frequently attaining heights of 5-6 m in the areas not heavily exploited (Polunin & Stantion, 1999). The leaves are entire, dull green and leathery. The flowers are sweetly scented, white, flushed externally pink or purplish. Flowering is usually from December to May depending on altitude and climatic factors. The fruit is an ellipsoid berry of about 1 cm long, green at first then purple or almost black when ripe. The fruit ripen from March to June; each fruit containing a single seed.

3.2.3 Data Collections

3.2.3.1 Field sampling

The field sampling was done in the month of March. Two sites, Surno Kharka and Wijung Ban, were selected. The general aspect of the slope of Surno Kharka is South facing and of Wijung ban is North facing.

In each site, three plots of 50 m × 100 m were marked along the elevation gradient from 2140 to 2480 m in Surno Kharka and 2100 to 2455 m in Wijung Ban. The first plot was marked from where *Daphne* was observed. The surface distance between two successive plots varied from 50-100 m. In each plot seventeen 5 m × 5 m quadrats were located randomly. Altogether 102 quadrates were sampled in two sites. In each quadrat, GPS coordinates (Garmin *e*trex GPS), slope (Clino meter) and aspect (Brunton compass) were recorded. Disturbance (in the scale of 0-3), rock cover (% of ground surface) and tree canopy (%) were visually estimated. Depth of the soil was measured with the help of calibrated rod (up to 50 cm.) that was pierced inside the ground until it was stopped by the rock. The average litter cover was estimated using Leaf Litter Index (Dupuy and Chazon 2008) by driving a sharpened wire stake into ground at each corner and the center of 5 × 5 m^2 quadrat. The mean number of leaves pierced at the five points, hereafter called leaf litter index (LLI), was used as an estimate of mean litter cover. Soil samples were collected from the four corners and middle of each quadrat at a depth of 15 cm using a soil digger. These sub-samples were mixed thoroughly and about 200 g was collected in zipper polythene bag. The soil samples were air dried in shade and stored in air tight plastic bags until laboratory analysis. There were 51 soil samples from each

sampling site. Number, height and girth (at 20 cm above ground surface) of individual *Daphne bholua* within the plot were noted. Associated species of shrub layer was also noted. Information pertaining to medicinal and food value of locally important plants were obtained from the local people.

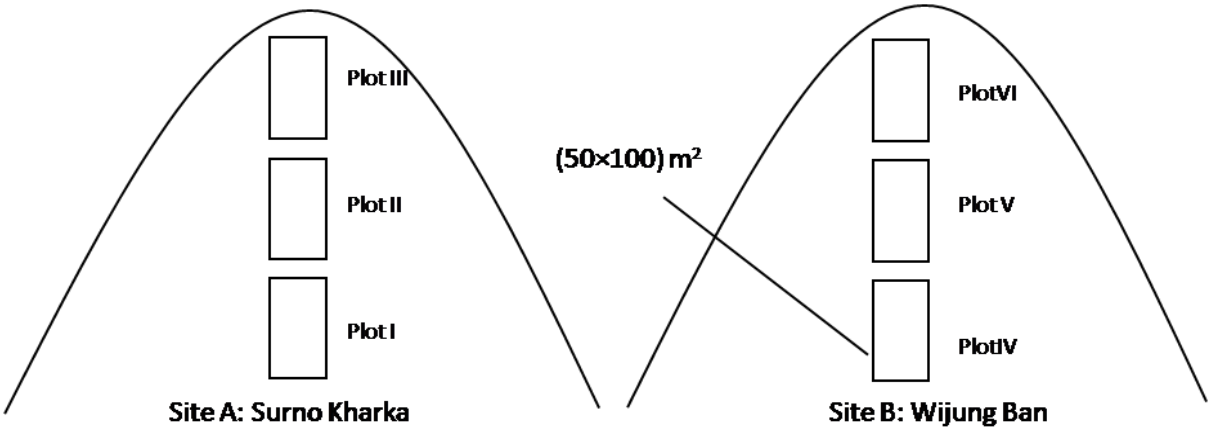


Fig 2: Plot layout for the inventory of *Daphne bholua* in the study sites

3.2.3.2 Herbarium preparation and identification

Specimens of all plant species encountered in sampling areas were collected, tagged and pressed in the field using a newspaper and herbarium presser. Local names, colour of the flower, fruit or any special features of the plants were noted in the field. The herbarium specimens were identified using references such as by Hara *et al.* (1978, 1982); Hara and Williams (1979); Polunin and Stainton (1984); and Stainton (1988). These were also compared with specimens at Tribhuvan University Central Herbarium (TUCH) and some of them were identified by plant taxonomyst. The nomenclature adopted in this document is in accordance to Press *et al.* (2000).

3.2.3.3 Soil analysis

Soil samples were analyzed at the laboratory in the Central Department of Environment Science, Tribhuvan University. Soil pH, organic matter (OM), and total Nitrogen (N) were estimated in the soil samples using methods described by Trivedy and Goel, 1984.

a. Soil pH

Soil pH is the measure of the hydrogen ion concentration and depends on the relative amount of the absorbed hydrogen and metallic ions. The pH of the soil suspension depends on the soil water ratio and increases with dilution. Soil pH was determined using Fischer's Digital pH meter in 1:5 ratio of soil-water mixture. Before measurement, the pH meter was calibrated using buffer solutions of known pH (pH 4 and pH 7).

During the measurements, 10 mL of distilled water was poured into 2 g of soil sample. The mixture was stirred at least 30 minute then allowed to settle down for five minutes. The electrode was dipped into the mixture and reading of pH was noted (Trivedy and Goel 1984)

b. Organic matter (OM)

The amount of OM in soil was determined by Walkey-Black rapid titration method (Piper 1996 as cited in Trivedy and Goel 1984). Soil sample (0.2 g) passed through fine sieve (0.5 mm) was taken in a 500 ml conical flask and added 10 ml of 1N $K_2Cr_2O_7$ and 20 ml of conc. H_2SO_4 with gentle swirling. The digestion reaction being exothermic, the flask was left for about 30 minutes to cool down to room temperature. To that mixture 200 ml distilled water, 10 ml orthophosphoric acid, and 1 ml diphenylamine indicator solution were added successively and shaken. The mixture was titrated with freshly prepared ferrous ammonium sulphate solution (0.4 N) which was run from burette, with constant stirring until the colour changed from violet to bright green through blue. The volume of ferrous ammonium sulphate consume was noted. A blank titration (without soil) was carried out with same amount of reagents in a similar manner. Then, the organic matter was calculated by following formula:

Organic carbon (%) = $3.951/\{g(1-T/S)\}$

Organic matter (%) = Percentage of organic carbon × 1.724

Where, g = weight of sample in gram

S = mL of ferrous ammonium sulphate solution with blank titration

T = mL of ferrous ammonium sulphate solution with soil

c. Nitrogen

The nitrogen of the soil sample was determined by the modified Kjeldahl method. Nitrogen in the soil is present in the organic form, together with small quantities of ammonium and nitrate forms. Kjeldahl method involves the conversion of organic Nitrogen into ammonia by boiling with conc. H_2SO_4; the ammonia was subsequently liberated from its sulphate by distillation in presence of an alkali, which is titrated against HCl. Kjeldahl method can measure organic and ammonium forms but not nitrate forms.

Digestion:1 gm air dry and sieved soil, 10 ml distilled water and 2 gm digestion catalyst mixture (which contains 1 part of the mixture of 20 g Copper sulphate, 3 g Mercuric sulphate and 1 g Selenium powder with 20 parts of Sodium sulphate) and 10 ml conc. H_2SO_4 was added to the soil mixture with gentle shaking. The mixture was heated on the preheated heating mantle at low heat until bubbles disappeared from the black mixture. When there was no frothing and then the heat was raised until the content of the flask would change to grey or greenish in colour for complete digestion. The digest was cooled to room temperature and about 40 mL distilled water was added to the mixture with gentle shaking.

***Distilation*:** The Kjeldahl distillation flask with 20 ml aliquot of the digested solution, 100ml distilled water and 20 ml sodium hydroxide (40% NaOH) was assembled on distillation. In the Kjeldahl distillation. In clean and dry (100 mL) beaker 20 mL boric acid and few drops of mixed indicator was pipetted and placed below the nozzle of the condenser in such a way that the end of nozzle dip in to the indicator. The heating mantle's temperature adjuster was set at 70. When the distillate began to condense, the color of boric acid indicator changed from blood red to blue.

***Titration*:** Beaker containing about 50 mL distillate was removed and titrated with hydrochloric acid (0.01 N) in burette. The volume of HCl consumed by distillate to change the green colour into blood red was recorded. The same procedure was followed for other samples.

Nitrogen (%) = {(a-b)×N of HCl×1.4}/S

Where, a = mL of HCl used in sample

b = mL of HCl used with blank

S = weight of soil sample taken in gram

d. Available Phosphorus

The P was measured by spectrophotometer method. This method uses 0.02N H_2SO_4 for the digestion of the sample. 1 gm of soil sample is mixed with 200ml 0.02N H2SO4 and was shaken well. After half an hour the suspension was filtered and 50 ml filtrate taken added with 2 ml Ammonium Molybdate and 5 drops of $SnCl_2$. It was left for 5 minutes to develop the colour. The reading was taken in spectrometer within 13 minutes al wavelength of 690nm.the spectrometer reading was also taken for various solution of

known concentration (standard solution). Then, the concentration of P was calculated using the calibration (standard) curve of standard solutions. Then, %available P was estimated as follows:

Available P (P_2O_5) in kg/ha= ppm in soil extract× 2.24×2.3

Where 2.24iconversionfactor for ppm in soil to kg/ha

2.3 is conversion factor for P in P_2O_5

e. Exchangeable Potassium

Available K is determined by flame photometer. 2 gm of soil sample and 20 ml of ammonium acetate buffer was taken in a beaker and shaken well. After half an hour it was filtered and the filtrate was used to take the reading in the flame photometer. The reading of the standard solution was also noted to make the standard curve from which the concentration of potassium was extrapolated.

Exchangeable K (K_2O) in kg/ha= ppm in soil extract×20/2×1.2×2×1.12=R×26.88

Where, R =K of soil extract in ppm from the standard curve

1.2= conversion factor for K to K_2O

2×1.12= conversion factor for ppm to kg/ha

20/2= dilution factor

3.2.4 Data Analysis

3.2.4.1 Density

Density is defined as the number of individuals of the species in unit area. Density represents the numerical strength of species in the community. It is usually expressed as number per hectare. It is calculated by using the following formula:

Density of species in a quadrat (stem/ha) = $\frac{\text{Number of individuals of a species}}{\text{Area of quadrat in m}^2} \times 10000$

Density of species in a plot (stem/ha) = $\frac{\text{Number of individuals of a species}}{\text{Number of quadrats sampled} \times \text{Area of a quadrat in m}^2} \times 10000$

Density of each girth = $\frac{\text{Number of individuals of a species of the girth class}}{\text{Number of quadrats sampled} \times \text{Area of a quadrat in } m^2} \times 10000$ (stem/ha)

Girth classes were categorized according to the diameter of the stem 20cm. above the ground level. To identify the age/size of *Daphne* species the following categorization was used following Ghimire and Nepal (2007):

Estimation of age/size of *D. bholua*:

Seedling: - Germinating plants of less then one year of age; < 1cm girth.

Juvenile: - Small sized plants less than four year of age; 1-4cm girth.

Immature: - medium size plant less than eight years of age; >4-8cm girth.

Mature: - Large size plants more than eight years of age; >8cm girth.

Adult 1: >8-12cm girth

Adult 2: >12cm girth

However, in the study the mature class i.e. more than 8cm girth was further divided into different sub classes keeping the class interval 4 cm. and the plant was also classified on the basis of height keeping the interval 20 cm to observe the clear trend of the *Daphne bholua* in different classes.

3.2.4.2 Frequency

Frequency as introduced by Raunkier (1934) indicates percentage of sampling units in which a particular species occur. It shows the degree of dispersion of the species. It is calculated by using the following formula:

$$\text{Frequency of a species (\%)} = \frac{\text{Number of quadrats in which species occurred}}{\text{Total number of quadrats sampled}} \times 100$$

3.2.4.3 Dry mass of inner bark

The dry mass of inner bark (bast) of *Daphne* spp. was calculated by using the following regression equation:

$$LnY = 2.165 + 2.052 LnD_{20}$$

where, Y is the total dry mass of the inner bark of *Daphne*

D_{20} is diameter of *Daphne* at height 20 cm above the ground (Ghimire & Nepal, 2008)

Using the above formula dry bark mass was estimated for all individual plant that was ≥ 20cm. Total dry mass of inner bark was calculated as summation dry mass of all the individual *Daphne* that was ≥ 20 cm in height. Whereas, the harvestable dry mass of inner bark was calculated as the summation of all dry mass of *Daphne* having diameter more than 2.5 cm or girth more than 8 cm (i.e. mature species only).

3.3 Statistical Analysis

All the statistical analysis including standard deviation, correlation and regression was done using SPSS 11.5 software. The correlation was determined between all the attributes viz. Soil nutrient parameters (OM. P, K, pH), litter index, average height and girth, maximum height and girth, total and harvestable bark mass, rock and tree cover, altitude, intensity grazing and harvesting (Disturbance). And only significant and important relation were filtered out for the further study the correlations that were significant and were of interest to the study were further regressed.

3.4 Socioeconomic Surveys

The socioeconomic surveys were carried out in 68 HHs of Bhujung Village Development Committee (VDC). A structured questionnaire was used for the survey and the household were selected under stratified random sampling technique. Each ward of the VDC was considered as a single strata resulting to the total of 9 strata in the study area. The HHs were selected randomly in a regular basis of 5 household to maintain 20% sampling intensity for the study, to avoid biasness in response and to obtain different type of responses as possible.

4. RESULTS

4.1 Habitat Characteristics of *Daphne bholua*

In the study site the *Daphne bholua* was observed from 2100 to 2500 m asl. The range of elevation, aspect and slope of each plot is given in the table below.

Table 1: Elevation, aspect and slope of different plots in the study sites

Site	Plot	Elevation (m)	Aspect (º)	Slope (º)
A: Surno Kharka	I	2141-2208	175-310 (S-NW)	17-46
	II	2230-2307	15-350 (N-NW)	16-40
	III	2370-2478	72-300 (NE-NW)	13-38
B: Wijung Ban	IV	2109-2172	80-355 (NE-NW)	12-30
	V	2256-2346	196-328 (SW-NW)	17-36
	VI	2399-2455	166-326 (SE-NW)	13-38

The species compositon on both the forest was similar with the dominance of Rhododendron, Jhingane (*Eurya acuminate*) Kalikath (*Myrsine semiserrate*), Chandan (*Daphniphyllum himalense*) and Chutro (*Berberis* spp.) were the most dominant species. Relatively, Surno Kharka was moist as it was facing towards the north and Wijung Ban was drier as it was facing south. The elevation of Surno kharka was upto 2480 m where there was a presence of Grassland or Kharka. Whereas Wijung ban starts with grassland and gradually turns into dense forest as we move up reaching to the elevation of 2455 m. Since the villagers practice open grazing, the disturbance could be seen which was more pronounced in grasslands which was relatively flat and easy to graze. The disturbance due to human activities was more in lower altitudes and it decreased as the elevation increased but grazing was nearly uniform across the elevation range.

Soil pH ranged from 4.2 to 5.8 in Surno Kharka with mean value of 4.89, and from 4.02 to 5.26 in Wijung Ban with mean value of 4.54, respectively. The mean organic matter in soil was 13.50% (range: 5.99 to 27.82%) in Surno Kharka and 9.33% (range: 3.24 to 19.18%) in Wijung Ban. Soil nitrogen content varied from 0.23 to 0.71% in Surno Kharka and from 0.16 to 0.47% in Wijung Ban. The mean soil nitrogen contents in these

two sites were 0.38 and 0.29, respectively. The value of available phosphorus ranged from 20.12 to 115.17 kg/ha in Surno Kharka with mean value of 71.66 kg/ha, and 12.98 to 182.75 kg/ha in Wijung Ban with mean value of 61.71 kg/ha. Potassium ranged from 42 to 126 kg/ha (mean: 78 kg/ha) in Surno Kharka and from 46 to 173 kg/ha (mean: 81 kg/ha) in Wijung Ban.

Table 2: Soil characteristics of the habitat of *Daphne bholua* in the study sites

Sites	Plots	pH	Organic matter (%)	Total Nitrogen (%)	Available Phosphorus (kg/ha)	Exchangeable Potassium (kg/ha)
Surno Kharka	I	5.08	12.75	0.35	62.57	79.85
	II	4.96	15.07	0.43	77.19	82.67
	III	4.60	12.69	0.36	75.23	68.44
	Mean	4.89	13.50	0.38	71.66	76.99
	SD	0.47	5.07	0.09	23.32	20.54
Wijung Ban	IV	4.84	8.78	0.27	59.00	71.01
	V	4.55	10.68	0.3	55.49	102.08
	VI	4.23	8.53	0.3	70.64	69.00
	Mean	4.54	9.33	0.29	61.72	80.69
	SD	0.45	3.06	0.62	30.62	32.34

4.2 Frequency and Density of *Daphne bholua*

Daphne bholua was more frequent in Wijung ban (98%) than in Sumno Kharka (78%). The frequency of *D. bholua* ranged from 59 to 100 % in Surno Kharka and 94 to 100% in Wijung Ban. It was more frequent in plots of higher elevation.

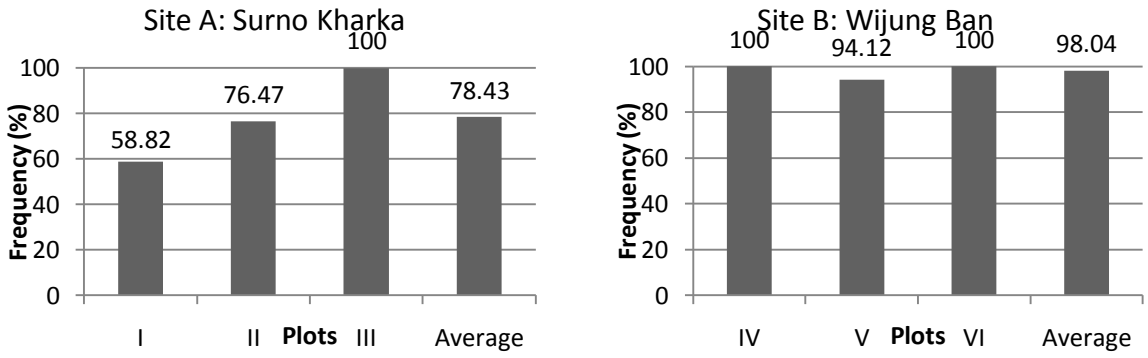


Fig 3: Frequency of *Daphne bholua* in different plots.

The average density of *D. bholua* in Surno Kharka was 5231 stem/ha and that in Wijung Ban was 6925 stem/ha. In both sites, density increased with increasing elevation; the plots (III and VI) lying at the highest elevation had the highest density of *D. bholua.*

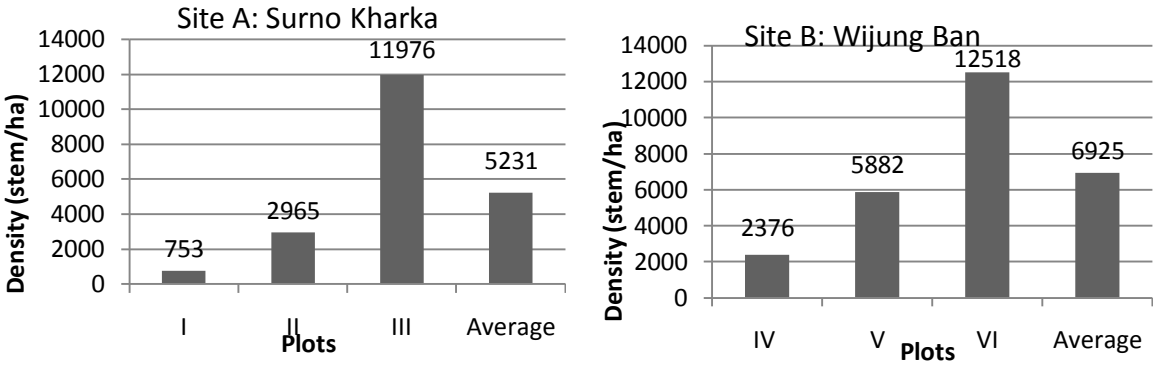


Fig 4: Density of *D. bholua* in different plots. Elevation range of each has been given in Table 1

4.3 Population Structure of *Daphne bholua*

Density of smaller individuals (i.e. seedlings and juvenile) were relatively low in most of the plots. In Surno Kharka immature class has the highest average density (1992 stem/ha) and in Wijung Ban juvenile class has the highest average density (2086 stem/ha). In Plot I seedlings were completely absent. The average density of mature class (adult 1 and adult 2) in Surno Kharka and Wijung Ban is1521.57 and 2196.08 stem/ha, respectively.

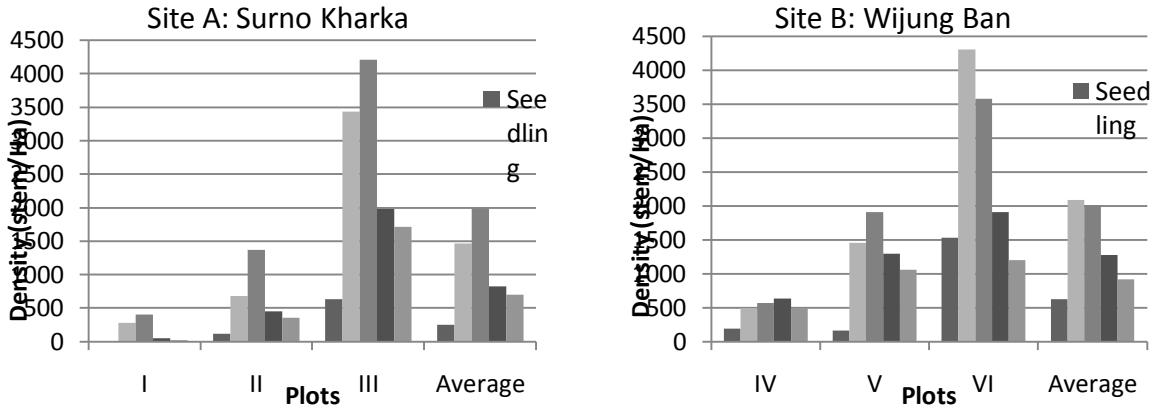


Fig 5: Density of *Daphne bholua* of diffeent age/size class in different plots

The girth size of the *Daphne bholua* corresponds its age. Density of smaller i.e. seedlings and juvenile classes were low in almost all six Plots. In Surno Kharka Immature class has the highest average density of 1992 stem/ha and in Wijung Ban Juvenile class has the highest average density of 2086 stem/ha. In Plot I seedlings were

completely absent. The girth of the *D. bholua* bark gives the idea about the age of the plant and the bard yield, hence very important.

4.4 Girth classification of *Daphne*

Density of both smaller and higher girth classes were low and that of intermediate class was higher in most of the plots. In Surno Kharka (plots I-III), density was the highest in 4-8 cm girth class but in Wijung Ban (plots IV-VI) the highest density varied with plots. When data of three plots of each samplig site were pooled, the girth class 4-8 cm had the highest density in Surno Kharka (1992 stem/ha) and the girth class1-4 cm in Wijung Ban (2086 stem/ha).

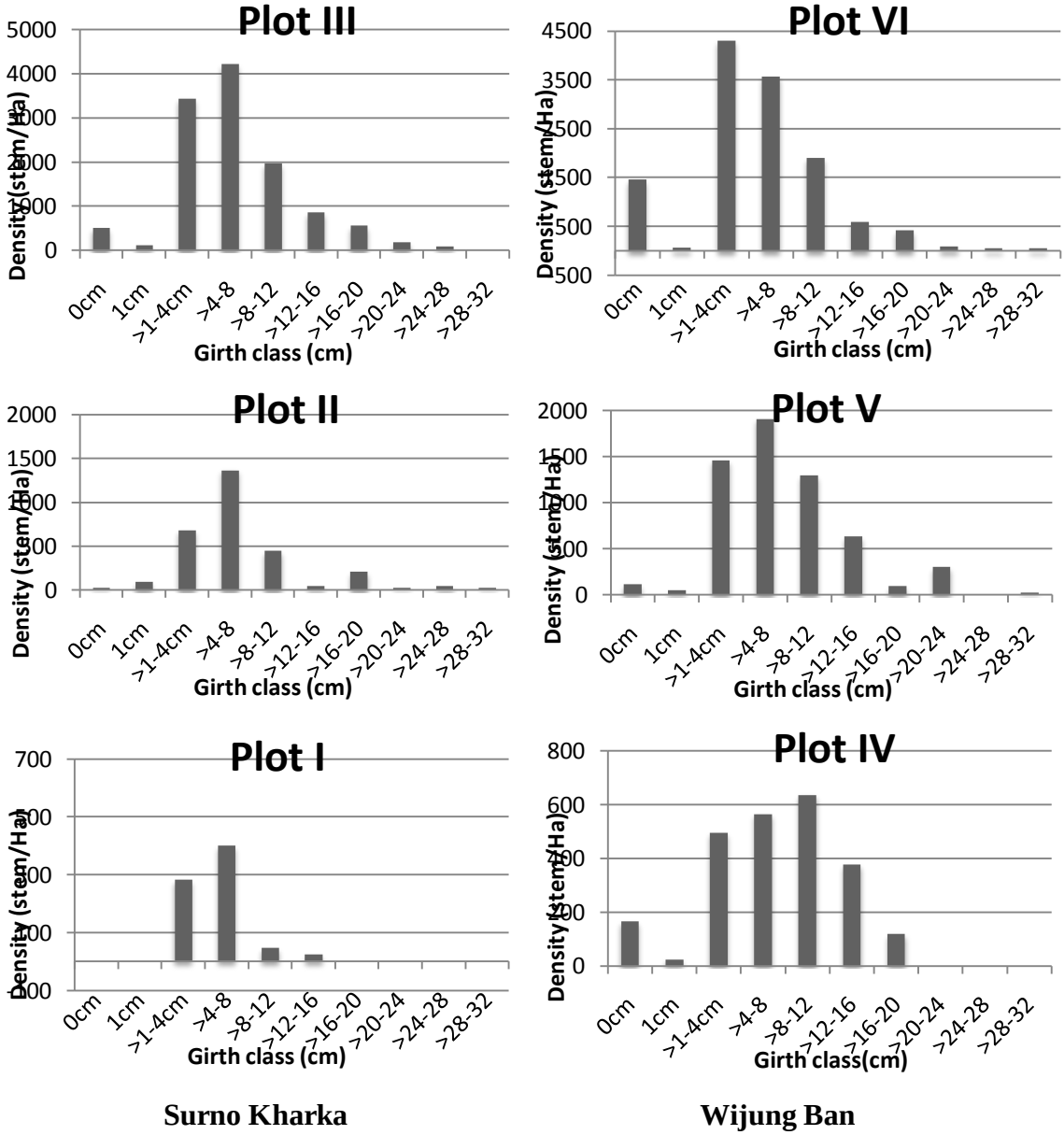
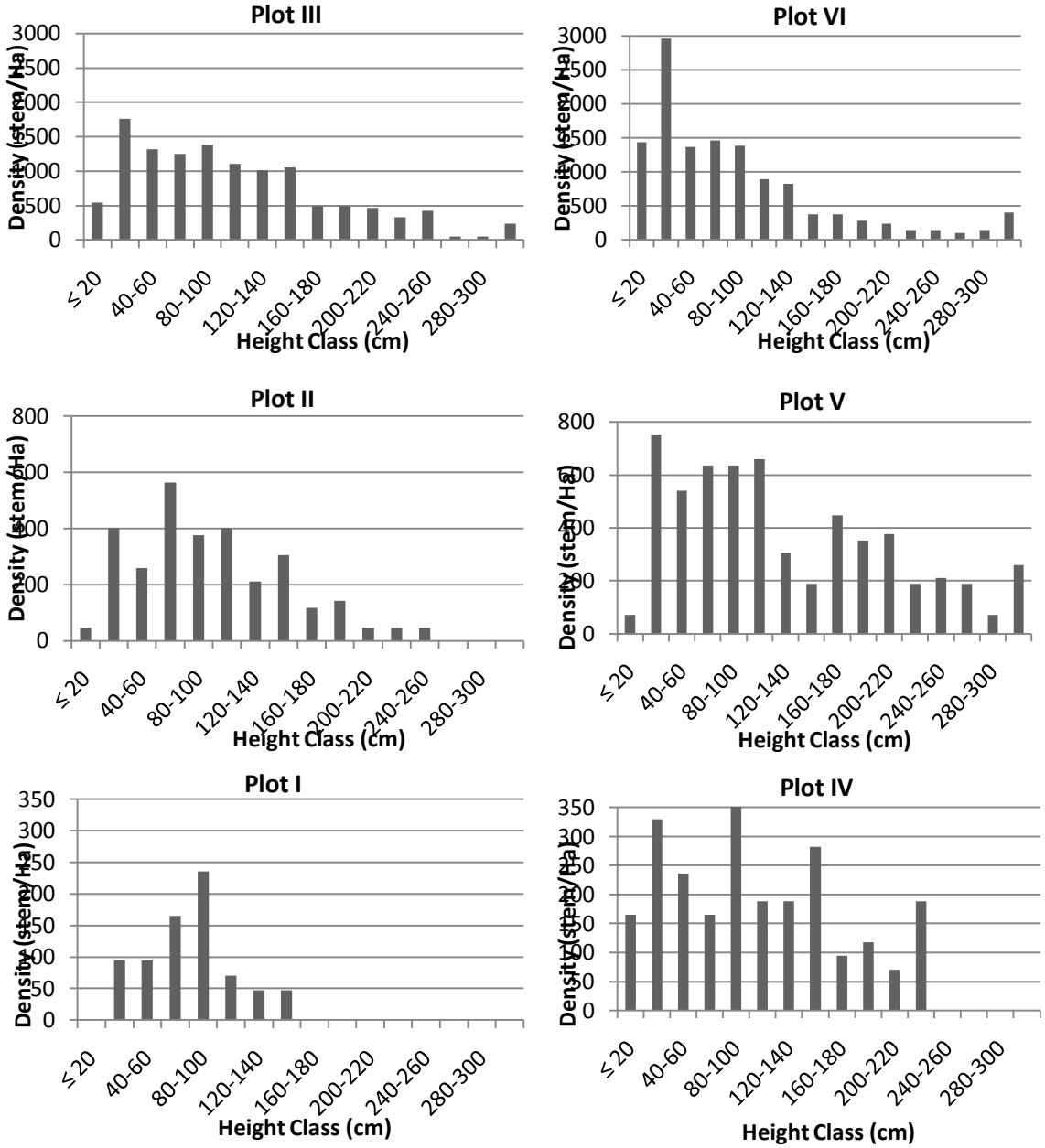


Fig 6. Density of *Daphne bholua* of different girth classes in the study area.

4.5 Height Classification of *Daphne bholua*

Height class distribution also showed the nearly same pattern as the girth class, with high density of intermediate classes. The height classes with highest density varied with the plots. On average, the height class 40-60 cm had the highest density both in Surno Kharka and Wijung Ban (753 and 1349 stem/ha, respevtively).



Site A: Surno Kharka Site B: Wijung Ban

Fig 7. Density of *D. bholua* of different height classes in the study area

4.6 Total and Harvestable Dry Inner Bark

Mass of the total inner bark mass of Plot I, II and III is 26, 216 and 856 kg/ha respectively and of Plot IV, V, and VI is 233, 535 and 732 kg/ha respectively, it includes the bark mass of all plants with height more than 20cm. Total inner dry bark mass for Site A and B is 367 and 501 kg/ha respectively

Harvestable dry mass of inner bark of *Daphne bholua* ranged from 9.4 to 690 kg/ha in Surno Kharka and from 170 to 552 kg/ha in Wijung Ban. The average harvestable dry mass of inner bark was 288 kg/ha in Surno Kharka and 391kg/ha in Wijung Ban.

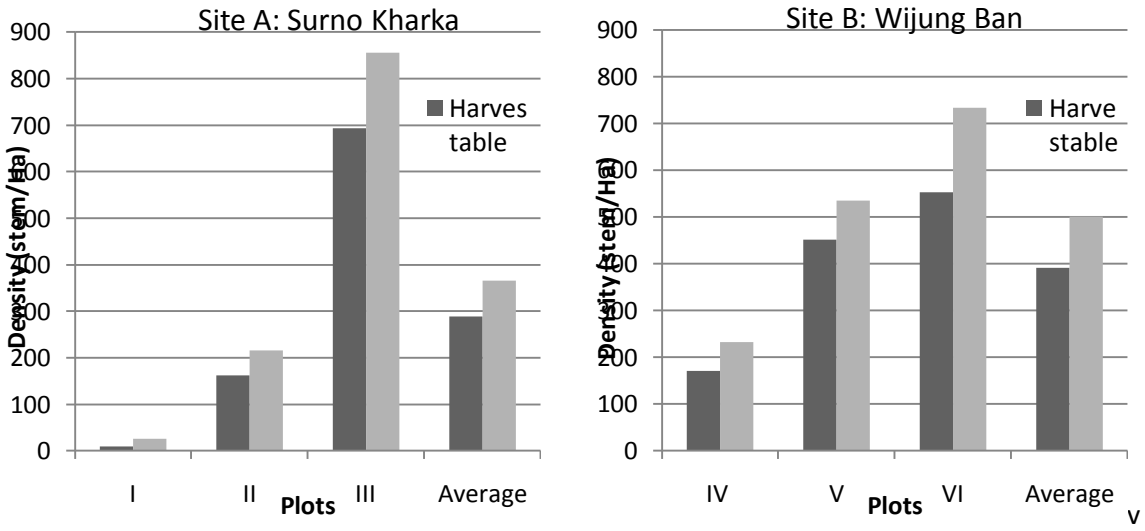


Fig 8. Dry mass of inner bark of *Daphne bholua*

4.7 Correlations

Correlation between different environmental variables and attributes were found as given below in Table 3.

There is a positive correlation of density of *Daphne bholua* with average height and girth, maximum height and girth, total mass of bark and harvestable bark mass, grazing, harvesting and altitude, and negatively correlated with pH, litter and rock cover.

There is a positive correlation of average height with average girth, maximum height and girth, total mass of bark, harvestable bark mass, species richness and negatively correlated with tree coverage and litter.

Table 3: Correlation coefficient between various attributes of *Daphne bholua* and other variables.

Attributes		Significance level	Attributes		Significance level
Density	Potash	−0.26**	Maximum height	pH	−0.39**
	pH	−0.43*		Maximum girth	0.87**
	Average height	0.27**		Total bark mass	0.87**
	Average girth	0.27**		Harvestable bark mass	0.83**
	Maximum height	0.76**		Litter	−0.35**
	Maximum girth	0.73**		Rock cover	−0.21*
	Total bark mass	0.89**		Grazing	0.23*
	Harvestable bark mass	0.78**		Harvesting	0.26**
	Litter	−0.24*		Aspect	0.22*
	Rock cover	−0.24*		Altitude	0.48**
	Grazing	0.21*	Maximum girth	pH	−0.23*
	Harvesting	0.20*		Total bark mass	0.88**
	Altitude	0.67**		Harvestable bark mass	0.85**
Average height	Average girth	0.87**		Litter	−0.29**
	Maximum height	0.54**		Rock cover	−0.27**
	Maximum girth	0.51**		Harvesting	0.20*
	Total bark mass	0.51**		Altitude	0.40**
	Harvestable bark mass	0.51**	Total bark mass	pH	−0.31**
	Species richness	0.23**		Bark Harvest	0.90**
	Tree cover	−0.38**		Litter	−0.33**
	Litter	−0.27**		Rock cover	−0.23*
Average girth	Maximum height	0.52**		Harvesting	0.22*
	Maximum girth	0.60**		Altitude	0.51**
	Total bark mass	0.56**	Harvestable bark mass	pH	−0.30**
	Harvestable bark mass	0.55**		Litter	−0.39**
	Tree cover	−0.33**		Rock cover	−0.20*
	Litter	−0.26**		Grazing	0.20*
	Rock cover	−0.21*		Harvesting	0.26**
				Altitude	0.44**

* correlation significant at the level of 5 %(2-tailed);

** correlation significant at the level of 1 % (2-tailed)

There is a positive correlation of average girth with maximum height and girth , total mass of bark and harvestable bark mass and negative correlation with tree coverage , litter and rock coverage.

Maximum height of the species in a plot is positively correlated with maximum girth, total mass of bark, harvestable bark mass , grazing , harvesting, aspect and altitude, and negatively correlated with pH, litter and rock cover.

Maximum girth is positively correlated with total mass of bark, harvestable bark mass, harvesting and altitude and negatively correlated with pH, litter and rock cover.

Total bark mass is negatively correlated with pH, litter and rock cover and positively correlated with harvestable bark mass, harvesting and altitude.

Similarly harvestable bark is also negatively correlated with pH, litter and rock cover and positively correlated with grazing, harvesting and altitude.

4.8 Variation of Density and Growth Attributes of *Daphne bholua*

Density of *Daphne bholua* decreased with increasing potassium content of soil and decreased with increase in soil pH.

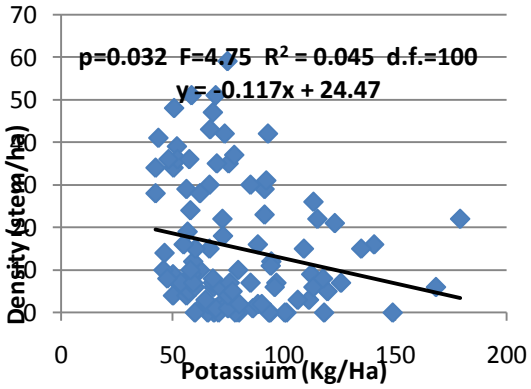


Fig 9: Variation of density of *D. bholua bholua* with soil potassium

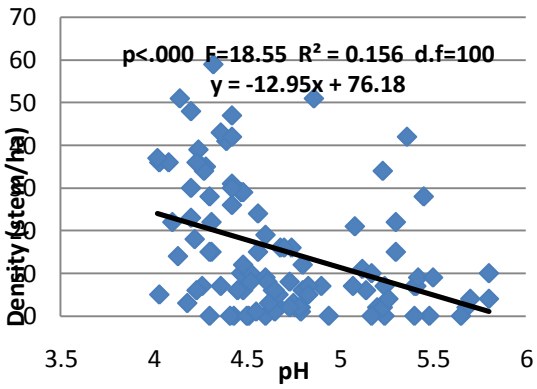


Fig 10 : Relation between density of *D.* and soil pH

Elevation had also significant influence over density and maxium girth of the species in the plot. Both density and maximum girth of *D. bholua* increased with increase in elevation.

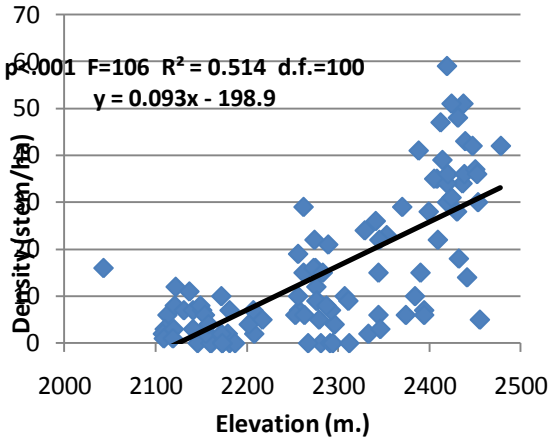


Fig 11: Change in density of *D. bholua*

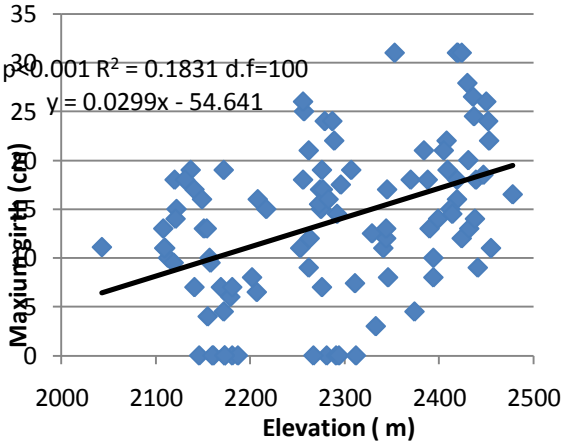


Fig 12: Variation in maximum girth of *D. bholua* with elevation

Tree canopy cover had negative impact on average height of *Daphne bholua*; the height declined with increasing canopy cover. Total dry mass of bark of *D. bholua* increased with elevation.

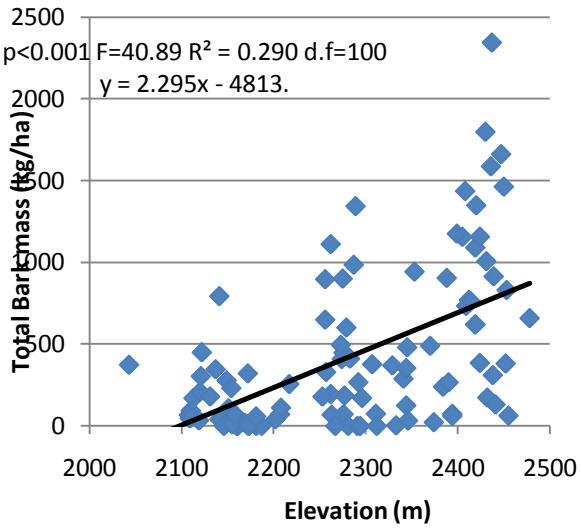


Fig 13 : Relation between mass of total bark of *D. bholua* and elevation

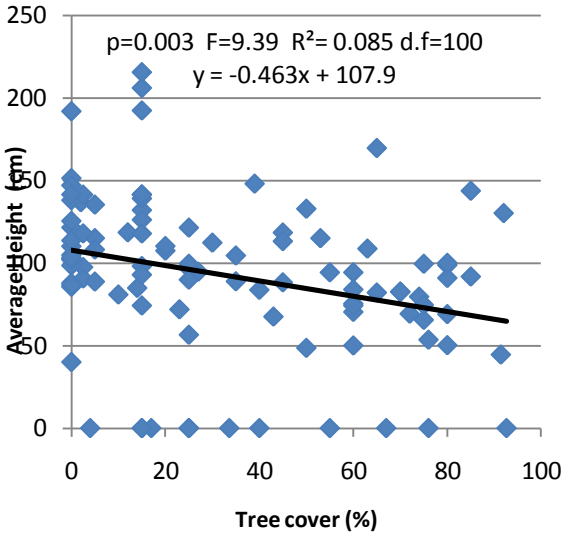


Fig 14 : Change in average height of *D. bholua* with tree canopy cover

Litter accumulation had negative impact on maximum height and bark yield; the harvestable bark declined with increasing litter index.

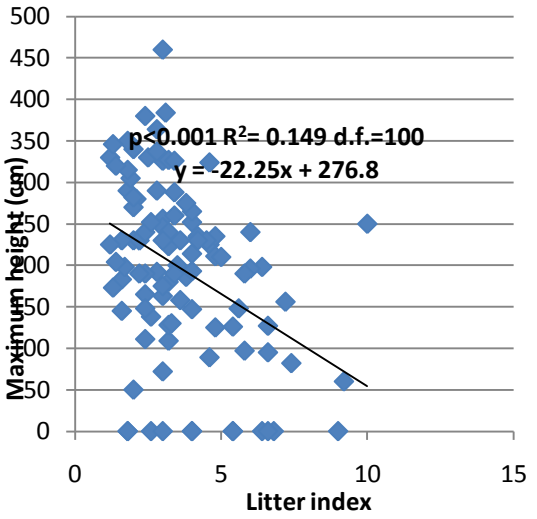


Fig 15: Relationship between maximum height of harvestable *D. bholua* and litter index

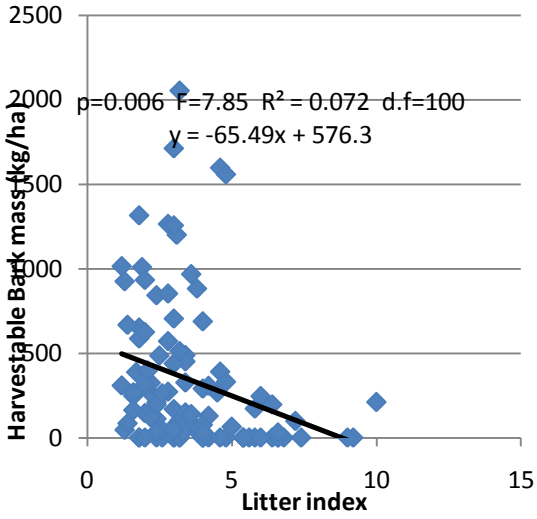


Fig 16: Relation between mass of bark and litter index

4.9 Socio economic analysis

4.9.1 Household information

Most of the households have joint family structure (60%). About half (47%) of the house hold has more than 6 members and average household size was found to be 7.

Literacy rate is very low in the village; nearly 52% of the respondents were illiterate. Only13% of the respondents were educated above secondary level and 35% of the respondents were educated up to primary level. The government is implementing old age education to increase the literacy rate.

4.9.2 Occupation and economic activities

96% of household has agriculture as the main occupation. People are involved in many income generationg activities as the outcome from agriculture alone is not sufficient. Only 12% households are dependent solely in agriculture and thus had no other source of income generation. Other sources of income were remittance (38%) labour work (31%), service (16%), pension (15%), cottage industry (13%) and business (3%).

4.9.3 Food sufficiency

Only 7% of household has sufficient food around the year, rest of them having food sufficiency for less than nine months. 3% households were land less and 4% didn't practice agriculture due to absence of manpower.

4.9.4 Knowledge about *Daphne bholua*

D. bholua (locally known as Sisoo patt) though existed locally in abundance was not given much consideration and not in proper use in the study area. Only 47% of the respondents knew its use for making rope and/or paper.

4.9.5 Availability and intensity of harvesting of NTFPs

Nearly 74% HHs are involved in harvesting and making goods from Nigalo and Allo as tradition, but they don't have any knowledge about paper making from Lokta. There is a tradition that all the households have to harvest Nigalo and NTFPs in a certain time of the year when the forest is opened or leased to harvest them (Bandhej phukuwa), to promote the regeneration of the species. But 27% HHs did not harvest those NTFPs.

Among the HHs that harvest NTFPs 76% believed that there was less NTFPs available and have to go far for the harvest, where as 14% believed that the condition was same and 6% believed that its even more abundant. 60% of HHs believed that the intensity of harvesting has decreased, 32% were harvesting in the same intensity and 4% were harvesting NTFPs in greater intensity.

4.9.6 Source and use of products from NTFPs

The NTFPs harvested by the villagers are used to make into different products for daily use. The household who harvest the NTFPs but use the products only for sustenance are 44 (64.71%), and the Household who can also sell surplus products for additional income are 6 (8.82%).

4.9.7 Willingness in *Daphne* spp. as income generating activity

Nearly 85% of the HHs showed interest in learning about paper making from Daphne bholua and using it as an additional source for income generation, where as 15 % showed no interes in *Daphne bholua.*

5. DISCUSSIONS

5.1 Habitats of *Daphne bholua*

Daphne bholua was more prevalent in shady and moist places with low disturbances. In places with no trees i.e. shrub land the species occurred under the canopy of shrubs. But when the canopy was too close and dense the density was quite low like under dense *Rhododendron* canopy. In the higher altitude, the gaps created by the natural falling of trees promoted the growth and regeneration of *Daphne bholua*. *Daphne* species is a shade loving plant which grows under-storey of large trees. Partial shading of >30% cover is necessary for good growth of *Daphne* species (Branney, 1994). *Daphne* was found to occur in both plain and sloppy terrain, but the density was more in sloppy terrain.

5.2 Density of *Daphne bholua*

Density of *D. bholua* increased from the plots of the lowest elevation (plot I and IV) to the highest elevation in both samplings sites (Fig. 4). This increase in density along with elevation might be due to lower disturbance and more favorable condition that prevailed at higher elevation. During the field visit it was observed that in lower plots there was high human disturbance, grazing and less canopy cover and as we moved higher the conditions improved which might be the reason for gradual increase in density of *D. bholua* while moving to higher altitude. Higher density of *D. bholua* in Wijung Ban than in Surna Kharka might be due to more mesic environment in Wijung Ban which lies on north facing slope.

Both density and frequency of *D. bholua* was greater in Wijung Ban. The general aspect of the slope of Surno Kharka is south facing and of Wijung Ban is of north facing. This might be the reason for the lesser density of *D. bholua* in Surno Kharka. Aspect of the terrain is another determining factor for availability of *D. bholua*. Density of *D. bholua* was higher in terrain facing north. Terrains facing east or west bear crops (*Daphne* spp.) of medium density while those facing south have usually the least amount (FSRO, 1984).

In Surno Kharka, Plot I and II had very low density. In Plot I, 11 out of 17 quadrats were SW facing, *D. bholua* was not present in 7 quadrats, among them two had very high

litter, one had rocky terrain and another had high canopy cover. In Plot II, (7 out of 17 quadrats were SW facing, *D. bholua* was not present in 4 quadrats, among them one quadrat was completely covered with Fern and in two quadrat there was severe disturbance by Allo (*Girardinia diversifolia*) harvesting and in last one landslide had occurred. Thus the density was lower. Occurrence of *D. bholua* is found to be less or absent in places having heavy biotic interference such as haphazard exploitation of *D. bholua* , frequent fires and heavy grazing (FSRO, 1984). Excessive grazing damages the regenerated or plant seedling by trampling and also makes the soil compact. Although 12 quadrats in Plot III were facing SW, proper canopy and moist environment favoured the growth of *Daphne* and density was higher.

In plot IV, 11 out of 17 quadrats were NW facing. It was a heavily grazed shrub land and trees canopy was completely absent. *D. bholua* occurred in all the plots but density of *D. bholua* was low. *D. bholua* prefer partial shade and so it avoids places with very close cover or too large gaps (FSRO, 1984). In places where there was no tree canopy *D. bholua* was found to occur under the canopy of other shrub species like Chutro (*Berberis* spp.) and Aiselu (*Rubus* spp.) which are grazing resistant species. In Plot V, 8 quadrats were NW facing, the density was comparatively higher as the canopy cover was better i.e. 15-25%. In plot VI, 9 quadrats were NW facing, the plot was comparatively moist and shady, hence presence of tall *D. bholua* were observed except for some plots where there was less tree canopy cover and grazing was prevalent. So, from the observation made on density, aspect and canopy cover we can say that canopy, disturbance and the aspect of the terrain influences the density of *D. bholua*. It was also observed that in higher altitude where there was not much human disturbance the natural falling of trees created tree gaps promoting growth of *D. bholua* population.

In the vegetation analysis carried in Tinjure-Milke region, east Nepal, the density of *D. bholua* in less degraded Tamafok forest was 4066 stem/ha and in highly degraded Madi Mulkharka was 3812 stem/ha, respectively (Koirala, 2004). Thus we can say, the population of *D. bholua* is better in less degraded forest.

5.3 Age, Girth and Height Classification of *Daphne bholua*

Age, girth and height class distribution of *D. bholua* (Fig 5, 6 and 7) showed higher density of intermediate class and lesser density of immature and mature classes. Thus, the diagram resembled bell-shape which indicates lack of continuous regeneration. For

sustainable regeneration the curve should actually be inverse J-shaped. The lesser number of individuals in smaller girth class might be due to biotic disturbances such as grazing and trampling. Though *D. bholua* is not a preferred species for the livestock, small individuals could be easily damaged mechanically by trampling when grazing pressure was high. Closed canopy and thick litter might have also hampered the regeneration of this species. Under such condition seed germination as well as seedling mortality is relatively high due to lack of sufficient light and high frequency of fungal infection. Earlier research has also reported that canopy cover >80% is not favorable for the growth of *Daphne* species. (Branney 1995). The combined effects of high trampling damage and dense tree canopy could have resulted in low regeneration of this species in the study area.

The study of *Daphne* species. done in four CF viz. Dobate, Lawajin, Dorangyabo and Tiptala of KCA showed that the population density of seedling was highest with gradual decrease in population as the size increased (Ghimire and Nepal, 2008). With most proportion of the studied population of *Daphne* species. in smaller size classes, it indicated a good regeneration. The density of adult *Daphne* species in the CF were 24, 154, 313 and 310 plants/ha respectively, according to the harvestable guidelines given by Ghimire and Nepal (2007) i.e. density of mature individual more than 700 per hectare, the *Daphne* population is scattered and none of the CF is not suitable for harvesting for at least for 6 years. But because of the good regeneration the projected population was also high, making the resource sustainable in the CF. But in the case of Bhujung VDC both the sites have value much higher than that and is suitable for harvesting

In Plot I *D. bholua* is completely absent and gradually the number increases. Plants of higher classes were also absent in Plots of lower altitude i.e. Plot I and IV. The reason might be either the habitat was not suitable and plants died before the reaching to higher height classes or the recruits were damaged by the livestock during grazing.

The lesser number of saplings might be due to grazing, trampling or unfavourable condition for germination and growth of seeds and saplings (due to deep shading, presence of thick litter, fungal disease, etc.). The combined effect is low regeneration of the species. If the condition continues it might be vulnerable for the *Daphne* species.

In some quadrats of Plot V that was harvesting site for Nigalo, *D. bholua* was not present. This condition was very similar to that of CF in Dolpa where the users harvest nigalo. Because of the steep hill slope people usually rolled down the bundles of cut stems of nigalo following straight and shortcut route down along the hill slope (Ghimire and Nepal 2007). In this process, a large number of newly regenerated as well as mature plants of D. nholua along with other species could be damaged.

5.4 Dry inner bark mass

Dry inner bark mass gives the stock of the *Daphne* bark. Forest services (1983a) has mentioned that moisture content in wet *Daphne* is 50% as compared with air dry weight and 64% in case of Oven dried, after analyzing 10 samples of different heights, considering the dry mass will be 36% of green weight. According to FSRO (1984) the air dry weight of bark mass in some districts like Baglung, Dolakha, Gorkha, Myagdi, Nuwakot, Parwat and Lamjung were 23, 6.49, 6.13, 25.9, 33.27, 14.76 and 14.14 Kg/ha. The survey being of very broad nature (including the forest within 1500- 3000m altitude) shows very less density compared to the study done locally. The total dry harvestable bark of various CCF of KCA namely Dobate, Lawajin, Dorangyabo- Phalekbas, Tiptala was 3.06, 21.57, 53.63 and 56.7 Kg/ha considering that dry mass is 50% of green weight or wet weight. According to Forest Service (1983a) lesser number of mature populations might be the reason for lesser bark yield. In comparison to the total dry harvestable dry bark mass obtained in this study, the total dry harvestable bark mass of Bhujung VDC is many times higher. It might also be because upto now the resource has not been used and has accumulated ever since it occurred.

In Hatiya forest range Baglung the total dry bark yield was found to be 14.4 kg/ha; if *Daphne* plant of greater than 2m height was harvested, it would be only 8.58 kg/ha. In the study assuming that only 50% of total forest can be accessible, only 4.3 kg/ha is available. If we make similar consideration, the average harvestable bark yield for Site A and B will be 143.70 and 195.65kg/ha respectively.

Both total and harvestable bark yield are many times higher than other district mentioned even if many other considerations are made the yield will still be comparable to other regions and good for harvesting. Due to the presense of higher number of mature plants the bark yield is also higher. According to guidelines given by Ghimire and Nepal (2007), except plot I all the other plots were good for collection of the bark. But serious

measure has to be taken to improve the regeneration of seedlings to make the resource sustainable.

5.5 Soil fertility status

Among soil parameters, soil OM, soil pH, macro and micro nutrient, soil erosion and soil depth were the core points for sustainable soil management in Nepal (Karki, 2004). The factor of the soil formation such as topography, parent materials, climate, time and land use, and management have contributed to the poor state of soil fertility in the middle mountain, and the humane influence must be considered to be the primary factor

5.5.1 pH

Value of soil pH was similar for both the sampling sites. It ranged from 4.02 to 5.8. Daphne can grow in acidic, neutral to slightly basic soil (Ghimire et, al. 2008). In KCA, soil pH of 4.2 to 6.9 has beenfound in *D. bholua* growing sites (Ghimire and Nepal, 2008). Forty percent of the soil samples analyzed were extremely acidic, 45% strongly acidic and 15% moderately acidic.

Soil get acidified over thousands of years by input of acids from atmospheric sources (Carbonic acid, sulphuric acid and nitric acid), plant exudates and decay of plant and animal residues and removal of basic cat ions by the natural processes of leaching and crop removal. Leaching losses is more severe in Churia hills and mid hills where rainfall rates are very high and soil is porous (Ball et.al, 2005) Likewise, the forest studied was prone to similar losses (leaching and runoff) as it remained on the hill slopes. According to Singh and Singh (1989), pH range of 4.5-5.5 is good for the sapling growth and the value of present study fall near to the range.

5.5.2 Organic Matter (OM)

The entire soil sample from the sampling site had acidic rating for OM (i.e. pH less than 7), the acidic rating of OM at the forest are basically due to climate, soil parent materials, and land cover and /or vegetation and topography. Low temperature and high rainfall are conducive to accumulation of OM in the soil. Natural vegetation contributes to the OM of soil. That's why the forest soil has higher organic content. Besides, high OM was also due to litters that fall on the ground.

5.5.3 Nitrogen content (N)

In the forest ecosystem N is one of the most important nutrient elements for maximum plant growth. The N in the soil to the plant is obtained through the resent addition of the plant materials.

On average the nitrogen content was high i.e. 0.33%. as per the NARC soil rating, 4% samples had medium, 78% had high rating and 18% had very high rating for nitrogen. This value is higher than the value 0.18-0.28 as reported Juwa (1989) on Nagarkot. The Bhandarkhal forest was estimated to have an average 0.29%N (Ghimire et.al. 2005) and average N was as 0.36% in the northern face of Phulchoki hill forest (Baral and Jha, 1984).

The high value of nitrogen may be due to the higher amount of organic matter. Nitrogen fixation and mineralization is limited by low pH (Greene, 1963) which also agrees with the present findings

High to medium rating for N of the forest land might be due to its pH value i.e. 4.02-5.8 (Annex XI). Soil pH should be within the range of 6.8-8.0 for optimum consumption of N. Beyond this range N remains in soil. In the study area pH was found to be in the range of 4.02-5.8, which was not optimum range for the effective utilization of N. So, Nitrogen content, remained in the soil as a result high percent of N found in the soil.

5.5.4 Available Phosphorus (P)

12% of the soil sample had low, 18% had medium, 67% had high and 3% had very high available P. The average value of available P in the sampling sites is 67kg/ha which is high value according to NARC rating.

The high value of P i.e. 67% P content in the study area might be due to the animal grazing and human activities that results availability of the faecal discharges and urine containing appreciable amount of P.

5.5.5 Exchangeable Potassium (K)

The average value of exchangeable K in the forest soil was found to be 78.84kg/ha which is low rating. This exchangeable K^+ ion may also be continuously lost through surface runoff and leaching under land of uneven topography (Allen, 1964). The

negative topography of the slopes receiving runoff water and fertilizing products of erosion- minerals collides, humus and soluble salts, might have resulted in high K-content of low lying arable land.

5.6 Correlation of *Daphne bholua* with different variables

Soil nutrients, N, P, did not show significant relation with the abundance of species, except potassium which was negatively correlated with density. It is seen that the density of *D. bholua* decreased with the increased in pH, litter and rock coverage is negatively correlated; where as increased with the rise in elevation. With the increase in elevation the maximum and average girth and height of the *D. bholua* increased. Since, the bark mass both total and harvestable, is directly proportional to girth, height and density, they too increased with the elevation. So, as we move up the environment are more suitable for the growth and survival of the species.

pH and litter were negatively correlated with the density, girth and height of the species. So we can say that the species favours the acidic environment with highly decomposed litter, more litter attributes to less decomposition and more accumulation of litter.

Tree cover is negatively correlated to average height and girth, *D. bholua* is a moderately shade loving plant but too much shade is also not favorable, it leads to stunted growth. So partial shade like tree fall gaps and shade of Chutro was favorable in the cases.

5.7 Socio economic condition

The main occupation of the people is agriculture but there had been increased out migration for work, service and studies. Hence the village has less working human resource. The most portion of the village population is children, old people and women.

The source of income is very mixed as the villagers rely on many sectors for their income. From the survey carried out in the village. Those dependent in agriculture was 96%, totally in agriculture was only 12% and those that are not involved in agriculture was 4%. Remittance one of the other source of income for the villagers as 37% of the household also depend on it, 31% of the household generate income by labour as well, service is source of income for only 16% household and cottage industry for only13.23% household.

The agriculture product is not enough for the whole year in most of the household. Only 7.6% had enough crops, for rest it was not enough for whole year. During the deficit months the needs were fulfilled by buying, bartering and loan. 24.24% of households had food available for less than 3 months, while in present case 53.03% of households had food availability of 3 to 6 months, suggesting increased food deficit conditions in majority of the households. Thus it is a challenge for Bhujung VDC to find out the other ways that can fulfill the food demands of local people.

NTFP especially Nigalo and Allo must be harvested as village custom and those who did not collect were even fined. So, the harvesting was going on but the intensity has decreased. Only 74% household was involved in harvesting NTFPs. Many did not harvest due to lack of man power and less use of goods from it and inability to modify into present days demand. Since, the use has decreased its harvest has too. Thus it has decreased highly as they did not need much for subsistence. Majority of the people find that the harvest of NTFPs has decreased i.e. 60%. And because the harvest has decreased its regeneration/density/availability has also decreased and 76% of the respondents believe the same. From the informal conversation with the villagers it was found that they had been generating income by harvesting Allo before ACAP has banned on commercial harvesting of NTFPs. The villagers had never harvested *D. bholua* for paper making purpose. Majority i.e.53% had no idea about it and only 29.41% knows that is is used for paper making. They have reported people especially from Khudi coming to the forest to harvest *D. bholua* for paper making. With the resource available, *D. bholua* could be one of the measures to increase the income for the people since 85% has shown willingness to get involved in paper making idea as a source of additional income if there is some kind of initiative for enterprise development for local livelihood.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

Density, total and harvestable dry inner bark of the *Daphne bholua* was more in Wijung Ban. The lesser number of recruit may be attributed to recurrent disturbance (grazing, fodder and fuel wood collection). This dearth of immature individuals indicates impaired sustainability of *D. bholua*. Though regeneration was not sustainable in both sites but in Wijung Ban the condition was considerably better. So, in total we can say that condition of *Daphne bholua* in Wijung Ban was better than in Surno Kharka; the environmental conditions in Wijung Ban might be more favourable. So, if cultivation of *Daphne bholua* is planned, then similar conditions could give better yield i.e. moist North to North-East facing slopes, controlled grazing, litter collection and proper canopy.

From the study it was found that adequate amount for *Daphne bholua* was available for harvesting. *Daphne bholua* can make a substantial contribution to poverty alleviation and community development as the locals are interested to learn about paper making and make it an alternative source of income. So, appropriate institutional support must be provided for the entrepreneurship development. If paper making is not possible immediately then at least the locals can generate income by bark collection.

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6.2 RECOMMENDATIONS

- Open grazing should be controlled to protect NTFPs including *Daphne* for continuous regeneration and local people should be encouraged for stall feeding of cattle.
- Partial canopy opening by old thinning may induce regeneration of *Daphne* in the study area.
- Large scale studies are needed to help determine more exact population stock and appropriate conservation and management strategies for the betterment of existing population and sustainability.
- Establish permanent growth and management trials plots in order to quantify regeneration, bark yield and optimum rotation length under the variety of management regiment of different elevation.
- Aware the people about the usefulness, importance and conservation of NTFPs that is readily available in the forest and to conserve them by providing knowledge for harvesting time and method.
- Give awareness to the people about not causing too much disturbance while harvesting any NTFPs (esp. Allo, Nigalo) that might affect other plants.
- Allow the locals to use the NTFPs not only for subsistence but for commercial use as well so that it would contribute to their economy.
- Help the locals in marketing of the NTFPs and its products in sustainable manner.
- Locals should be trained for sustainable harvesting of NTFPs and training for paper making from *Daphne bholua*.
- Managing the forest in the sustainable way to gain FSC certification by meeting the guidelines promulgated by FSC and produce FSC certified handmade paper and other NTFP products which ensure environmental and economical sustainability.

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Annexes:

Annex I: Data sheet for a plot

For 50×100 m^2 plot:

Plot ……

Location:……..

Altitude:…… Aspect:…….. Slope:……

Most dominant species:

S.N.	Local name	Scientific Name	Type	Remarks

Name of other species present.

……
……
……
……
……
……
……
……

Remarks:

……
……
……
……

Annex I: Data sheet for a quadrat

For 5×5m^2 quadrats:

Plot no. …….. Quadrat no. …….

1. GPS coordinates:……
   Altitude:…….. Aspect:…….. Slope:…….
2. Litter index:
   1)……..2)…… 3)……
   4)……5)……...
3. Disturbance:
4. Grazing and trampling: 0 1 2 3
5. Cutting / Harvesting/ Lopping: 0 1 2 3
6. Soil depth: 1)……2)…… ……3)……4)…….5)……..
7. Tree Canopy:1)……. 2)…… 3)…… 4)……
   5)……
8. Rock cover (%): ……..
9. Cut stumps:

S.N.	Name of Species	Girth	Height	S.N.	Name of Species	Girth	Height

10. Daphne sps. Analysis:

S.N.	Girth at 20 cm	Height	S.N.	Girth at 20 cm	Height

11. Associated shrub species (including saplings) presence and absence:
    ……
    ……
    ……
    ……
    ……
12. Remarks:

……
……
……

Annex III: Questionnaire for socio-economic survey

Name of the interviewer:……
Date:…….. Place:……. Time:……..

Introduction of respondent:
Name: ……..……
Age:…… Gender: …….. Literacy: …….
Residence period: …….

Household characteristic:
1. Name of the Household head:……..
2. Religion: ……
3. Ethnicity:……...

4. Family Structure:

S.N.	Name	Age	Gender	Relation to head	Marital Status	Education	Occupation

4. Type of house:
a) Pucca b) Semi pucca c) Kutchha

5. Do you own any agricultural land?
If 'yes', how much and what type? ……..
If 'no' what happened? …….

6. What type of crop do you grow?

S.N.	Crop type		Area	Production	Consumption	Surplus/ deficit	Deficit period (months)

7. Does agricultural production sustain your family for a whole year? Yes / No
If 'no' for how many months? …….
8. How will you manage for the deficit months?
Buy/ Burrow/ Barter/ Wage labor/ Others.(……)

9. If surplus what d o you with surplus crop?
Store/ Sale/ Barter/ Other(……..)

10. Livestock and feeding habit:

Do you have any livestock? Yes / no. if 'yes':

S.N.	Type	Numbers	Feeding habit

NTFPs collection:

11. How many from your family are involved in NTFP collection?.....

12. Purpose:

a) Subsistance b) Commercial c) Cottage industry d) Big industries

13. Do they go on their own or by forming a group? ……

14. How far do you have to go for collection?.....

15. Is NTFP collection done regularly or for additional income?.....

16. Do the collectors go only for NTFP collection or do other works as well(grazing etc)? …….....

17. Which NTFPs are abundantly available.

S.N.	Name of Species	Location	Uses

18. Most preferred species:

S.N.	Name of Species	Purpose	Uses	Remarks

19. Do you have any idea about sustainable harvesting of NTFPs?.....

20. Is there any particular season for collection? Yes/ No……

21. Is the collection done in same place every time or is there rotation of harvesting sites?.....

22. How much income do you generate from NTFPs yearly?.....
……

23. Changes in population of NTFPs :
a) More or less abundant than past:……
b) Found near or distant than past:…….
c) Any new species / species not found now …….

24. Harvesting intensity –
a. Increased b. Decreased d. Constant

Annual income and expenditure:

25. How much is your annual income and expenditure in terms of money?

S.N.	Source	Amount			S.N.	Source	Amount	
		Calculated	Rectified				Calculated	Rectified
	Agriculture					Education		
	Service					Health		
	Business					Maintenance		
	Livestock					Agriculture		
	Remittance					Livestock-poultry maintenance		
	Off-farm employment					Loss of livestock		
	Others					Loss of crops		
	Total					Total		

Remarks:……
……
……

30. Who will help you in case of need for taking loan?
From the above table the saved amount becomes Rs. ……do you save this much annually? Yes/ no.

Annex IV: Data for Plot I and II:

Plot	Quadrate	Longitude	Latitude	Aspect (^{0})	Slope (^{0})	Altitude (m)	Tree canopy (%)	No.of stems.	Density (per ha)	Av. Girth (cm)	Max. girth (cm)	Av. Height (cm)	Max Height (cm)
1	1	84.27119444	28.33219444	255	34	2141	27	3	1200	6.07	7	94.67	109
	2	84.27105556	28.33211111	298	17	2161	33.6	0	0	0	0	0	0
	3	84.27072222	28.33216667	232	40	2169	39	1	400	7	7	148	148
	4	84.268	28.33194444	300	22	2146	25	0	0	0	0	0	0
	5	84.27113889	28.33219444	215	28	2157	12	2	800	9	10	118.5	128
	6	84.27108333	28.33216667	235	19	2160	17	0	0	0	0	0	0
	7	84.27116667	28.33211111	210	20	2181	67	0	0	0	0	0	0
	8	84.27105556	28.33241667	217	28	2179	43	2	800	5	6	67.5	95
	9	84.27105556	28.33222222	175	52	2155	91.4	2	800	3.5	4	44.5	60
	10	84.271	28.33227778	196	46	2187	76	0	0	0	0	0	0
	11	84.27111111	28.33252778	233	50	2173	92.6	0	0	0	0	0	0
	12	84.27122222	28.33252778	242	28	2172	76	2	800	3.75	4.5	53.5	82
	13	84.27141667	28.33258333	232	34	2173	25	0	0	0	0	0	0
	14	84.28261111	28.33261111	290	34	2181	14	7	2800	4.57	7	84.43	125
	15	84.28261111	28.33261111	215	31	2207	74	7	2800	5.21	6.5	79.57	89
	16	84.28238889	28.33238889	245	20	2208	53	2	800	11	16	115	156
	17	84.28247222	28.33247222	310	22	2202	72	4	1600	5	8	69.25	97
2	18	84.27338889	28.33241667	250	24	2274	85	22	8800	6.16	17	91.75	198
	19	84.27336111	28.33225	193	21	2257	60	7	2800	8.57	25	94.29	196
	20	84.27361111	28.33213889	216	51	2276	65	12	4800	7.69	19	108.67	225
	21	84.27369444	28.33205556	250	27	2277	23	9	3600	5.83	17	71.89	234
	22	84.27383333	28.33211111	230	22	2276	60	9	3600	4.33	7	70.33	111
	23	84.27383333	28.332	165	30	2281	15	0	0	0	0	0	0
	24	84.27402778	28.33211111	140	34	2291	4	0	0	0	0	0	0
	25	84.274	28.33233333	168	38	2294	40	0	0	0	0	0	0
	26	84.27422222	28.33252778	015	36	2296	15	4	1600	9.13	17.5	4	230
	27	84.27361111	28.33263889	190	31	2307	5	10	4000	9.15	19	135.3	192
	28	84.27330556	28.33227778	240	37	2262	60	15	6000	5.54	9	83.93	127
	29	84.27336111	28.33252778	320	36	2253	85	6	2400	8.25	11	143.67	256
	30	84.27375	28.33244444	315	20	2311	70	9	3600	14.33	7.4	82.44	126
	31	84.27341667	28.33263889	167	17	2263	75	6	2400	4	12	65.5	158
	32	84.27338889	28.33263889	295	15	2267	55	0	0	0	0	0	0
	33	84.27311111	28.33288889	273	34	2256	15	10	4000	13.9	23	141.5	240
	34	84.27386111	28.3325	350	24	2292	65	7	2800	9.64	14.5	169.57	250

Annex V: Data of Plot III and IV:

Plot	Quadrate	Longitude	Latitude	Aspect (^{0})	Slope (^{0})	Altitude (m)	Tree canopy (%)	No.of stems	Density (per ha)	Av. Girth (cm)	Max. girth (cm)	Av. Height (cm)	Max Height (cm)
3	35	84.27594444	28.33233333	265	20	2394	80	7	2800	4.98	8	98.71	252
	36	84.27583333	28.33230556	300	14	2384	80	10	4000	6	21	90.9	190
	37	84.276	28.33244444	234	18	2374	60	6	2400	3.13	4.5	50	72
	38	84.27605556	28.33247222	278	21	2396	45	15	6000	6	13	118.4	235
	39	84.27608333	28.33222222	273	22	2370	40	29	11600	5.45	18	83.69	228
	40	84.27694444	28.33258333	258	13	2394	60	6	2400	4.05	10	75.33	186
	41	84.27636111	28.33244444	265	23	2388	25	41	16400	6.18	18	121.36	265
	42	84.27644444	28.33244444	243	22	2419	80	30	12000	5.46	18	100.13	288
	43	84.27672222	28.33236111	198	15	2439	<5	43	17200	6.17	18	43	290
	44	84.27686111	28.33211111	250	19	2478	45	42	16800	5.81	16.5	113.17	193
	45	84.27705556	28.33252778	214	25	2419	35	59	23600	6.07	16	104.49	246
	46	84.27694444	28.33261111	232	37	2408	15	35	14000	9.04	22	132	364
	47	84.27694444	28.33266667	250	38	2424	55	31	12400	5.14	12	94.3	200
	48	84.27705556	28.33286111	250	46	2436	5	34	13600	9.12	26.5	115.12	324
	49	84.27702778	28.33302778	072	20	2430	50	28	11200	11.03	27.9	132.82	326
	50	84.27702778	28.333	115	30	2447	75	42	16800	8.2833	18.5	99.47	211
	51	84.27733333	28.33305556	296	29	2437	92	51	20400	12.05	185	130.49	327
4	52	84.27591667	28.31761111	310	20	2117	0	5	2000	11	15	104.8	183
	53	84.27594444	28.3175	302	21	2113	0	6	2400	8.08	10	121.5	223
	54	84.27577778	28.31730556	257	22	2110	0	3	1200	9	11	151.33	214
	55	84.27588889	28.31722222	268	30	2108	0	2	800	8	13	98.5	163
	56	84.27608333	28.31713889	080	21	2109	0	1	400	11	11	138	138
	57	84.27619444	28.31727778	314	15	2120	<5	3	1200	13	18	141.33	165
	58	84.27619444	28.3175	294	17	2122	0	12	4800	9.5	15	125.42	198
	59	84.27613889	28.31769444	296	30	2119	0	1	400	9.5	9.5	147	147
	60	84.27638889	28.31736111	306	31	2121	0	8	3200	9.21	14	110.13	230
	61	84.27630556	28.31713889	298	34	2137	<5	11	4400	7.5	19	90.54	230
	62	84.27627778	28.31708333	233	31	2131	0	7	2800	6.21	18	87.85	230
	63	84.27675	28.31658333	270	40	2141	0	7	2800	5.93	17	85.57	240
	64	84.27677778	28.31675	274	32	2151	10	7	2800	5.48	13	80.86	210
	65	84.27638889	28.31666667	271	33	2149	5	8	3200	8	16	108.13	230
	66	84.27672222	28.31686111	272	31	2154	15	6	2400	9.83	13	126.17	190
	67	84.27675	28.31694444	269	26	2158	0	4	1600	6.7	9.5	102.5	148
	68	84.27694444	28.31688889	274	28	2172	5	10	4000	6.6	19	88.7	230

Annex VI: Data for Plot V and VI:

Plot	Quadrate	Longitude	Latitude	Aspect (^{0})	Slope (^{0})	Altitude (m)	Tree canopy (%)	No.of stems	Density (per ha)	Av. Girth (cm)	Max. girth (cm)	Av. Height (cm)	Max Height (cm)
5	69	84.27938889	28.31602778	312	18	2256	15	19	7600	8.08	18	139.05	290
	70	84.27947222	28.31627778	267	13	2262	0	29	11600	9.01	21	141.45	305
	71	84.27963889	28.31636111	267	12	2275	15	16	6400	11.53	15	192.31	275
	72	84.27975	28.31616667	252	14	2273	15	16	6400	7.86	15.5	141.31	280
	73	84.27980556	28.31627778	273	12	2279	15	5	2000	15.2	24	206	315
	74	84.28005556	28.31622222	260	17	2287	15	8	3200	16.17	24	215.5	340
	75	84.28011111	28.31636111	305	19	2289	25	21	8400	11.52	22	191.86	350
	76	84.28044444	28.31583333	295	18	2283	35	15	6000	7.17	16	113.6	270
	77	84.28058333	28.31588889	270	18	2312	15	0	0	0	0	0	0
	78	84.28083333	28.31597222	262	20	2333	0	2	800	2	3	40	50
	79	84.28111111	28.31619444	328	25	2329	0	24	9600	6.06	12.5	102.04	190
	80	84.28136111	28.31611111	300	17	2341	0	26	10400	5.07	11	86.65	173
	81	84.28147222	28.31611111	285	22	2344	15	6	2400	7	12	117.83	204
	82	84.2815	28.31605556	176	30	2346	10	3	1200	5	8	103.33	180
	83	84.28144444	28.31625	280	21	2353	20	23	9200	7.85	31	107.43	380
	84	84.28161111	28.31605556	264	27	2345	25	22	8800	7.0	17	96.68	252
	85	84.28119444	28.31616667	262	25	2344	<5	15	6000	7.02	13	117.86	225
6	86	84.28313889	28.31619444	214	36	2412	15	47	18800	5.86	15	98.10	260
	87	84.28316667	28.31636111	308	28	2405	25	35	14000	7.07	21	99.48	330
	88	84.28322222	28.31652778	310	27	2403	15	16	6400	7.44	11.1	92.87	145
	89	84.28322222	28.31597222	197	28	2399	25	28	11200	7.08	14	89.86	170
	90	84.28325	28.31613889	202	35	2409	30	22	8800	8.04	19	122.27	320
	91	84.28333333	28.31625	270	17	2414	35	39	15600	6.35	14.5	88.87	240
	92	84.28344444	28.31644444	290	31	2419	60	35	13600	6.19	31	74.20	330
	93	84.28347222	28.31602778	245	30	2420	45	36	14400	6.99	31	88.22	384
	94	84.28355556	28.31638889	250	25	2424	65	51	20400	5.56	31	82.07	346
	95	84.28358333	28.31655556	320	15	2431	70	48	19200	4.80	20	82.67	337
	96	84.28386111	28.31641667	285	22	2432	15	18	7200	3.18	13	48.54	190
	97	84.28372222	28.31608333	166	18	2438	50	38	14400	3.59	14	56.51	230
	98	84.28388889	28.31613889	297	20	2441	25	14	5600	4.78	9	69	130
	99	84.28413889	28.31633333	290	18	2450	80	37	14800	8.43	26	142.78	460
	100	84.28433333	28.31652778	318	23	2455	75	5	2000	3.6	11	74.6	230
	101	84.28436111	28.31633333	287	20	2452	80	36	14400	2.81	24	50.19	326
	102	84.28422222	28.31597222	215	19	2453	20	30	12000	7.28	22	115.96	282

Annex VII: Plot wise density, mass of total and harvestable bark of *Daphne* in both the sites:

Site	**Plots**	**Quadrates**	**Mean density (stem/ha)**	**Total dry bark mass (kg/ha)**	**Harvestable dry inner bark (kg/ha)**
Surno Kharka	I	1-17	752.94	26.31	9.76
	II	18-34	2964.70	216.14	162.60
	III	34-51	11976.47	855.98	693.389
	Average		5231.37	366.14	288.58
Wijung Kharka	IV	51-68	2376.47	232.92	170.16
	V	69-85	5882.35	535.11	451.49
	VI	86-102	12517.65	732.81	552.22
	Average		6925.49	501.34	391.31

Annex VIII: Plot wise density of *Daphne* in different Age/Size class in both the sites:

Size class	**Site A: Surno Kharka**				**Site B: Wijung Ban**			
Plots	**I**	**II**	**III**	**Average**	**IV**	**V**	**VI**	**Average**
Seedling	0	118	635.29	250.98	188.24	164.71	1529.41	627.45
Juvenile	282	682	3435.29	1466.7	494.12	1458.8	4305.88	2086.28
Immature	400	1365	4211.77	1992.15	564.71	1905.88	3576.47	2015.68
Adult 1	47	447	1976.47	823.53	635.3	1294.118	1905.88	1278.43
Adult 2	24	353	1717.65	698.04	494.12	1058.82	1200	917.65
Mature (Adult 1+2)	70.58	800	3694.12	1521.57	1129.42	2352.938	3105.88	2196.08
Total	752.93	2965.21	11976.47	5231.4	2376.49	5882.33	12517.64	6925.49

Annex IX: Table for different attributes of *Daphne bholua*

Attributes	Surno Kharka			Weijung Ban			Both		
	Mean	S.d	C.V.	Mean	S.d	C.V.	Mean	S.d	C.V.
Number	13.08	15.72	120.18	17.31	13.95	80.62	15.20	14.94	98.30
Av. height	78.98	49.12	62.19	106.13	40.35	38.02	92.56	46.76	50.52
Av. Girth	6.01	5.31	88.38	7.38	3.00	40.70	6.69	4.35	64.94
Mx. Height	153.64	106.82	69.52	238.49	85.15	35.70	196.06	105.14	53.62
Mx. girth	11.17	8.42	75.44	16.28	6.69	41.10	196.06	105.14	53.62
Total Bark	366.14	549.24	150.00	500.27	411.52	82.26	433.20	487.57	112.54
Harvestable Bark	287.39	506.66	177.23	391.31	366.30	93.60	338.59	443.07	130.85

Annex X: Table for environmental variables

Attributes	Surno Kharka			Weijung Ban			Both		
	Mean	S.d	C.V.	Mean	S.d	C.V.	Mean	S.d	C.V.
Soil OM	13.50	5.06	37.51	9.33	3.05	32.84	11.41	4.66	40.85
Soil N	.378	.096	25.55	.290	.062	21.41	.334	.092	27.58
Soil P	71.66	23.32	32.54	61.72	30.62	49.62	66.69	27.54	41.30
Soil K	76.98	20.54	26.68	80.69	32.34	40.07	78.84	27.02	34.27
Soil pH	4.87	0.486	9.97	4.53	0.353	7.78	4.70	0.456	9.69
Species richnes	7.22	2.55	35.40	6.33	2.35	37.20	6.77	2.485	36.70
Tree cover	48.31	27.52	56.96	18.08	23.26	128.60	33.20	29.55	89.02
Litter	4.69	1.89	40.42	2.56	.910	35.48	3.62	1.82	50.29
Rock cover	17.50	19.23	109.93	16.26	20.74	127.53	16.88	19.91	117.96
Grazing	1.45	.757	52.20	1.90	.413	21.73	1.68	.647	38.51
Harvesting	1.10	.700	63.63	1.67	.554	33.17	1.38	.690	50
Aspect	232.75	61.49	26.42	269.33	44.94	16.68	251.04	56.66	22.57
Altitude	2288.55	101.68	4.44	2283.92	126.91	5.55	2286.24	114.45	5.00

Annex XI: Soil parameters

SN	OM(%)	N	P	K	pH	SN	OM(%)	N	P	K	pH
1	12.23	0.329	60.827	73.386	4.65	52	10.55	0.329	91.883	57.22	4.67
2	8.99	0.245	107.621	68.587	4.43	53	7.55	0.252	84.329	59.999	5.14
3	14.63	0.385	63.555	86.016	4.79	54	9.11	0.266	25.154	111.275	4.75
4	10.55	0.329	87.267	93.846	4.41	55	11.15	0.301	111.608	65.808	4.78
5	8.27	0.385	53.902	64.04	4.79	56	7.07	0.224	87.267	69.345	4.65
6	11.63	0.301	45.509	101.171	4.94	57	7.91	0.217	65.653	64.798	4.62
7	9.23	0.273	44.669	65.808	4.51	58	7.43	0.238	80.972	59.241	4.48
8	13.91	0.308	50.335	74.649	4.76	59	12.95	0.322	73.837	74.902	4.55
9	15.82	0.364	59.983	88.289	5.2	60	4.44	0.196	62.925	68.082	4.73
10	8.63	0.287	45.089	100.413	5.48	61	11.03	0.308	32.289	94.099	5.12
11	17.98	0.49	65.863	93.341	5.24	62	8.15	0.266	14.452	53.684	5.24
12	11.63	0.322	106.992	90.057	5.68	63	11.99	0.315	12.983	59.241	5.07
13	8.27	0.378	56.21	79.701	5.65	64	14.51	0.364	61.037	75.659	4.83
14	26.14	0.539	48.658	52.421	5.4	65	5.99	0.252	58.938	47.622	4.61
15	22.42	0.448	22.216	96.624	5.41	66	8.39	0.294	56.84	113.295	4.65
16	9.83	0.378	93.982	78.943	5.23	67	7.07	0.252	21.587	74.902	5.26
17	6.59	0.231	50.964	50.148	5.8	68	3.96	0.161	61.247	57.978	5.17
18	12.59	0.336	46.768	115.064	5.3	69	8.03	0.238	61.037	56.715	4.6
19	14.03	0.364	62.506	85.005	4.9	70	6.6	0.182	51.174	56.201	4.48
20	14.99	0.399	61.037	94.351	4.8	71	8.75	0.238	73.627	140.575	4.68
21	19.67	0.462	43.83	112.285	5.42	72	12.83	0.343	40.682	88.289	4.74
22	14.51	0.406	43.41	50.148	5.5	73	11.27	0.308	67.962	119.61	4.83
23	19.07	0.448	54.532	118.095	4.6	74	10.91	0.294	59.988	117.59	4.52
24	9.35	0.329	52.014	70.608	4.5	75	9.35	0.252	48.656	122.894	5.08
25	8.27	0.294	108.041	59.999	5.4	76	10.79	0.301	67.962	134.766	4.31
26	6.95	0.266	80.702	56.21	5.7	77	7.91	0.273	82.231	148.911	5.17
27	7.91	0.322	93.352	62.272	5.8	78	11.03	0.259	61.456	79.953	4.73
28	23.14	0.684	97.129	109.001	5.3	79	10.91	0.28	22.216	57.978	4.56
29	20.74	0.532	81.182	95.867	4.8	80	13.07	0.371	84.329	113.295	4.42
30	13.67	0.399	96.29	58.483	4.6	81	15.47	0.406	24.844	168.36	4.23
31	14.51	0.413	82.021	68.334	4.64	82	9.71	0.301	17.6	106.223	4.18
32	18.23	0.49	115.176	78.185	4.3	83	9.71	0.315	19.278	91.32	4.2
33	10.79	0.371	107.621	45.854	4.47	84	12.47	0.399	81.601	72.376	4.1
34	27.82	0.714	86.637	125.672	4.26	85	12.83	0.364	79.293	60.251	4.3
35	7.67	0.259	85.588	68.082	4.36	86	7.55	0.252	182.745	68.082	4.42
36	16.67	0.441	77.824	79.448	4.52	87	11.03	0.357	43.62	69.85	4.26
37	13.67	0.392	87.267	71.113	4.48	88	11.39	0.329	20.747	54.947	4.7
38	14.27	0.406	80.972	66.566	4.56	89	8.75	0.294	70.48	62.272	4.3
39	11.27	0.336	70.899	91.32	4.47	90	6.59	0.224	22.426	179.222	4.31
40	11.27	0.322	82.86	58.736	4.45	91	8.39	0.28	67.962	51.916	4.24
41	13.43	0.413	100.697	43.58	4.39	92	8.03	0.315	18.439	50.4	4.27
42	5.99	0.315	86.008	66.566	4.2	93	19.18	0.476	71.949	52.168	4.03
43	20.38	0.42	95.87	66.819	4.36	94	8.99	0.364	98.179	69.345	4.14
44	7.91	0.266	76.985	73.386	4.42	95	7.67	0.322	53.273	50.653	4.2
45	13.67	0.364	45.299	74.649	4.32	96	5.75	0.224	93.352	72.628	4.22
46	11.99	0.329	75.726	75.154	4.28	97	4.55	0.203	77.614	48.127	4.08
47	19.66	0.462	20.118	92.078	4.42	98	3.24	0.308	83.07	46.359	4.13
48	10.67	0.322	82.86	42.317	5.23	99	11.75	0.343	79.293	77.68	4.02
49	11.99	0.336	87.477	42.317	5.45	100	8.87	0.329	73.208	76.922	4.03
50	14.51	0.392	39.843	92.836	5.36	101	8.15	0.315	76.565	57.473	4.23
51	10.79	0.315	82.65	58.483	4.86	102	5.15	0.196	67.962	85.005	4.42

Annex XII: Rating for different soil parameters

Rating	pH	Rating	pH	Rating	Organic matter (%)	Nitrogen (%)	P_2O_5 (Kg/Ha)	K_2O_5 (kg/Ha)
Extremely acidic	<4.5	Slightly alkaline	7.1-7.5	Very low	<1.0	<0.05	<10	<55
Strongly acidic	4.5-5.2	Moderately alkaline	7.6-8.3	Low	1.0-2.5	0.05-0.1	10-30	55-110
Moderately acidic	5.3-5.9	Strongly alkaline	8.4-9.0	Medium	2.5-5.0	0.1-0.2	30-55	110-280
Slightly Acidic	6.0-6.5	Extremely alkaline	>9.0	High	5.0-10	0.2-0.4	55-110	280-500
Nearly neutral	6.6-7.0			Very high	>10	>0.4	>110	>500

Source: Nepal Agricultural research Council, Soil Science Division, Khumaltar, Lalitpur.

Annex XIII: Plot wise density of *Daphne bholua* in stems/ha in different girth classes (in cm.)

Site	Plot	≤1cm	>1-4cm	>4-8cm	>8-12cm	>12-16cm	>16-20cm	>20-24cm	>24-28cm	>28-32cm
Surno Kharka	I	0	282.35	400	47.06	23.53	0	0	0	0
	II	117.65	682.35	1364.71	447.06	47.06	211.76	23.53	47.06	23.53
	III	635.29	3435.29	4211.77	1976.47	870.59	564.70	188.23	94.12	0
	Average	**250.98**	**1466.67**	**1992.16**	**823.53**	**313.73**	**258.82**	**70.59**	**47.06**	**7.84**
Wijung Kharka	IV	188.23	494.12	564.71	635.29	376.47	117.65	0	0	0
	V	164.71	1458.82	1905.88	1294.12	635.29	94.12	305.88	0	23.53
	VI	1529.42	4305.9	3576.47	1905.88	588.23	423.53	94.12	47.06	47.05
	Average	**627.451**	**2086.27**	**2015.68**	**1278.43**	**533.33**	**211.76471**	**133.33**	**15.68**	**23.53**

Annex XIV: Plot wise Density of *Daphne bholua* in stems/ha. in different height classes (in cm.)

Site	Plot	<=20	20-40	40-60	60-80	80-100	100-120	120-140	140-160	160-180	180-200	200-220	220-240	240-260	260-280	280-300	>300
Surno Kharka	1	0	94.12	94.12	164.71	235.29	70.588	47.06	47.06	0	0	0	0	0	0	0	0
	2	47.06	400	258.82	564.70	376.47	400	211.76	305.88	117.65	141.18	47.06	47.06	47.06	0	0	0
	3	541.17	1764.70	1317.65	1247.06	1388.23	1105.88	1011.76	1058.82	494.12	494.12	470.59	329.42	423.53	47.06	47.06	235.29
	Average	**196.08**	**752.94**	**556.86**	**658.82**	**666.67**	**525.49**	**423.53**	**470.59**	**203.92**	**211.76**	**172.55**	**125.49**	**156.86**	**15.68**	**15.68**	**78.43**
Wijung Kharka	4	164.70	329.41	235.29	164.71	352.94	188.23	188.23	282.35	94.12	117.65	70.59	188.23	0	0	0	0
	5	70.59	752.94	541.17	635.29	635.29	658.82	305.88	188.23	447.06	352.94	376.47	188.23	211.76	188.23	70.6	258.82
	6	1435.29	2964.70	1364.70	1458.82	1388.24	894.12	823.53	376.47	376.47	282.35	235.29	141.18	141.17	94.12	141.17	400
	Average	**556.86**	**1349.02**	**713.73**	**752.94**	**792.16**	**580.39**	**439.22**	**282.35**	**305.88**	**250.98**	**227.45**	**172.55**	**117.65**	**94.112**	**70.59**	**219.61**

Annex XV: List of associated species of the shrub layer with *Daphne bholua*

S.N.	Local name	Scientific name	S.N.	Local name	Scientific name
1	Arupate	*Prunus* sps.	25	Majiri	*Smilax sps.*
2	Ainselu	*Rubus ellipticus*	26	Marja	*Anaphalis triplinervis*
3	Allo	*Girardinia diversifolia*	27	Masine jhar	*Vitis* sps.
4	Angeri	*Lyonia sps.*	28	Najiri	*Smilax* sps.
5	Bajra danti	*Potentilla* sps.	29	Nigalo	*Drepanostachyum intermedium*
6	Bilaune	*Maesa chisia*	30	Pudke	*
7	Bhuin timur	*	31	Padke	*
8	Chiraito	*Swertia* sps	32	Paiyun	*Prunus cerasoides*
9	Chutro	*Berberis* sps.	33	Phalant	*Quercus* sps
10	Dudhilo Lahar	*	34	Phosur	*
11	Dudhilo Rukh	*Ficus* sps.	35	Pipla	*Piper* sps.
12	Faiyun	*Machilus* sps.	36	Satuwa	*Paris polyphylla*
13	Gofle	*	37	Saudi	*Arisaema nepenthoides*
14	Guyenli	*Elaeagnus parvifolia*	38	Shilinge	*Taxus baccata*
15	Jhingan	*Eurya acuminata*	39	Sikhaja lahar	*
16	Kade ghans	*Berberis wallichiana*	40	Siltimur	*Lindera neesiana (Wall.ex Nees)Kurz*
17	Kalikath	*Myrsine semiserrata*	41	Sisnu	*Urtica dioica*
18	Kande	*Cirsium arvense(L.)Soop*	42	Souma	*Arisaema* sps.
19	Kathe Kaulo	*Machilus* sps.	43	Rakta chandan	*Pterocarpus santalinus* Linn.F
20	Katus	*Castonopsis hystrix*	44	Teka tree	*Stranvaesia nussia*
21			45	Timur	*Zonthooxylum arametum D.C.*
22	Kukur daino	*Smilax ovalifolia*	46	Thosne	*Polygonum molle D.Don*
23	Lali Gurans	*Rhododendron arboreum*	47	Tokne Kanda	*Zanthoxylum oxyphyllum*
24	Lekh Chulitro	*Micropanex sps.*	48	Ursin	*Litsea* sps.

* Unidentified

Annexes XVI: Information of the respondents

ID	Longitude	Lattitude	Respondent's Name		RESPONDENT INFORMATION				
				Ward	RS	MS	RA	RE	FST
1	84.26272	28.30836	Nanda Kashi Gurung	1	F	Ma	37	P	2
2	84.26325	28.30839	Ganja Lal Gurung	1	M	Ma	75	I	2
3	84.26328	28.30839	Santa Kumari Gurung	1	F	Ma	44	L	2
4	84.26333	28.30861	Purna Kashi Gurung	1	F	Ma	30	L	1
5	84.26356	28.30944	Ram Kumari Gurung	1	F	Ma	34	L	2
6	84.26089	28.30969	Kumari Gurung	2	F	Ma	60	I	1
7	84.2635	28.30808	Par Jung Gurung	2	M	Ma	35	L	1
8	84.26333	28.30817	Botiseri Gurung	2	F	Ma	52	I	2
9	84.26375	28.30803	Parwati Gurung	2	F	Ma	35	L	2
10	84.26425	28.30817	Dipti Maya Gurung	2	F	Un	73	I	2
11	84.26339	28.30889	Sheri jung Gurung	2	M	Ma	71	I	1
12	84.26331	28.30908	Dal B. Gurung	2	M	Ma	84	I	2
13	84.26386	28.30842	Sher B. Gurung	3	M	Ma	51	L	1
14	84.26317	28.30911	Uma Gurung	3	F	Ma	69	I	2
15	84.26306	28.30903	Pitra Man Gurund	3	M	Ma	45	P	2
16	84.26317	28.30864	Himala Gurung	3	F	Un	28	P	1
17	84.26333	28.30858	Lok Kumari Gurung	3	F	Ma	22	P	2
18	84.26367	28.30964	Man Devi Gurung	3	F	Ma	25	I	2
19	84.26383	28.3095	Bal B. Gurung	3	M	Ma	58	I	1
20	84.26417	28.30939	Min Kumri Gurung	3	F	Ma	32	L	1
21	84.26417	28.30914	Chandra Kashi Gurung	3	F	Ma	21	L	2
22	84.26433	28.30947	Khir Jung Gurung	3	M	Ma	48	L	1
23	84.2635	28.30975	Sher B. Gurung	4	M	Ma	65	L	2
24	84.26411	28.30983	Bakhat Man Gurung	4	M	Ma	48	P	1
25	84.26394	28.31014	Chuda ram Gurung	4	M	Ma	72	I	2
26	84.26447	28.309	Naule Gurung	4	F	Ma	40	L	2
27	84.26467	28.31022	Sushmita Gurung	4	F	Un	13	L	2
28	84.26375	28.30978	But Kumari Gurung	4	F	Un	21	I	1
29	84.26503	28.30914	Bhalu Gurung	4	M	Ma	52	I	1
30	84.26417	28.31044	Sarki Gurung	5	M	Ma	55	I	2
31	84.26428	28.31036	Surja Man Gurung	5	M	Ma	86	I	1
32	84.26464	28.31008	Batti Bahadur Gurung	5	F	Ma	57	L	2
33	84.26436	28.30968	Tul B. Gurung	5	M	Ma	62	I	1
34	84.26478	28.30992	Kul Kumari Gurung	5	F	Ma	27	I	2
35	84.26472	28.30992	Khagun Dhoj Gurung	6	M	Ma	35	I	1
36	84.26539	28.31011	Bhoj Kumari Gurung	6	F	Ma	40	I	2
37	84.26511	28.30936	Chandra Kumari Gurung	6	F	Ma	55	I	2
38	84.26406	28.30989	Jamuna Gurung	6	F	Ma	20	C	2
39	84.2645	28.30928	Bishnu Kashi Gurung	6	F	Ma	30	L	2
40	84.26473	28.30936	Dabel gurung	6	M	Ma	75	L	2
41	84.26489	28.30897	Dil Bahadur Gurung	6	M	Ma	70	L	2
42	84.26469	28.30928	Kal Bahadur Gurung	7	M	Ma	66	L	2
43	84.26467	28.30933	Kanta Kumari	7	F	Ma	33	L	1

ID	Longitude	Lattitude	Respondent's Name		RESPONDENT INFORMATION				
				Ward	RS	MS	RA	RE	FST
44	84.26394	28.30961	Yurini Gurung	7	F	Ma	70	I	1
45	84.26403	28.30911	Dhundhari Gurung	7	F	Ma	35	I	1
46	84.26383	28.30908	Sarkisyo Gurung	7	F	Ma	36	I	2
47	84.26375	28.30967	Kashi Gurung	7	F	Un	70	I	1
48	84.2645	28.30958	Nar Bina Gurung	7	M	Ma	80	I	2
49	84.26458	28.30931	Sushmita Gurung	7	F	Un	19	P	2
50	84.26536	28.30897	Tek Bahadur	7	M	Ma	63	L	2
51	84.26469	28.30911	Lil Kumari Gurung	8	F	Ma	38	L	2
52	84.26472	28.30908	Sume Gurung	8	M	Ma	35	L	2
53	84.26369	28.30706	Narayan B, Gurung	8	M	Ma	35	P	2
54	84.26528	28.309	Siula Gurung	8	F	Ma	28	L	1
55	84.26519	28.30917	Kashi Gurung	8	F	Ma	23	L	2
56	84.26511	28.30922	Tul Bir Gurung	8	M	Ma	68	L	1
57	84.26496	28.30826	Til maya Gurung	8	F	Ma	32	P	2
58	84.26372	28.3065	Ran Bahadur B.K.	9	M	Ma	51	I	1
59	84.26389	28.30644	Purne B.K.	9	M	Ma	57	I	2
60	84.26378	28.30642	Munna B.K.	9	F	Ma	29	I	1
61	84.26389	28.30636	Jaifale B.K.	9	M	Ma	73	I	2
62	84.26397	28.30619	Jamuna B.K.	9	F	Ma	30	I	1
63	84.26397	28.30547	Bubbha Bahadur B.K.	9	M	Ma	39	I	1
64	84.26369	28.30583	Sani B.K	9	F	Un	25	I	1
65	84.26347	28.30581	Oja Bahadur B.K>	9	M	Ma	45	I	1
66	84.2635	28.30583	Durpati B.K.	9	F	Ma	37	I	2
67	84.26381	28.30683	Sushila B.K.	9	F	Ma	35	L	2
68	84.26389	28.30872	Buddha Kumari B.K.	9	F	Ma	40	I	2

Note:

RS Respndent Sex, M= Male, F=Female

MS Maritail status, Ma= Married, Um= Unmarried

RA Respondent Age

RE Respondent Education, I=Illiterate, L=Literate, P=Primary, S=Secondary, C=Collage

Photo plates

Photo plate I

Photo1: *Daphne bholua* (Lokta) at flowering Stage.

Photo 2: *Daphne bholua* at fruiting stage

Photo 3: *Daphne bholua* with ripe fruits

Photo 4: At field work

Photo plate II

Photo5: Measuring the heights of seedlings *Daphne*

Photo 6: Measuring the height of above 3m.

Photo 7: Discussion with group and key informant