

FEASIBILITY STUDY REPORT

on

**Production and Processing of *Prunus persica* (Khamu) and
Prunus armeniaca (Chuli) in Karnali Province**



Karnali Province Government
Ministry of Industry, Tourism, Forests and Environment
Forest Research and Training Center
Birendranagar, Surkhet

June 2023

Feasibility Study Report:

Feasibility Study for the production and processing of Khamu & Chuli in Karnali

Submitted to:

Karnali Province Government

Ministry of Industry Tourism Forest and Environment

Forest Research and Training Center

Birendranagar, Surkhet

Submitted by:

Alpine Nature Services Pvt. Ltd.

Birendranagar-07, Surkhet

Karnali Province Nepal

alpinenature2077@gmail.com

Date: June 2023

Copyright: @Forest Research and Training Center, Birendranagar, Surkhet



Prunus persica (Khamu)



Prunus armeniaca (Chuli)



For More Information:
Forest Research and Training Center, Birendranagar, Surkhet
Email: kfrtc.skt@gmail.com
Website: <https://karnalifrtc.gov.np>

Executive Summary

Prunus spp. is a fruit available in the upper hills and mountainous zones of Karnali Province, mostly in between 1500 and 3500 meter above the mean sea level. In Karnali province, *Prunus persica* and *Prunus armeniaca* are commonly known as **Khamu(Aaru)** and **Chuli**, respectively in local dialects. Despite the Karnali Province endowed with diverse natural resources of high economic value and comparative advantages, its commercial production, processing, value addition and marketing through industrial establishment is yet to be materialized. Out of numerous resources, Khamu/Chuli is one of the lucrative resource of Karnali province still highly available in all districts of then Karnali zone.

Approximately 568,182.8 hectares, accounting for about 26.69% of the entire land area, is identified as the most suitable region for cultivating Khamu and Chuli in the study area. The potential area for the Khamu and Chuli production is found higher in Jumla (53.39% i.e. 136214.6 ha) followed by Mugu (35.97% i.e. 115812.9 ha) and Kalikot (31.58% i.e. 51463.43 ha) district. Dolpa and Humla districts have the least suitable areas for production, with percentages of 10.40% (82315.37 ha) and 17.67% (105462 ha) respectively. A total quantity of 34,04,492.00 liter oil could be obtained if only one percent (5682 ha) of the suitable land area is cultivated with Khamu and Chuli. Nevertheless, Khamu/Chuli has not been commercially cultivated due to the lack of market potential.

Financial analysis shows that annual expenses of Karnali Province (study area) on cooking oil is about is about 1,05,47,29,028.57 NPR. Khamu/Chuli cultivation in 1% of the suitable area with proper operation of the oil extraction plant can reduce the oil import to zero. Additionally, use of local resources increases the employment generation and it helps to minimize the public dependency to national forest areas and improves the living standards of potential areas. The oil production of a single machine that is assumed to run for three months in one season will be 21,600 liter. Considering the sell of cooking oil and oil cake, project return in the first year would become 11,160,000.00 NPR whereas 5% deduction is made for each subsequent year assuming the reduction of maching yielding capcity with the passage of time.

The provincial government in coordination with the federal government should do all efforts for the betterment of infrastructures such as road, electricity, and market. Building road links up to the Khamu/Chuli industrial, electricity lines up to the industrial point, and market should be the major responsibility of the provincial government. The government should provide some incentive to the farmers willing to plant Khamu/Chuli tree. The government should also support on advancing the traditional processing of Khamu/Chuli oil. The Division Forest Office or the District Industry and Consumer Welfare Office in Humla should prioritize the development of this particular oil processing industry, considering that the local community is already engaged in running such businesses. It is essential for the government to provide assistance for the technological advancement of these industries.

Key Words: *Khamu, Chuli, Feasibility Study, Prunus persica, Prunus armeniaca, Habitat suitability,*

Table Of Content

Executive Summary.....	i
List Of Tables	iv
List Of Map	iv
Chapter: 1	1
1. Introduction.....	1
1.1 Background.....	1
1.2 Objectives:	7
1.3 Scope Of The Work:	8
1.4 Rationale Of The Study:	9
1.5 Limitation Of The Study:.....	10
Chapter: 2	11
2. Methodology	11
2.1 Study Area:	11
2.2 Methods:	13
Chapter: 3	17
3.1 Context Analysis	17
3.1.1 Geographic Setting.....	17
Chapter: 4	22
4.1 Species, Natural Habitat And Cultivation	22
4.1.1 Khamu (Prunus Persica)	22
4.1.2 Chuli (Prunus Armeniaca)	28
Chapter: 5	31

5.1 Results And Discussions	31
5.1.1 Feasibility Of Khamu/Chuli Cultivation In Karnali Province	31
5.1.2 District Wise Feasibility	33
5.1.3 Oil Processing Industry Establishment Feasibility:	37
5.1.4 Oil Processing Plant:	42
5.1.5 Oil Extraction Machine:.....	44
5.1.6 Financial Analysis:.....	45
5.1.7 Location Criteria For Oil Processing Industry	51
5.1.8 Market Analysis	53
Chapter: 6	55
6.1 Conclusion And Reccomendations	55
6.1.1 Key Findings:.....	55
6.1.2 Recommendations:.....	57
References:	59
Annex I: Questionnaire.....	61
Annex Ii: Field Photo Snaps	64

List Of Tables

Table 1: Land Use Of Karnali Province	3
Table 2: Elevation Wise Forest Cover In Karnali Province	3
Table 3: Physiographic Zones Of Karnali Province	4
Table 4: Land Cover Type In Different Physiographic Zones	5
Table 5: Scientific Classification Of Khamu/Aaru.....	22
Table 6: Silvicultural Characteristics Of Khamu.....	26
Table 7: Scientific Classification Of Chuli.....	28
Table 8: Suitable Area For Khamu/Chuli Production.....	33
Table 9: Yield From Cultivation Area.....	45

Table 10: Annual Oil Consumption.....	46
Table 11: Annual Expenses And Return.....	47
Table 12: Yearly Net Cash Flow	48
Table 13: Financial Indicators Of The Project.....	48
Table 14: Feasibility Indicators Examples.....	51

List Of Map

Map 1: Map Of Study Area	11
Map 2: Land Use Map Of Karnali Province.....	18
Map 3: Vegetation Type Map Of Karnali Province	20
Map 4: Feasibility Map For The Production Of Khamu/Chuli.....	31
Map 5: Habitat Suitability Map Of Khamu/Chuli	32
Map 6: Khamu/Chuli Cultivation Potentiality In Humla.....	33
Map 7: Khamu/Chuli Cultivation Potentiality In Jumla.....	34
Map 8: Khamu/Chuli Cultivation Potentiality In Mugu.....	35
Map 9: Khamu/Chuli Cultivation Potentiality In Dolpa.....	35
Map 10: Khamu/Chuli Cultivation Potentiality In Kalikot.....	36

List Of Figure

Figure 1: General Layout Of The Building Required For Oil Processing	42
Figure 2.....	43
Figure 3: Side View Of A General Oil-Processing Unit.....	43
Figure 4: Oil Extraction Machine And Working Principle (Alibaba.Com).....	44

List Of Photo

Photo 1: Typical Farmland In Humla	21
Photo 2: A Khamu Tree.....	24
Photo 3: Khamu Seedling	25
Photo 4: Heaps Of Chuli At Micha, Jumla	29
Photo 5: Heap Of Oil Cake (Locally Called Pina) At Suwarna Simkot Khadhya Udhyog, Karnali Province	39
Photo 6: Traditional Oil Extraction Method (Wooden Duno) (<i>Photo By Rabindra Roy</i>)	41
Photo 7: Interaction With Farmer	64
Photo 8: Discussing With Farmers About Khamu And Chuli At Dadafaya, Humla.....	64
Photo 9: A Khamu/Chuli Farm In Jumla	65
Photo 10: People Collecting Chuli In Mugu.....	65

Photo 11: Interaction With Locals In Jumla	65
Photo 12: Khamu Blossoms In Dolpa	65
Photo 13: A Typical Fruit Farm In Kalikot	65
Photo 14: Old Chuli Tree In Kalikot	65
Photo 15: Khamu Tree With Fruits Near Chilkhaya, Kalikot	65
Photo 17: Analysing Tree Morphology Of Khamu At Pialgaun, Jumla.....	65
Photo 18: Khamu Tree At 2598 Meter Altitude	65
Photo 16: Traditional Oil Processing Unit.....	65
Photo 20: Khamu Oil.....	65
Photo 21: Khamu Fruit	65
Photo 19: Seed (Mijula) Collection At Industry	65
Photo 22: Aaru Farm Near Jumla Headquarter	65

CHAPTER: 1

1. INTRODUCTION

1.1 Background

Karnali Province is one of the seven provinces in Nepal, located in the western part of the country. It is known for its rich biodiversity and diverse ecosystems. Forests and scrublands cover 44.74% of Nepal's total area. Of the total forest area, 67.80% of the forest is in the low mountains, 32.25% in the high mountains, 23.04% in the Churei area, and 6.90% in the Terai area. Karnali has a total area of 30,211 square kilometers. Outside the land, forests, including scrublands and grasslands, cover 11,706 km², almost 38.5% of the state's total area. From the snow-capped peaks of the Himalayas to the lush forests and river valleys, the province is home to a rich array of flora and fauna. The region's biodiversity includes numerous endemic and endangered species, such as the red panda, Himalayan black bear, musk deer, and several species of birds, butterflies, and plants. The province boasts protected areas like the Rara National Park and Shey Phoksundo National Park, which safeguard these precious habitats and support the conservation of unique species. The biodiversity of Karnali Province not only contributes to the ecological balance but also serves as a valuable resource for scientific research, eco-tourism, and the livelihoods of local communities, highlighting the need for its continued preservation and sustainable management.

The genus *Prunus* includes several species, such as *Prunus persica* (peach), *Prunus armeniaca* (apricot), *Prunus domestica* (plum), and *Prunus avium* (sweet cherry), among others. Each species within the genus *Prunus* may have a different elevation range. In Nepal, the elevation range for different *Prunus* species can vary based on their specific characteristics and adaptations. However, as a general guideline, many *Prunus* species thrive in temperate to subalpine regions, where they are adapted to cooler temperatures.

Prunus persica and *Prunus armeniaca* are commonly known as **Khamu(Aaru)** and **Chuli**, respectively in local dialects in Karnali province. *Prunus spp.* is a fruit available in the upper hills and mountainous zones of Karnali Province, typically between 1,500 meters (4,921 feet) and 3,500 meters (9,843 feet) above sea level. This range allows for the favorable climatic conditions needed for these trees to grow and produce fruit. This is also available in Himalayan and mountain regions of Afghanistan, Pakistan, Kashmir and Himanchal states of India and Sudur Pashchim, Gandaki and Lumbini province of Nepal. Chuli is a type of apricot that grows

wild in the dry temperate region of the western Himalayas falling within Karnali Province adjoining Tibet. The altitude of this region ranges between 2000-3500 MSL. As monsoons fail to reach these areas, so the annual rainfall here is around 25 cm. Most of the precipitation is in the form of snow during winter. The minimum temperature during the most part of the year is below 0° C. The growing season is quite short. Further, the soil of this region is hard and shallow (*Singh. A, et.al.2007*).

Chuli is a spreading tree, round topped, 5-7 m high, spread 6 m, trunk girth 56 cm, bark reddish brown. Leaves broadly ovate, apex cuspidate, base cordate, margin serrulate, pose intermediate, lamina green, upper and lower surface pubescent, length 6.81 cm, breadth 5.73 cm, length/breadth ratio 1.19, petiole pubescent, colour red, length 2.80 cm; glands shape orbicular, colour dark tan, 2-3 in number (*www.fruitipedia.com*).

Chuli is the tree which bears several cultural and economic importances in the communities. Historically, it's oil has been used in pain recovery and twigs are being used as a substitute for toothbrush. Its extraction is being used as traditional medicines particularly anti-fungal agents and insecticides and oil is used in cooking too (*D. Alan, 2014*). However, there are limited commercial uses of Chuli products due to lack of adequate skills and knowledge about its multiple uses by the local people. Hence, subject to further study and exploration, it has a huge potential to boost local economy by establishing a Khamu/Chuli-based industries in a suitable location in the province as well as in the district.

The industrial sector in Nepal is in the pace of improving and still a lot has to be done in order to change the present condition. Along with globalization and modernization, the nation as a whole need to develop infrastructures (physical, social and economic) and human resources leading to social wellbeing and economic prosperity. It's very necessary to make "optimum utilization of resources (natural, human) available in the provinces of the country Nepal" (*openjicareport.jica,NIT Report*). For the "Prosperous Nation, Happy Nepali" industrial economic development is being made through different attempts such as promoting "One village, One Product", among others. It could also be said that, for an economic boom and development of nation, industrialization is one smart way that is local inclusive. It also develops the skills and helps establish competitive international trade. In this context Forest Research and Training Center of Karnali Province is carrying out feasibility study for the production and processing of Khamu/Chuli in the province.

Data suggested that Karnali Province occupies a total area of 3,064,004 hectares of land. Out of the land area, the forest covers 978,879 hectares which is almost 31.9% of the total area of the province. The land use of the province is grouped under Degraded Forest, Forest, and Non-Forest Area (Table 1) shown below:

Table 1: Land use of Karnali Province

Land Use	Area (ha.)	Percentage
Degraded Forest	178,698	5.8
Forest	978,879	31.9
Non-Forest	1,906,427	62.2
Total	3,064,004	100.0

Source: FRTC, 2018 (Landsat, 2018)

All the land use beside forest and degraded forest comes under Non-Forest area. This includes, barren land, settlements, wetlands (rivers, ponds, lakes, etc.). This corresponds to 62.2% of the state's total area. Forest cover in Karnali Province can also be classified elevation wise, where the elevation class are grouped under different class starting from less than 500 to 4000-4500 m. It was found that the maximum forest cover lies between 3000-3500 m. This range comprise almost 19% of the total forest area of Karnali Province. This is followed by the elevation range 1000-1500 m with 17.38% of forest area. Very low forest area accounting to less than 500 hectare of forest area are present in areas above 4000 m. This shows that the elevation ranges from 500 to 3500 m comprise almost 92% of the total forest area of the province. The elevation wise forest area in the Karnali Province is shown in the Table 2 below:

Table 2: Elevation wise forest cover in Karnali Province

Elevation (m)	Forest area (ha.)	Percentage
<500	31400	3.21
500-1000	157208	16.06
1000-1500	170127	17.38

1500-2000	126988	12.97
2000-2500	119182	12.18
2500-3000	145179	14.83
3000-3500	187026	19.11
3500-4000	41285	4.22
4000-4500	485	0.05
Total	978879	100.00

Karnali Province is spread over four physiographic zones: High Mountain, Middle Mountain, Hill and Siwalik/Chure. Among these, High Mountain covers the larger area of the province (47%) followed by Middle Mountains and Siwalik respectively as shown in Table 3.

Table 3: Physiographic zones of Karnali Province

Physiography	Area (ha)	Percentage
High Mountain	1447002	47
Middle Mountain	983151	32
Hill	480270	16
Siwalik	153581	5
Total	3064004	100

In these different physiographic zones, the Middle Mountains has the largest portion of forest area (516,910 Ha.) followed by forest in the Hills (309942 Ha.) and Siwaliks (4.1 Ha.) see Table 4.

Table 4: Land cover type in different physiographic zones

Physiography/Forest Description	Area (ha)	Percentage
High Mountain	1447002	47.2
Forest	25273	0.8
Degraded Forest	12881	0.4
Non-Forest	1408848	46.0
Middle Mountain	983151	32.1
Forest	516910	16.9
Degraded Forest	89745	2.9
Non-Forest	376497	12.3
Hill	480270	15.7
Forest	309942	10.1
Degraded Forest	70497	2.3
Non-Forest	99832	3.3
Siwalik	153581	5.0
Forest	126755	4.1
Degraded Forest	5575	0.2
Non-Forest	21251	0.7
Total	3064004	100.0

Khamu and *Chuli* are in great demand as organic edible oil because of its health benefits. For a long time, fruits and vegetables have been the target of many studies and have been greatly

promoted due to their nutritional value and abundance of bioactive compounds, known for their protective effects (*Jimenez. C et. al. 2020*). The peach has been part of the human diet for hundreds of years, being a very common fruit consumed worldwide. It is very rich in phytochemicals like phenolic compounds, carotenoids, vitamins, volatiles and organic acids. Phenolics, carotenoids and vitamins are known for their antioxidant properties. They exert a number of beneficial effects on cells through free radical scavenging and by participating in cells' signaling pathways. The phenolic compounds in peach-like quercetin, catechins and cyanidin derivatives have been found to play important roles due to their antioxidant, antimicrobial and anti-inflammatory properties.

Evidence has risen about their preventive effects on multiple chronic and age-related diseases such as diabetes, obesity, hypertension, inflammation, cardiovascular, neurodegenerative and oncologic diseases. A variety of studies have focused on testing and determining the phenolic content of peach extracts, which have shown great potential as free-radical scavengers and providing protection against several chronic/age-related diseases. In this review, we will present the peach as a potential medicinal food, giving emphasis to its phenolic compounds as health promoters.

Khamu (Peach) is a species native to China. It is widely cultivated in temperate regions around the world for its delicious fruit. In Nepal, including the Karnali Province, peaches are grown in certain areas where the climate is suitable. Karnali Province, located in the northwestern part of Nepal, has diverse climatic conditions due to its varying altitudes and topography. The lower regions of Karnali Province, such as the districts of Jajarkot, Rukum, and Salyan, have a subtropical climate, which can be favorable for growing peaches. Peach cultivation requires specific conditions to thrive, including a cold winter period for proper dormancy and a certain number of chilling hours. The tree also prefers well-drained soil and a sunny location. While I do not have specific information about peach cultivation in Karnali Province, it is possible that peaches are grown in certain areas with suitable climatic and soil conditions.

Chuli (Apricot) are valued for their fruits, which are eaten fresh and used in various culinary preparations. The trees are deciduous, with broad leaves and attractive pink or white blossoms in spring. The fruits ripen in early summer and are typically orange or yellow, with a sweet and tangy flavor. Apricot cultivation in Nepal not only serves as a source of fresh fruit but also contributes to the local economy. Farmers may cultivate apricots for domestic consumption, as

well as for commercial purposes, selling them in local markets or processing them into products such as jams, jellies, and dried fruits.

Despite the Karnali Province endowed with diverse natural resources of high economic value and comparative advantages, its commercial production, processing, value addition and marketing through industrial establishment is yet to be materialized. It is necessary to scale up the extraction of oil with indigenous knowledge as an alternative livelihood both in terms of technology and engagement of community with economy of scale. The reasons for the bottlenecks could be many, but some of them are openly said as being lack of capital, infrastructure and other policy environment. Out of numerous resources, Khamu/Chuli is one of the lucrative resources in Karnali Province still highly available in all local levels of the upper karnali districts.

1.2 Objectives:

The main objective of the project is to carry out the feasibility study for the Khamu/Chuli production and possibility of processing based industry in Karnali Province. To meet this main objective; the consultant team has thoroughly reviewed the available literature on history, socio-culture, and politico-economy and on experiences of the other region including core technical aspects of the Khamu/Chuli production and processing. It has assessed the existing infrastructures such as connectivity and electricity. The availability, accessibility (distances) and sustainability of the resource base and further manufacturers in consideration of the forward backward linkages is a very core aspect of the study. Such feasibility study should also be considerate of the enhancing the socio-economic livelihood of the locals of the individual places according to their availability and skills.

The planning, design and feasibility analysis works are undertaken considering the climate, environmental surrounding, geo-technical conditions and all the necessary topographic status with the involvement of the relevant skilled human resources working together as a team. The above-mentioned feasibility study tries to refer and analyze secondary data including topographic profile, available resources, accessibility and other prevailing working circumstances.

The researcher's team has reaffirmed the specific objectives of this assignment as per designed by the (TOR) Forest Research and Training Center(FRTC) but with some further elaborations;

- To review/study existing Khamu/Chuli processing industry and its status in Karnali Province.
- To assess the distribution and habitat status of Khamu and Chuli in Karnali Province.
- To document the potential and existing uses (including medicinal use) of these species in the Province
- To explore the existing marketing scenario of the products from these species
- To conduct the financial analysis for the cultivation and production of these species.
- Mapping the existing and potential sites of the habitat using GPS/GIS
- To examine the feasibility for establishment of Khamu/Chuli based industry for the sustainable development of the identified area.
- To examine local people perception about Khamu/Chuli in relation to livelihood, economic value etc.
- To analyze about the availability of the resources and raw materials and prospects of new growing or commercial cultivation.
- To analyze industrial input output, labour, market situation etc
- To conduct socio-economic field survey for the establishment and financial feasibility for construction and sustainability of the Khamu/Chuli processing industry.
- To analyse multi-aspects of industrial production such as fruit, oil, by-products, nursery establishment and seedling production etc

1.3 Scope of the work:

The consultant, under provided Terms of Reference (ToR) has carried out activities, service deliverable and documents as follows:

- Base map preparation of the new identified ‘Khamu/Chuli’ hotspots along with the other existing industrial areas in the surroundings.
- Conduct necessary meetings and reconnaissance surveys/analysis for the feasibility from Khamu/Chuli based industry along with possible benefits and impacts.
- Market analysis and backward forward linkage analysis of the Khamu/Chuli based industry minimizing the cost of transportation.
- Assessing impacts of the Khamu/Chuli based industry to the locals, surrounding, socio-economic condition and others by linking up traditional knowledge of oil production, technological updating with their micro industries.

1.4 Rationale of the study:

This study has the following rationales;

- Reduce poverty by generating employment and increasing per capita income of Karnali citizens.
- May help to start up Industrialization process with value chain and backward and forward linkages.
- Help to reduce central dependancy and to reduce adverse consequences of centre-periphery dependency on oil (edible and medicinal).
- Find the way of sustainable production and operating of oil processing unit.
- May promote investment, trade, new technology and increase revenue for the Province, etc.

1.5 Limitation of the study:

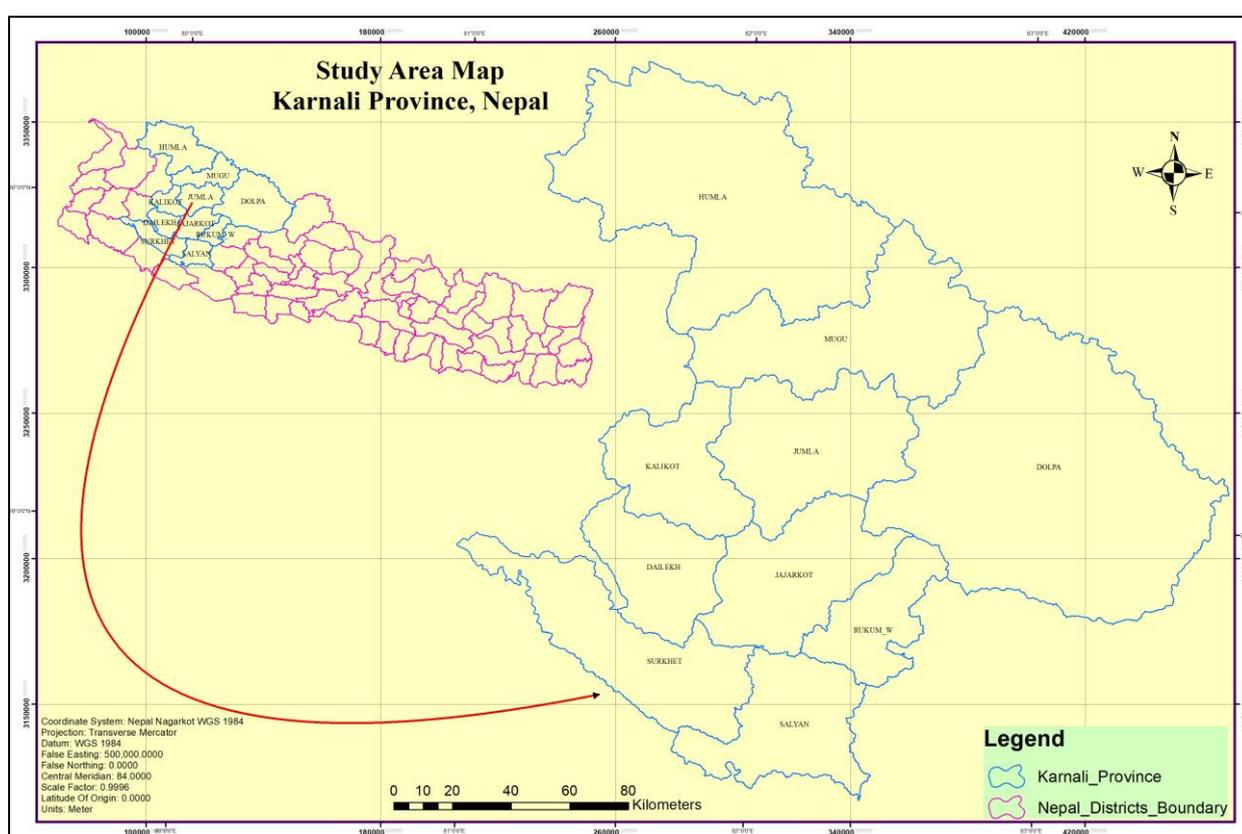
- The study has to cover the scattered large area with difficult terrain, so some important information might have missed out during the study.
- Climatic and seasonal variability during the study time (Magh, Falgun and Chaitra) has imposed some limitations for local travel and interactions with the people as local traders and key informants migrated due to cold in upper regions in Karnali Province.
- Given the constraining time and situation, the strategy of extended expert's contribution has been adopted by the consultancy to complete the task while not compromising the quality output.

CHAPTER: 2

2. METHODOLOGY

2.1 Study area:

Karnali is the largest province of Nepal with an area of 30,211 km² (11664.5 sq mi). The province is surrounded by Gandaki Pradesh in east, Province No. 5 in south-east and south, Sudurpashchim Pradesh in the west and Tibet Autonomous Region of China in north which ranges from 28.16-30.44 N & 80.98-83.68 E. It includes 10 districts like Dailekh, Dolpa, Humla, Jajarkot, Jumla, Kalikot, Mugu, Rukum (west), Salyan and Surkhet. The Province headquarter lies in Birendranagar of Surkhet district. This province has 25 Municipalities, 54 Rural Municipalities, and 718 wards. According to the 2021 Nepal census, the population of the province is 1,688,412, making it the least populous province in Nepal.



Map 1: Map of study area

The province has occupied higher mountains land of north and mid-hills of Nepal. It contains Kubi Gangri, Changla and Kanjiroba mountains in north. The Shey Phoksundo National Park with Phoksundo lake is the largest national park of Nepal and Rara lake is the

largest lake of Nepal which are located in Karnali Pradesh. Karnali River is the biggest river of the province which is thought to be longest river of Nepal.

Karnali Province has two distinct faces. Both of the faces will take your breath away. On the one hand, Karnali Province is a unique and beautiful place where the nature's true gifts are still intact. Its icy cold water is rich in minerals, the fresh air is free from carbon monoxide, its mesmerizing landscape full of known and unknown herbs and vegetations, and food grown in the region is 100% organic. But on the other hand, its isolation has pushed Karnali Province far behind from the rest of the world. Isolation and poverty in this beautiful yet harsh Trans Himalayan mountains deprive people of all but their bare life. In one sentence fact Karnali Province is Middle of nowhere.

Karnali Province has the lowest growth rate in the country with an annual economic growth rate of 5.7% and is also contributes the least to the GDP at 4.1%. The province is among the poorest in Nepal with an estimated 28.9% people living under absolute poverty (second highest in the country) and 51.7% of the people are multidimensionally poor (highest in the country). The unemployment rate in the province stands at 9.7% which is the third lowest in the country (Economic Survey, 2019). Those in rural areas practice subsistence agriculture and animal husbandry for their livelihoods and depend heavily on forest resources for timber, firewood, fodder, non-timber forest products, litter, and grazing grounds (WWF Nepal, 2011). The total population of cattle is estimated at over 4.5 million, with many of them grazing freely in the national forests. The average farmland per capita is declining, landlessness is on the rise and nearly 20% of the population live below the poverty line (MoFE, 2016). Fuelwood is the most common source of energy used by 72.4 % of the households. People are still heavily dependent upon forests and ecosystem services for their livelihoods and wellbeing (MoFE, 2016). It is rich in natural resources especially forest products, Non Timber Forest Products (NTFPs) and Medicinal and Aromatic Plants (MAPs).

The assignment of the feasibility study is carried out in five districts of upper Karnali region. The field study and interview is carried out in the rural/municipalities with the potential of Khamu/Chuli production. More details of geographic, ecological and demographic setting are included in the third chapter. For extracting information from the secondary sources and collecting primary data from the field, the methodology has embraced socio-economic as well as environmental considerations apart from the technical aspects of Khamu/Chuli cultivation,

production and processing. Necessary consultations have been made between the client and research team. The following details of methodology have been applied for the study.

2.2 Methods:

2.2.1 collection and review of literature and secondary information

The research team has studied the available documents, reports, maps etc. and linkages associated to the establishment of the oil processing industries, its effects on the surrounding environment and measures for the sustainability. The standards and processing industries related documents, acts and regulations were also reviewed during the study for *Khamu and Chuli* production and local livelihood improvement.

- Review of social, cultural, political, economic and historical literature related to *Prunus spp.* (*Prunus persica* (*Khamu*) and *Prunus armeniaca* (*Chuli*)) and its' use in Karnali Province.
- Literature review related to *Prunus spp.* (*Prunus persica* (*Khamu*) and *Prunus armeniaca*(*Chuli*)) products and use
- Local processing methods, existing production and market potentials
- Input and output costs and market analysis
- Availability of road networks and power supply for the accessibility and transportation of *Prunus spp.* *Prunus persica* (*Khamu*) and *Prunus armeniaca*(*Chuli*) products and also for the establishment of oil processing plant.
- Environmental suitability and sustainability information

2.2.2 Consultations and meetings

Prior to the commencement of the field work to initiate data collection, a start-up meeting with the client was organized which was participated by relevant stakeholders and experts. This meeting has helped to further clarify the Terms of Reference of the study including the safety and security measures to be observed during the study.

- **Expert and Field Consultations:** The study team had carried out consultations with local people in order to know the local use of *Prunus spp.* (*Prunus persica* (*Khamu*) and *Prunus armeniaca* (*Chuli*)) products.

- **Bi-lateral Phone Calls:** For the field assessment, webinar such as zoom meetings and telephone calls were used with the stakeholders of rural municipalities of Karnali Province district.
- **Open ended key questions:** Key questions have been prepared to explore the real situation such as; what do you know about history of the *Prunus spp.* (*Prunus persica* (Khamu) and *Prunus armeniaca* (Chuli)) trees in your areas? How have people been using *Prunus spp.* (*Prunus persica* (Khamu) and *Prunus armeniaca* (Chuli)) in oil etc for centuries? What was the transportation managed from the farmland to the site of use? How can we carry out its plantation and conservation while seeing the prospect of sustainable use? What are the major locations/ sites of this *Prunus spp.*? What is existing local knowledge to use its oil, fruit, wood etc for medicinal value and aroma? Do you think these can be sustainable income sources for local people once if they are interlinked with entrepreneurial activities? Etc.

2.2.3 Reconnaissance and gps survey

- Final report has been prepared and presented with GIS based maps (appropriate scale) showing the suitable area for the *Prunus spp.* (*Prunus persica* (Khamu) and *Prunus armeniaca* (Chuli)) habitat suitability and small oil processing unit. Further sites confirmations of *Prunus spp.* are better indicated with the help of GIS maps.
- Our dedicated field researchers have access and familiarized themselves with the area and collected reference materials for the availability of the resources and accessibility of the site so that it's feasibility has been assessed practically and the GIS map has verified with resource availability, accessibility, power supply, community and settlement, appropriateness of location sites, etc.
- The reconnaissance survey was conducted to investigate potential areas for establishing the processing industry inferred with the public consultation.
- The members of research team had conducted reconnaissance survey of the selected areas for production and also processing industry establishment in the individual rural municipality of the district and its contribution to the local development (socio-economically).

2.2.4 Primary data collection methods

- **Consultations:** The consultation meetings were organised at district, rural municipality and community levels to get actual information as aforementioned.
- **Focus Group Discussions (FGD):** Focus Group Discussions have been conducted to know the area of *Prunus spp.* (*Prunus persica* (Khamu) and *Prunus armeniaca* (Chuli)) and its verification from the GIS information. Similarly, social, economic, environmental information has been collected with the local communities regarding the potentiality of Prunus industry products.
- **Key Informants Interview (KII):** Key informants like Divisional Forest Officer and forestry personnel, District Agriculture Development Office, Local Peoples were interviewed regarding the location of *Prunus* wild stand, quantity, socio-economic and environmental information.
- **On site observation and photographs:** On site observations and taking of photographs has further substantiated the field study.

2.2.5 Data analysis

- **Khamu/Chuli Farms in Karnali Province:** Khamu/Chuli farm is primarily found in all the rural/municipalities of Karnali Province (especially in temperate region). Khamu/Chuli data of the concerned *Palika*, tentative area of Khamu/Chuli farmland has been gathered and analyzed. Socio, economic and environmental aspects of the Khamu/Chuli has been analysed towards ensuring sustainability and sustainable production.
- **Stakeholder analysis (Key stakeholders):** The preliminary stakeholders of the Khamu/Chuli-based industries are: Community Forestry User Groups (CFUG), Leasehold Forest User Groups(LHFUG) Divisional Forest Office, Provincial Industry Office/Ministry, Private Investors for the Khamu/Chuli oil products and enterprises, financial institutions (providing loan for the investment), local Palikas, local beneficiaries and others (they are directly or indirectly benefitted or negatively affected by the Khamu/Chuli industry).

- **Potential industrial products identification and analysis:** There are primarily two products for the Khamu/Chuli industry namely: (i) Khamu/Chuli fruit and (ii) Another product is the Khamu/Chuli oil, which is primarily produced from its seed. Details of its potentialities were identified from the secondary information. Khamu/Chuli is profusely found in India, Pakistan, Nepal, Afghanistan and have wide use for its fruit and oil.
- **Market analysis:** India and China (specialy Tibet) are the major markets for Khamu/Chuli oil. Thus, its price, market and marketing process has been further analyzed in Nepal. This will be a new product in Nepal. For example, price of Khamu/Chuli oil is USD 31\$ per 100ML by salvia company at Amazon.com. Thus, competitive production cost at industrial level is important for the market and marketing of the products.
- **Inputs:** Khamu/Chuli fruit will be the primary inputs both for food and also for Khamu/Chuli oil. In Karnali Province it has been used for physical massage and bodily use. Khamu/Chuli farmland is found in Temperate climatic condition, thus, growth is very slow. Hence, how farmer's land could be fast regenerated will be the primary concern of the farmer's and local stakeholders.
- **Outputs:** Fruits and Khamu/Chuli oil are supposed to be finished products (output) as value added products of the Khamu/Chuli fruit. This matter has been analyzed in the feasibility report.
- **Physical Infrastructures and Road Networks:** Road networks will have a crucial role in transporting the Khamu/Chuli products, machinery for the establishment of Khamu/Chuli oil processing industry. Thus, it has been analyzed in the report.
- **Triangulation of the data:** Data gathered from the various sources are triangulated for the true information.

CHAPTER: 3

3.1 CONTEXT ANALYSIS

3.1.1 Geographic Setting

Karnali Province is the largest among the seven federal provinces of Nepal with the total area of 30,211 square kilometers (sq. km). It borders the Tibet Autonomous Region of China to the north, Gandaki Pradesh to the east, Sudurpashchim Pradesh to the west, and Province No. 5 to the south. The east-west length of the province is 265 kilometers while north-south width is 250 kilometers. The lowest land of the province is Karnali Dovan is at altitude of 180 meters from the sea level while the highest point Churen Himal is at the height of 7348 meters from the sea level. Surkhet valley is the largest valley in the province. It is 9 km long and 7 km wide with at the height of 700 meters from the sea level. Birendranagar is the Provincial capital city situated in this valley. Other famous valleys and river basins of Karnali province are Jumla, Rakam, Chaurjahari, Ramghad, Baddichaur, Chaukune etc. Limi valley is at 4000 meter from the sea level with unique geographic specificities (KPPC, 2020). According to Hagen (1968), Bishop C Berry (1999), Shakai etel (1997) the geological formation of Karnali region is complex thus poses the unique altitudinal geographic, climatic and vegetation variation in Nepal.

The province is irrigated by the Karnali River and its tributaries. This river is the biggest river of the province and is also the longest river (507 kilometer) of Nepal. Seti River and Bheri River are major tributaries of Karnali River. It is the province of lakes with more than 936 at different altitudes with the largest and deepest lakes of Nepal such as Rara and Shey Phoksundo.

According to the 2021 Nepal Census, the population of the province is 16,88,412 (823761 male and 864651 female), making it the least populous province in Nepal. The population distribution in Karnali is very sparse. The population density of Karnali is 60 people per square km as compared with national 198 people per square km. The total household number estimated in 2021 is 3,66,255.

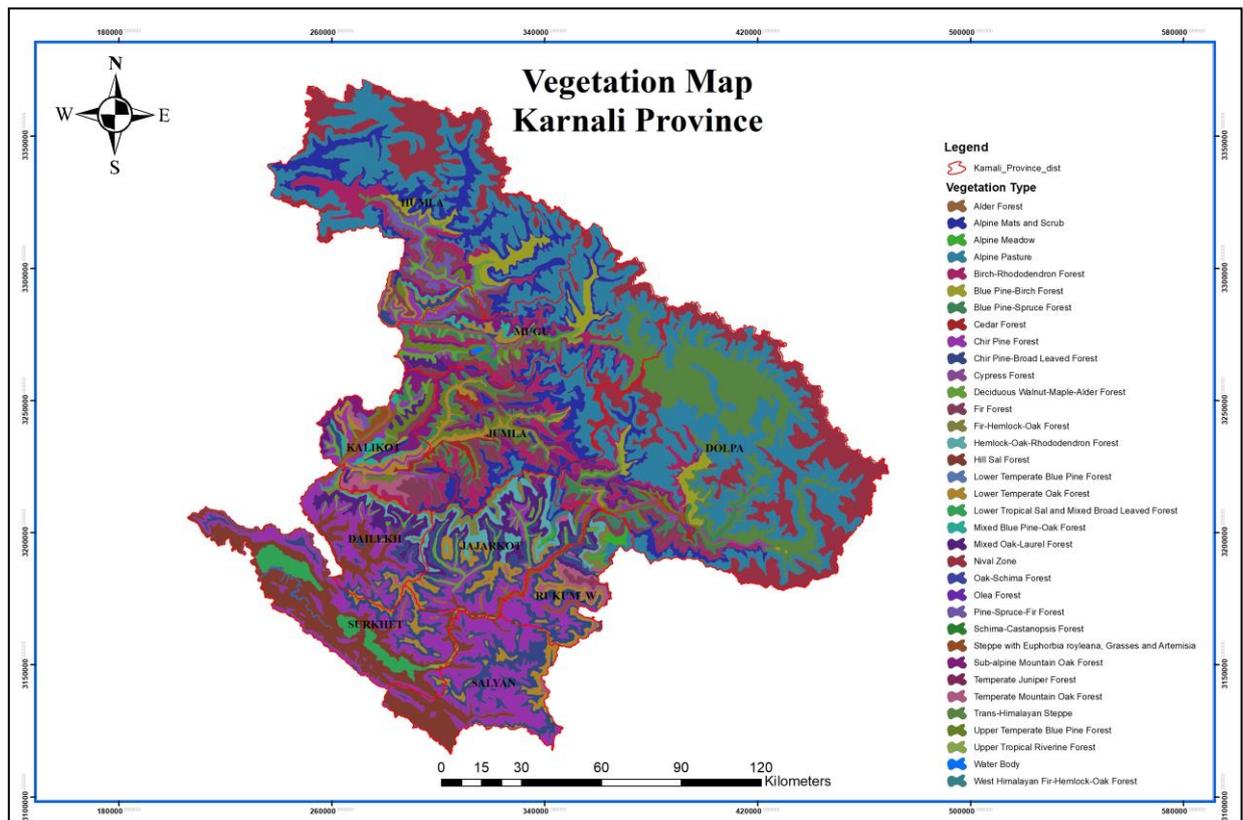
The feasibility study has been carried out encompassing all the palikas of the upper Karnali district but focusing the areas having Khamu/Chuli farmland, market with backward and forward linkages. The more focused palikas were the Simikot, Kharpunath, Namkha and Sarkeghad of Humla, Chandannath, Hima, Guthichaur and Sinja of Jumla, Rara chhayanath, Chankheli and Soru of Mugu, Thulibheri, Mudkechula and Kaile of Dolpa and Khadachakta, Mahabu and Palata of Kalikot district are included in field study due to having scattered

subtropical forests to alpine meadows. Here are some of the prominent vegetation types found in the province:

- **Tropical and Subtropical Moist Broadleaf Forests:** These forests are found in the lower elevation areas of Karnali Province, particularly in the southern plains (Terai). The vegetation here consists of a mix of broadleaf trees, including sal (*Shorea robusta*), sissoo (*Dalbergia sissoo*), and various species of figs (*Ficus* spp.). These forests are characterized by high species diversity and are home to a variety of wildlife.
- **Chir Pine Forests:** As the elevation increases, the subtropical forests transition into Chir Pine (*Pinus roxburghii*) forests. These forests dominate the mid-hills of Karnali Province, covering a significant portion of the landscape. Chir Pine is a coniferous species well-adapted to the drier and rocky terrain of the region.
- **Temperate Broadleaf Forests:** In the higher regions of the mid-hills, temperate broadleaf forests are prevalent. These forests are composed of deciduous and evergreen trees, such as oak (*Quercus* spp.), maple (*Acer* spp.), rhododendron (*Rhododendron* spp.), and birch (*Betula* spp.). They offer a diverse range of vegetation and support a variety of wildlife, including several bird species.
- **Alpine Meadows and Scrublands:** As the elevation continues to rise, the vegetation transitions into alpine meadows and scrublands. These areas are characterized by a lack of trees due to harsh weather conditions and lower temperatures. Instead, they are covered with grasses, shrubs, and hardy flowering plants that can withstand the challenging alpine environment.
- **High Himalayan Vegetation:** In the upper reaches of Karnali Province, particularly in the Himalayan ranges, the vegetation is dominated by alpine grasslands and sparse shrubs. As the altitude increases, the vegetation becomes more limited, and only specially adapted species like mosses and lichens can survive in these extreme conditions.

Desktop review is so crucial to understand first the perspective of Khamu/Chuli as a fruit tree and ecosystem and thus possible processing industry especially in the Karnali Province. Notwithstanding the literature available particularly on Khamu/Chuli farm in Karnali Province

are not available much, some reference can be extracted from historical-cultural and vegetation cover aspects.



Map 3: Vegetation type map of Karnali province

Although its botanical name *Prunus persica* refers to Persia, genetic studies suggest peaches originated in China, where they have been cultivated since the neolithic period. Until recently, cultivation was believed to have started around 2000 BC. Evidence that is more recent indicates that domestication occurred as early as 6000 BC in Zhejiang Province of China. The oldest archaeological peach stones are from the Kuahuqiao site. Archaeologists point to the Yangtze River Valley as the place where the early selection for favorable peach varieties probably took place. Peaches were mentioned in Chinese writings and literature beginning from the early first millennium BC (Geissler, C. 2009).

A domesticated peach appeared very early in Japan, in 4700–4400 BC, during the Jōmon period. It was already similar to modern cultivated forms, where the peach stones are significantly larger and more compressed than earlier stones. This domesticated type of peach was brought into Japan from China. Nevertheless, in China itself, this variety is currently attested only at a later date around 3300 to 2300 BC (Arakelyan, B, 1968).

In a burial cave of the second prehistoric period, fruits and seeds imported from the subtropical lowlands were found among the grave goods (*Knörzer, KH, 2000*).



Photo 1: Typical farmland in Humla

CHAPTER: 4

4.1 SPECIES, NATURAL HABITAT AND CULTIVATION

4.1.1 Khamu (*Prunus persica*)

4.1.1.1 Introduction/Description:

The Khamu (*Prunus persica*) is a deciduous tree native to the region of Northwest China between the Tarim Basin and the north slopes of the Kunlun Mountains, where it was first domesticated and cultivated. It bears edible juicy fruits with various characteristics, most called peaches and others (the glossy-skinned varieties), nectarines. The specific name *persica* refers to its widespread cultivation in Persia (modern-day Iran), from where it was transplanted to Europe. It belongs to the genus *Prunus*, which includes the cherry, apricot, almond, and plum, in the rose family. The peach is classified with the almond in the subgenus *Amygdalus*, distinguished from the other subgenera by the corrugated seed shell. Due to their close relatedness, the kernel of a peach stone tastes remarkably similar to almond, and peach stones are often used to make a cheap version of marzipan, known as *persipan*. Peaches and nectarines are the same species, though they are regarded commercially as different fruits. The skin of nectarines lacks the fuzz (fruit-skin trichomes) that peach skin has; a mutation in a single gene (*MYB25*) is thought to be responsible for the difference between the two. In 2018, China produced 62% of the world total of peaches and nectarines.

Table 5: Scientific classification of Khamu/Aaru

Scientific classification	
Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Rosids
Order:	Rosales

Family:	Rosaceae
Genus:	Prunus
Subgenus:	Prunus subg. Amygdalus
Species:	<i>P. persica</i>

Prunus persica grows up to 7 m (23 ft) tall and wide, but when pruned properly, trees are usually 3–4 m (10–13 ft) tall and wide. The leaves are lanceolate, 7–16 cm (3–6+1/2 in) long, 2–3 cm (3/4–1+1/4 in) broad, and pinnately veined. The flowers are produced in early spring before the leaves; they are solitary or paired, 2.5–3 cm diameter, pink, with five petals. The fruit has yellow or whitish flesh, a delicate aroma, and a skin that is either velvety (peaches) or smooth (nectarines) in different cultivars. The flesh is very delicate and easily bruised in some cultivars, but is fairly firm in some commercial varieties, especially when green. The single, large seed is red-brown, oval shaped, around 1.3–2 cm long, and surrounded by a wood-like husk. Peaches, along with cherries, plums, and apricots, are stone fruits (drupes). The various heirloom varieties including the 'Indian Peach', or 'Indian Blood Peach', which ripens in the latter part of the summer, and can have color ranging from red and white, to purple (Davidson. A, 1999) .

4.1.1.2 Edible parts of Khamu:

Fruit - raw, cooked or dried for later use. The fruit is often used in ice creams, pies, jams etc. When fully ripe, the fruit of the best forms are very juicy with a rich delicious flavour. Wild trees in the Himalayas yield about 36.5kg of fruit a year. The fruit of the wild form contains about 5.2% sugars, 2% protein, 1.6% ash. Vitamin C content is 2.3mg per 100g. The fruit is a good source of vitamin A. Fruits of the wild peach are richer in nutrients than the cultivated forms. The size of fruit varies widely between cultivars and the wild form, it can be up to 7cm in diameter and contains one seed. Flowers - raw or cooked. Added to salads or used as a garnish. They can also be brewed into a tea. The distilled flowers yield a white liquid which can be used to impart a flavour resembling the seed. Seed - raw or cooked. Do not eat if it is too bitter, seed can contain high concentrations of hydrocyanic acid. See the notes above on toxicity. A semi-drying oil is obtained from the seed. Although the report does not mention edibility it can be assumed that it is edible. The seed contains up to 45% oil. A gum is obtained

from the stem. It can be used for chewing.

4.1.1.3 Other uses: A green dye can be obtained from the leaves. Yellow according to another report. A dark grey to green dye can be obtained from the fruit. A semi-drying oil is obtained from the seed. It is used as a substitute for almond oil in skin creams. The bruised leaves, when rubbed within any container, will remove strong odours such as garlic or cloves so long as any grease has first been fully cleaned off. A gum obtained from the stem is used as an adhesive.



Photo 2: A Khamu tree

4.1.1.4 Propagation of Khamu:

Seed requires 2 to 3 months cold stratification and is best sown in a cold frame as soon as it is ripe. Sow stored seed in a cold frame as early in the year as possible. The stored seed is best given 2 months warm followed by three-month cold stratification. Protect the seed from mice etc. The seed can be rather slow, sometimes taking 18 months to germinate. Prick out the seedlings into individual pots when they are large enough to handle. Grow them on in a greenhouse or cold frame for their first winter and plant them out in late spring or early summer of the following year. Cuttings of half-ripe wood with a heel, July/August in a frame. Softwood cuttings from strongly growing plants in spring to early summer in a frame.

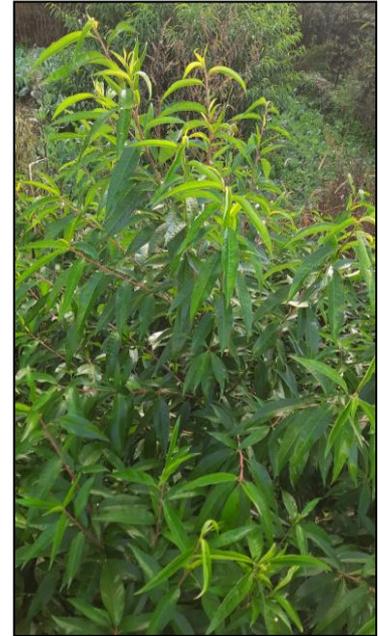


Photo 3: Khamu seedling

4.1.1.5 Germination & Cultivation :

Peaches grow in a fairly limited range in dry, continental or temperate climates, since the trees have a chilling requirement that tropical or subtropical areas generally do not satisfy except at high altitudes (for example in certain areas of Ecuador, Colombia, Ethiopia, India, and Nepal). Most cultivars require 500 hours of chilling around 0 to 10 °C (32 to 50 °F). During the chilling period, key chemical reactions occur, but the plant appears dormant. Once the chilling period is fulfilled, the plant enters a second type of dormancy, the quiescence period. During quiescence, buds break and grow when sufficient warm weather favorable to growth is accumulated. Not known in a truly wild situation, it is possibly derived in cultivation from *P. davidiana*. Among various treatments highest percent germination in peach (31.33%), plum (75.33%) and apricot (73.33%) was obtained by soaking the seeds in water for 9 days (Rafiq. A *et.al*, 2013).

The trees themselves can usually tolerate temperatures to around -26 to -30 °C (-15 to -22 °F), although the following season's flower buds are usually killed at these temperatures, preventing a crop that summer. Flower bud death begins to occur between -15 and -25 °C (5 and -13 °F), depending on the cultivar and on the timing of the cold, with the buds becoming less cold tolerant in late winter.

Another climate constraint is spring frost. The trees flower fairly early (in March in Western Europe), and the blossom is damaged or killed if temperatures drop below about $-4\text{ }^{\circ}\text{C}$ ($25\text{ }^{\circ}\text{F}$). If the flowers are not fully open, though, they can tolerate a few degrees colder (*Desmond R. et.al. 2008*).

Climates with significant winter rainfall at temperatures below $16\text{ }^{\circ}\text{C}$ ($61\text{ }^{\circ}\text{F}$) are also unsuitable for peach cultivation, as the rain promotes peach leaf curl, which is the most serious fungal disease for peaches. In practice, fungicides are extensively used for peach cultivation in such climates, with more than 1% of European peaches exceeding legal pesticide limits in 2013. Finally, summer heat is required to mature the crop, with mean temperatures of the hottest month between 20 and $30\text{ }^{\circ}\text{C}$ (68 and $86\text{ }^{\circ}\text{F}$). Typical peach cultivars begin bearing fruit in their third year. Their lifespan in the U.S. varies by region; the University of California at Davis gives a lifespan of about 15 years while the University of Maine gives a lifespan of 7 years there. Its silvicultural characteristics in summary is shown in the table below;

Table 6: Silvicultural Characteristics of Khamu

Native region: N-W China	<u>Characteristics:</u>	<u>Products:</u>
Native habitat: Not known in a truly wild situation	form: medium sized	Fruit: Drupes: July- Sep. Sweet, yellow flesh.
family: Rosaceae	layer : Lower Canopy	Yield: 20Kg -30KG of fruit after 7 years
<u>Pest and Predators:</u>	habit: Standard Tree	Flowers: April, good source of nectar for bees.
Peach Leaf Curl	height x width (m): 6m x 6m	Seeds can be used to grow an excellent root stock for grafting, compatible with all species from the Prunus genus inc. plum, cherry, apricot and almond.
<u>Needs, tolerances:</u>	years to bearing fruit: 3-4 years	<u>Functions, behaviours:</u>
Light: Semi-shade or no shade	productive life span: 15-18 years	
soil pH: Acid, neutral - basic alkaline	Deciduous Tree growing upto 6m	
	It is in flower in April, and	

<p>USDA Hardiness Zone: 4b - 9b</p> <p>Prefers well drained soil</p> <p>Mulch with compost in the spring and keep weed free as plant establishes</p> <p>If there is little rainfall, water well when fruits are setting</p> <p>Plants in this genus are notably susceptible to honey fungus</p> <p><u>Known hazards:</u></p> <p>The seed can contain high levels of hydrogen cyanide, a poison that gives almonds their characteristic flavour. This toxin is readily detected by its bitter taste. Usually present in too small a quantity to do any harm, any very bitter seed or fruit should not be eaten. In small quantities, hydrogen cyanide has been shown to stimulate respiration and improve digestion, it is also claimed to be of benefit in the treatment of cancer. In excess, however, it can cause respiratory failure and even death.</p>	<p>the seeds ripen from July to August.</p> <p>The flowers are hermaphrodite (have both male and female organs) and are pollinated by Bees. The plant is self-fertile.</p> <p>Suitable for: light (sandy), medium (loamy) and heavy (clay) soils and prefers well-drained soil.</p> <p>Suitable pH: acid, neutral and basic (alkaline) soils.</p> <p>It cannot grow in the shade.</p> <p>It prefers moist soil.</p>	<p>The trees themselves can usually tolerate temperatures to around -26 to -30 °C, although the following season's flower buds are usually killed at these temperatures, leading to no crop that summer. Flower bud kill begins to occur between -15 and -25 °C.</p> <p>The trees tend to flower fairly early in spring. The blooms often can be damaged or killed by frosts; typically, if temperatures drop below about -4 °C, most flowers will be killed. However, if the flowers are not fully open, they can tolerate a few degrees colder.</p>
---	---	---

4.1.2 Chuli (*Prunus armeniaca*)

4.1.2.1 Introduction/Description:

Chuli is a type of apricot that grows wild in the dry temperate region of the Western Himalayas falling within Kashmir and the Indian state of Himachal Pradesh adjoining Tibet. The altitude of this region ranges between 2000-3200m. As monsoons fail to reach these areas, so this region, so the annual rainfall here around 25 cm. Most of the precipitation is in the form of snow during winter. The minimum temperature during the most part of the year is below 0 C. The growing season is quite short. Further, the soil of this region is hard and shallow. Chuli is a spreading tree, round topped, 5-7 m high, spread 6 m, trunk girth 56 cm, bark reddish brown. Leaves broadly ovate, apex cuspidate, base cordate, margin serrulate, pose intermediate, lamina green, upper and lower surface pubescent, length 6.81 cm, breadth 5.73 cm, length/breadth ratio 1.19, petiole pubescent, colour red, length 2.80 cm; glands shape orbicular, colour dark tan, 2-3 in number.

Table 7: Scientific classification of Chuli

Scientific classification	
Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Rosids
Order:	Rosales
Family:	Rosaceae
Genus:	<i>Prunus</i>
Subgenus:	<i>Prunus</i> subg. <i>Prunus</i>
Section:	<i>Prunus</i> sect. <i>Armeniaca</i>
Species:	<i>P. armeniaca</i>

Prunus armeniaca is a small tree, 8–12 m (26–39 ft) tall, with a trunk up to 40 cm (16 in) in diameter and a dense, spreading canopy. The leaves are ovate, 5–9 cm (2.0–3.5 in) long and 4–8 cm (1.6–3.1 in) wide, with a rounded base, a pointed tip and a finely serrated margin. The flowers are 2–4.5 cm (0.8–1.8 in) in diameter, with five white to pinkish petals; they are produced singly or in pairs in early spring before the leaves. The fruit is a drupe similar to a small peach, 1.5–2.5 cm (0.6–1.0 in) diameter (larger in some modern cultivars), from yellow to

orange, often tinged red on the side most exposed to the sun; its surface can be smooth (botanically described as: glabrous) or velvety with very short hairs (botanically: pubescent). The flesh is usually firm and not very juicy. Its taste can range from sweet to tart. The single seed is enclosed in a hard, stony shell, often called a "stone", with a grainy, smooth texture except for three ridges running down one side.

4.1.2.2 Fruit bearing in chuli:

The flowering period extends between 16th and 28th March.

Flowers white with a pink tinge, diameter 2.9 cm; petals 1.24 cm long, 1.13 cm broad, stamens 38, 1.03 cm long; style straight, yellowish white, 1.17 cm long.

4.1.2.3 Seeds of

chuli: Fruit round with compressed sides, apex depressed with russeted dot, base round, colour deep

yellow with red

blush, length 2.74 cm, breadth 2.59 cm, weight 11.53 g, TSS (total soluble solid) 13.5%, acidity 2.24%, total sugars 5.54%, reducing sugars 3.55%, non-reducing sugars 1.89%. Stone shape ovate, surface rough, free stone, length 1.8 cm, breadth 1.55 cm; kernel shape ovate, length 1.49 cm, breadth 1.55 cm.

4.1.2.4 Flowering and fruiting season: The flowering takes place between during the second half of March. The fruits ripen between 15 and 30 July.



Photo 4: Heaps of Chuli at Micha, Jumla

4.1.2.5 Other uses:

The leaves are astringent, demulcent, diuretic, expectorant, febrifuge, laxative, parasiticide and mildly sedative. They are used internally in the treatment of gastritis, whooping cough, coughs and bronchitis. They also help to relieve vomiting and morning sickness during pregnancy, though the dose must be carefully monitored because of their diuretic action. The dried and powdered leaves have sometimes been used to help heal sores and wounds. The leaves are harvested in June and July then dried for later use. The flowers are diuretic, sedative and vermifuge. They are used internally in the treatment of constipation and oedema. A gum from the stems is alterative, astringent, demulcent and sedative. The seed is antiasthmatic, antitussive, emollient, haemolytic, laxative and sedative. It is used internally in the treatment of constipation in the elderly, coughs, asthma and menstrual disorders. The bark is demulcent, diuretic, expectorant and sedative. It is used internally in the treatment of gastritis, whooping cough, coughs and bronchitis. The root bark is used in the treatment of dropsy and jaundice. The bark is harvested from young trees in the spring and is dried for later use. The seed contains "laetrile", a substance that has also been called vitamin B17. This has been claimed to have a positive effect in the treatment of cancer, but there does not at present seem to be much evidence to support this. The pure substance is almost harmless, but on hydrolysis it yields hydrocyanic acid, a very rapidly acting poison - it should thus be treated with caution. In small amounts this exceedingly poisonous compound stimulates respiration, improves digestion and gives a sense of well-being.

4.1.2.6 Germination & Cultivation:

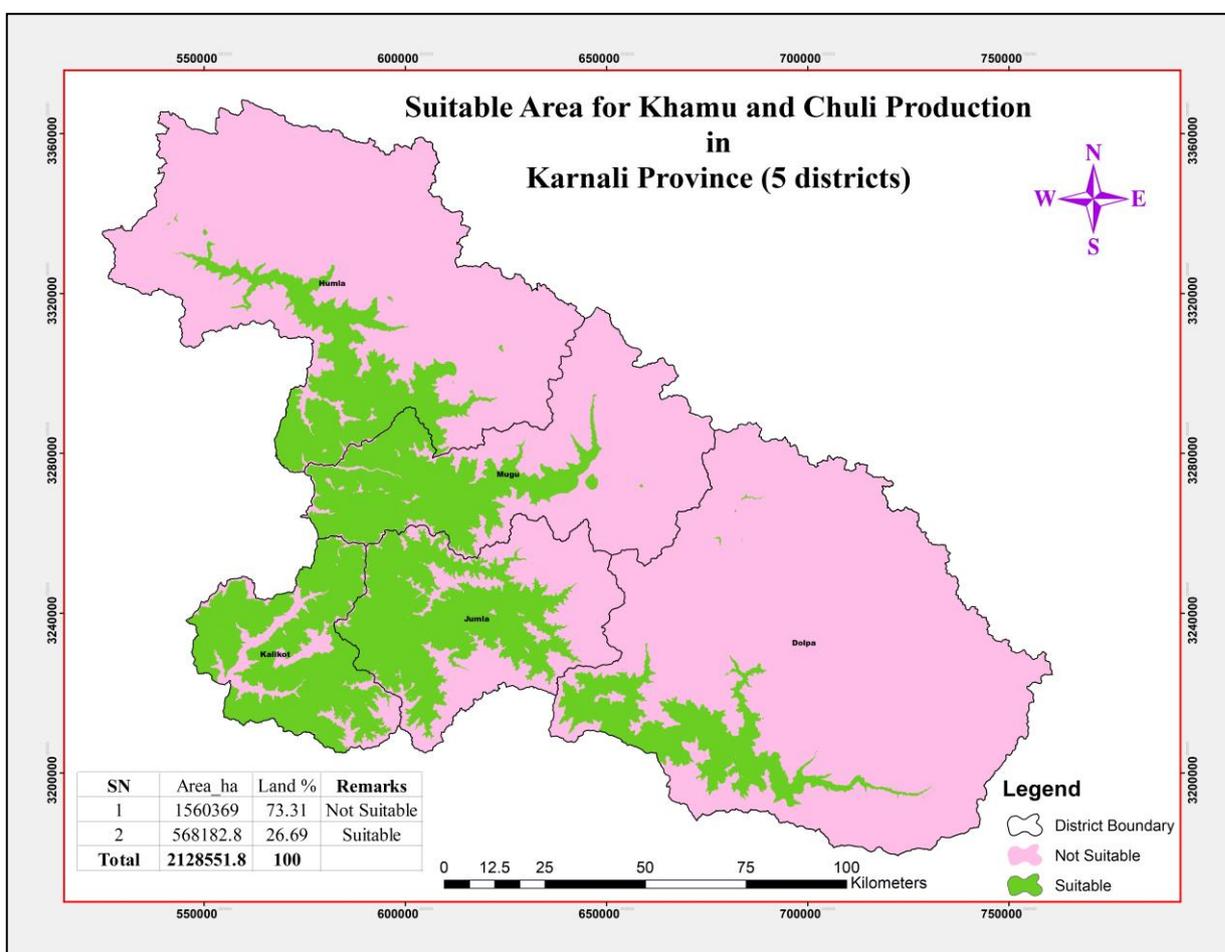
A case study: The seeds of wild apricot (*Prunus armeniaca*) were buried at the soil depths of 0-cm, 4-cm, 8-cm, and 12-cm, respectively, to simulate the seed hoarding behavior of rodents in the field. The results revealed that the rates of seed germination and established seedlings from buried seeds were both the highest in 4-cm burial depth group, and then decreased with increasing soil depth. The number of rotten seeds increased in deeper burial depth. It is unfavourable for seed germination at 0-cm burial depth (i.e., seeds were laid on soil surface). There was insignificant effect of burial depth on growth of established seedlings. The results from this study indicated that proper burial depth in soil would be helpful for the seed germination and seedling growth. The seedlings derived from buried seeds at shallower depth (4 cm) in this research have advantage in their early development (Guo, C. et. al. 2010).

CHAPTER: 5

5.1 RESULTS AND DISCUSSIONS

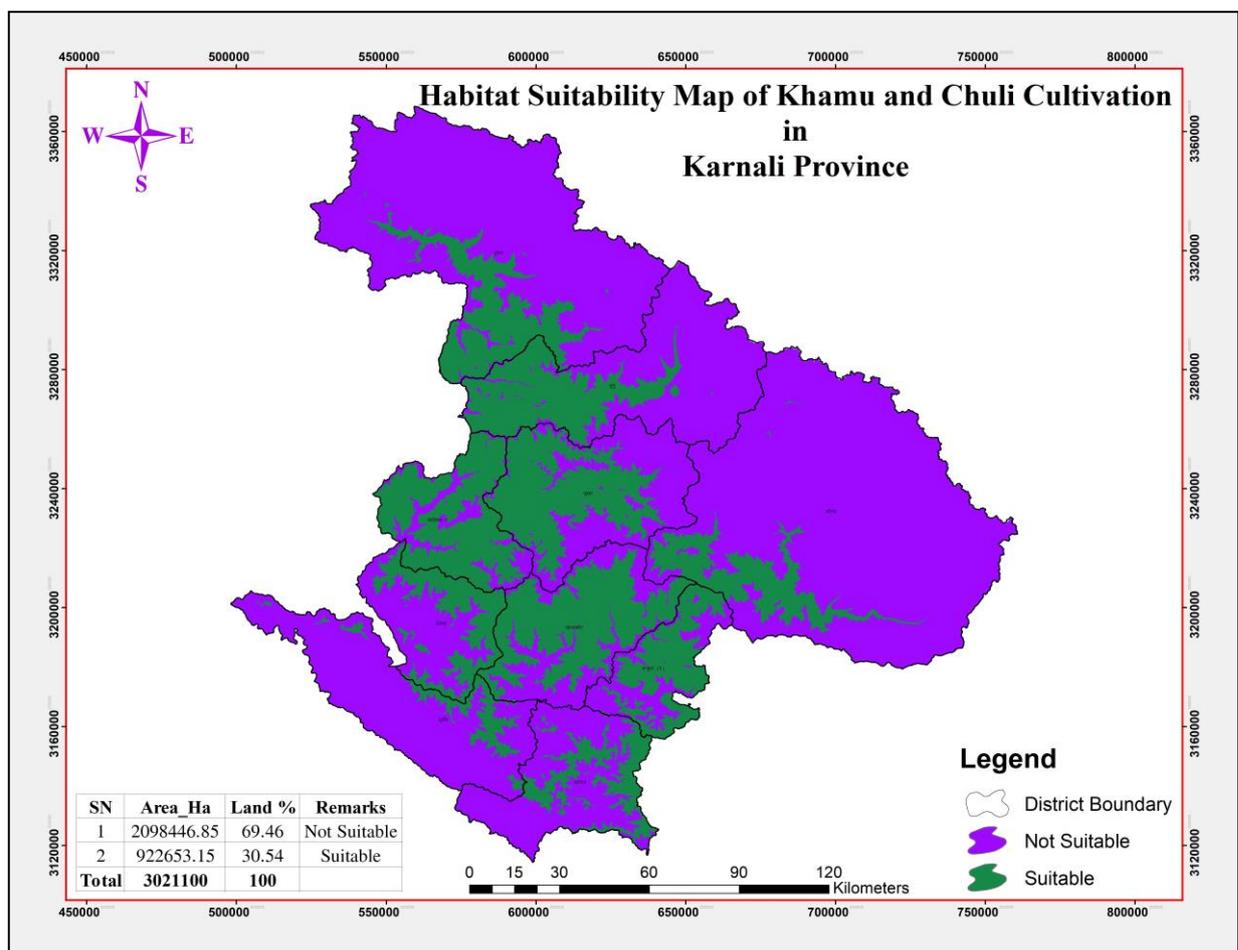
5.1.1 Feasibility of khamu/chuli Cultivation in Karnali Province

Preliminary locations and sites of Khamu/Chuli farms have been identified in different local levels of Karnali Province. This information is being further verified and substantiated by contacting local people, government representatives and key informants. It is found that 26.69% (i.e. 568182.8 ha) of the land in upper karnali district has potential for the cultivation and production of Khamu/Chuli as shown in Table 8. This area is considered as the most probable resource base area. The research team has also verified the particular location and farmland go get actual information on Prunus spp.



Map 4: Feasibility map for the production of Khamu/Chuli

But in Karnali province; a total area of 922653.15 ha is found feasible for Khambu/Chuli cultivation which is 30.54 % area of the province (see Map 5). This study focused on the five districts of Karnali (i.e. Humla, Jumla, Mugu, Dolpa and Kalikot) province. Khambu/Chuli is cultivated in their farmland as a fruit tree. Moreover, its commercial cultivation not done yet in the province because of lack of market potentiality in Nepal. However, many districts in the province is going to be linked with the national road network and its accessibility makes people motivated to cultivate this fruit in large scale in Karnali Province. Farmer's choices form the substantant use to market driven cultivation along with the awareness program is necessary to promote Khambu/Chuli production in Karnali Province.



Map 5: Habitat suitability map of Khmau/Chuli

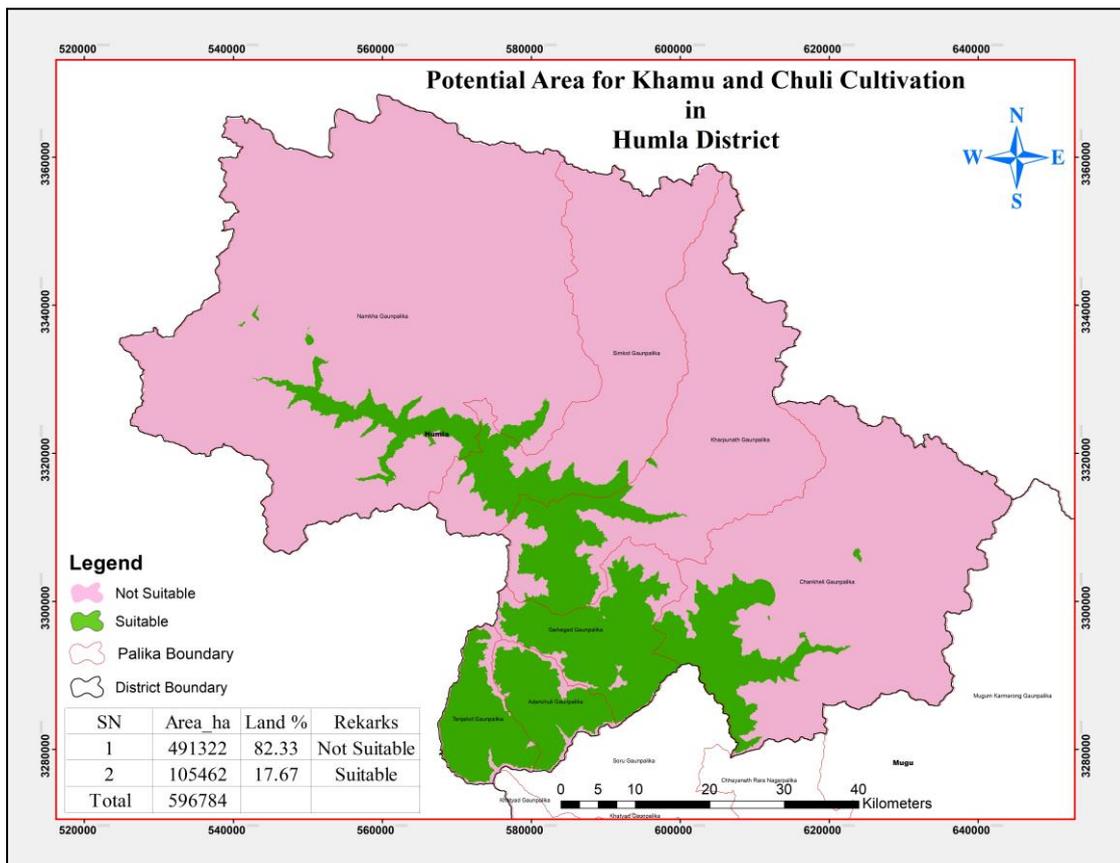
The potential area for the Khambu and Chuli production is found higher in Jumla (53.39%) and followed by Mugu (35.97%) and least area is found suitable in Dolpa (10.40%) district with respect to the district land area as shown in Table 8.

Table 8: Suitable area for Khamu/Chuli Production

District	Area_ha	Land %	Remarks
Kalikot	111476.5	68.42	Not Suitable
	51463.43	31.58	Suitable
Jumla	118907.9	46.61	Not Suitable
	136214.6	53.39	Suitable
Dolpa	709395.1	89.60	Not Suitable
	82315.37	10.40	Suitable
Mugu	206182.2	64.03	Not Suitable
	115812.9	35.97	Suitable
Humla	491322	82.33	Not Suitable
	105462	17.67	Suitable
Total	1560369	73.31	Not Suitable
	568182.8	26.69	Suitable

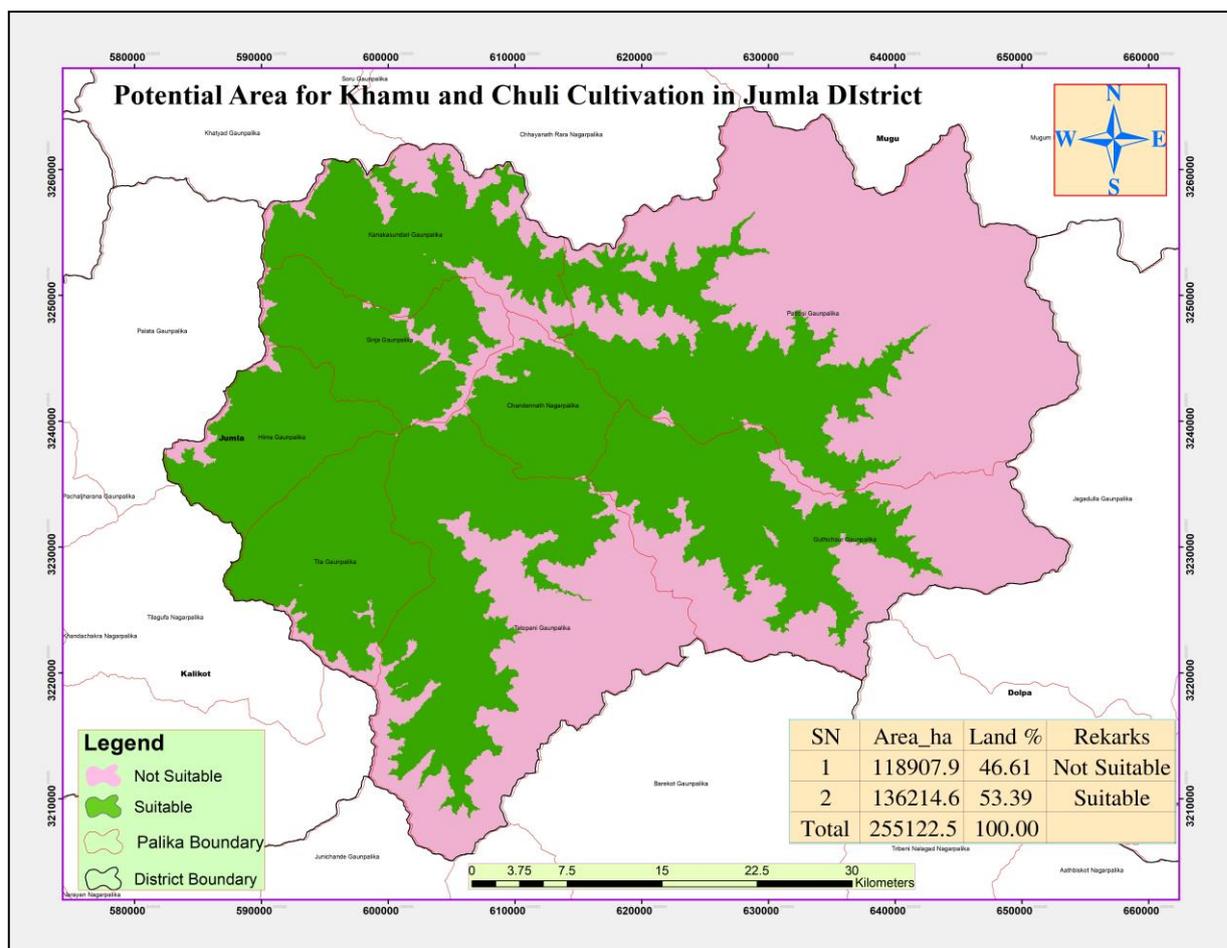
5.1.2 District wise Feasibility

Khamu and Chuli are mostly cultivated by the farmers of then Karnali Zone. This study found that these species are rarely found in wild habitat. Farmers grow Khamu and Chuli in their terrace bund and boarder primarily for fruit. The Suitable area for its cultivation is found highest in Jumla and Mugu and least in Dolpa and Humla district.



Map 6: Khamu/Chuli cultivation potentiality in Humla

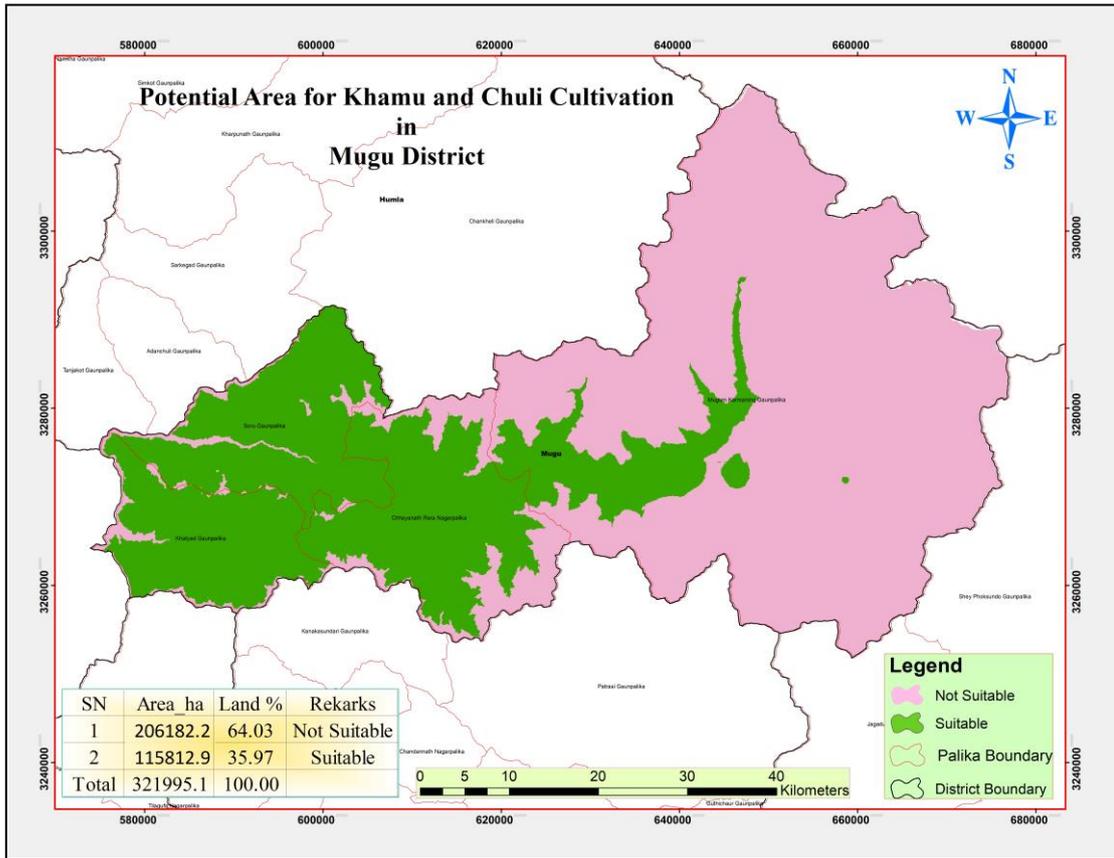
In Humla, approximately 82.33% of its total land area, equivalent to 491,233 hectares, is deemed unsuitable for growing and producing Khamu and Chuli. On the other hand, about 17.67% of the land area, accounting for 105,462 hectares, is considered suitable for cultivating and producing Khamu and Chuli within the district.



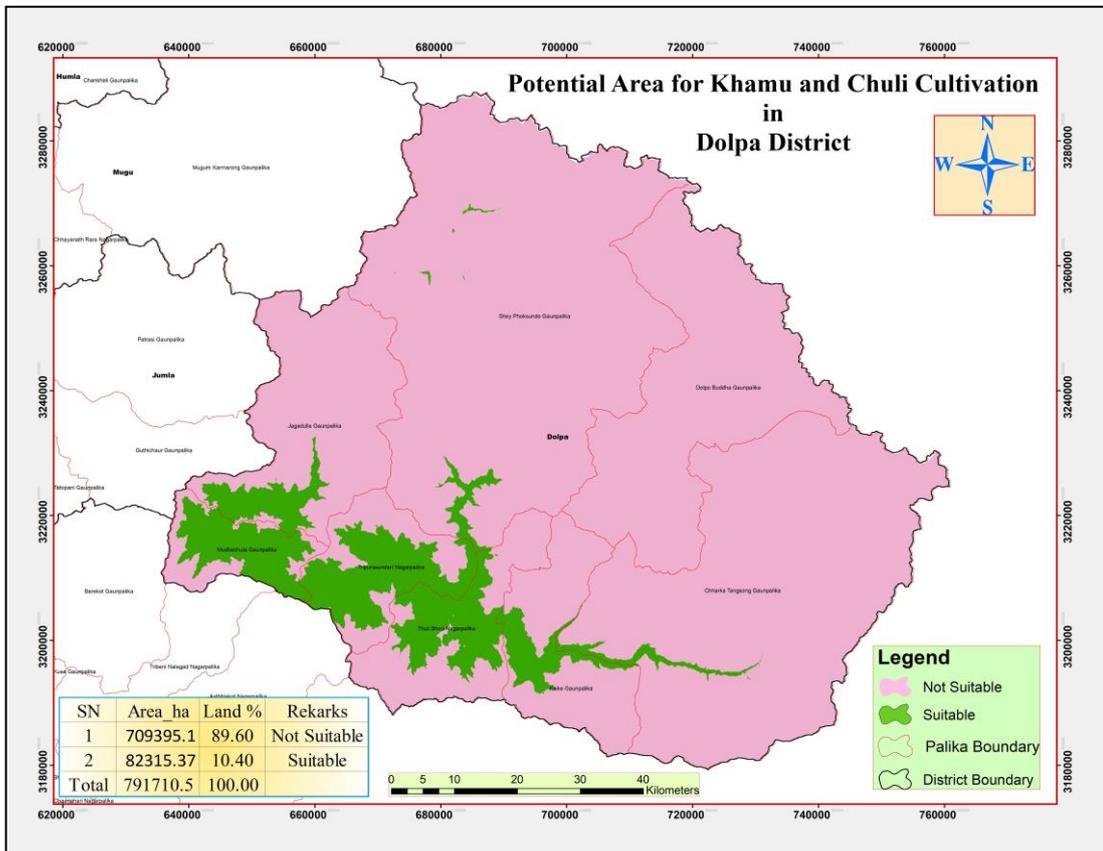
Map 7: Khamu/Chuli cultivation potentiality in Jumla

In Jumla, approximately 46.61% of its total land area, equivalent to 118,907 hectares, is deemed unsuitable for growing and producing Khamu and Chuli. On the other hand, about 53.39% of the land area, accounting for 136,214 hectares, is considered suitable for cultivating and producing Khamu and Chuli within the district.

Similarly; in Mugu, approximately 64.03% of its total land area, equivalent to 206,182 hectares, is deemed unsuitable for growing and producing Khamu and Chuli. On the other hand, about 35.97% of the land area, accounting for 115,812 hectares, is considered suitable for cultivating and producing Khamu and Chuli within the district.

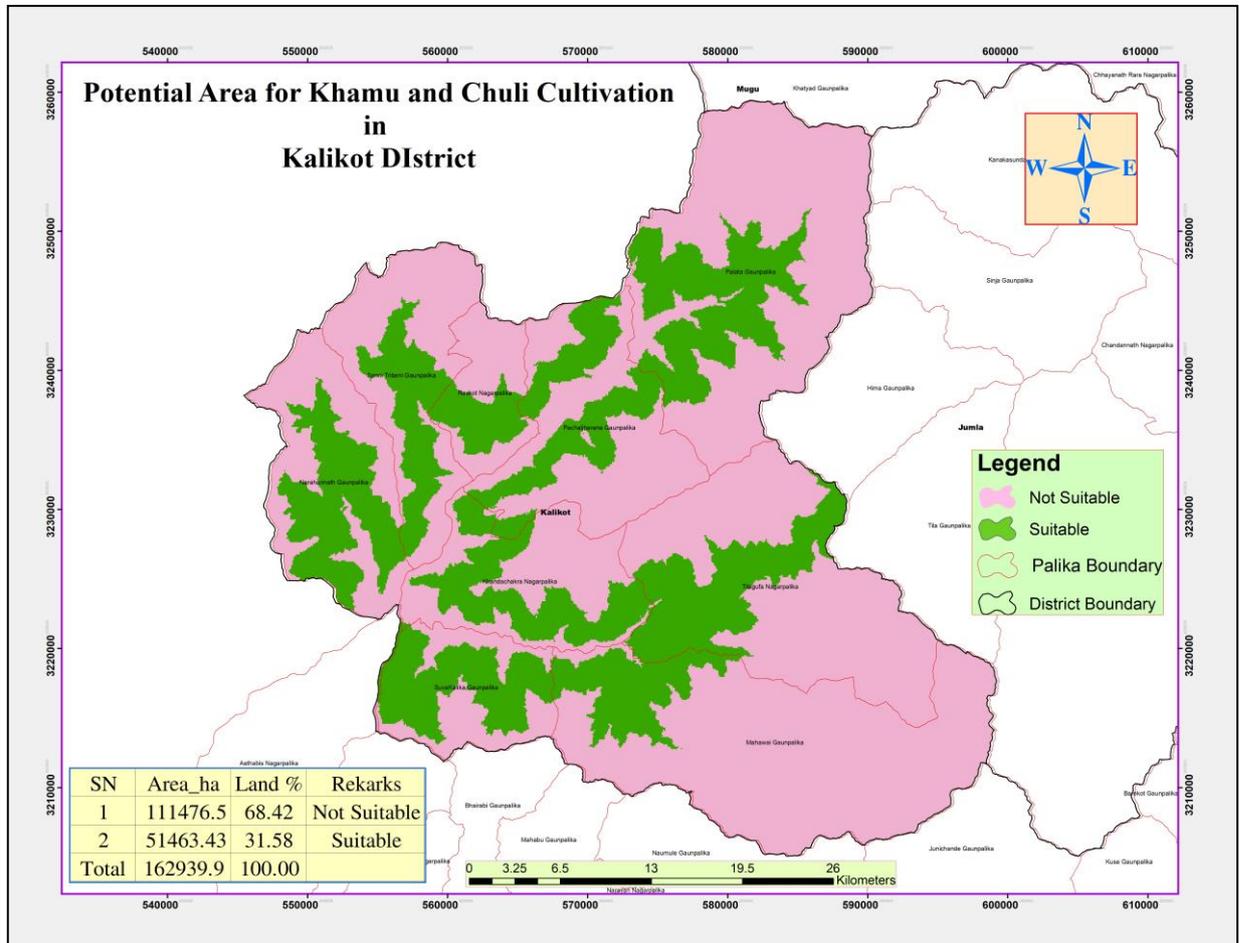


Map 8: Khamu/Chuli cultivation potentiality in Mugu



Map 9: Khamu/Chuli cultivation potentiality in Dolpa

In Dolpa, approximately 89.60% of its total land area, equivalent to 709,395 hectares, is deemed unsuitable for growing and producing Khamu and Chuli. On the other hand, about 10.40% of the land area, accounting for 82,315 hectares, is considered suitable for cultivating and producing Khamu and Chuli within the district.



Map 10: Khamu/Chuli cultivation potentiality in Kalikot

Similarly; in Kalikot district, approximately 68.42% of its total land area, equivalent to 111,476 hectares, is deemed unsuitable for growing and producing Khamu and Chuli. On the other hand, about 31.58% of the land area, accounting for 51,463 hectares, is considered suitable for cultivating and producing Khamu and Chuli within the district. Approximately 568,182.8 hectares, accounting for approximately 26.69% of the entire land area, was identified as the most suitable region for cultivating Khamu and Chuli in the study area.

5.1.3 Oil processing industry establishment feasibility:

A project feasibility study is a comprehensive report that examines in detail the five frames of analysis of a given project. It also takes into consideration its four Ps, its risks and Points of Vulnerability (POVs), and its constraints (calendar, costs, and norms of quality). The goal is to determine whether the project should go ahead, redesigned, or else abandoned altogether. The five frames of analysis are the frame of definition; the frame of contextual risks; the frame of potentiality; the parametric frame; the frame of dominant and contingency strategies.

The four Ps are traditionally defined as Plan, Processes, People, and Power. The risks are considered to be external to the project (e.g., weather conditions) and are divided in eight categories: (Plan) financial and organizational (e.g., government structure for a private project); (Processes) environmental and technological; (People) marketing and sociocultural; and (Power) legal and political. POVs are Points of Vulnerability: they differ from risks in the sense that they are internal to the project and can be controlled or else eliminated.

The constraints are the standard constraints of calendar, costs and norms of quality that can each be objectively determined and measured along the entire project lifecycle. Depending on projects, portions of the study may suffice to produce a feasibility study; smaller projects, for example, may not require an exhaustive environmental assessment.

Resource availability but very limited uses: From the GIS and consultations with local community, it is known that there are many farmlands of Khamu/Chuli in Karnali Province but it has been used mainly for the fruit. It is evident that Khamu/Chuli can be used for producing essential oils and Biochar (seed coat) which can generate employment and income to the local community people using the natural resources (Khamu/Chuli trees) available in the province. At the same time, this tree can be again regenerated with its proper management by planting or natural regeneration process.

Lack of knowledge, skills and technology not only in Karnali Province but also in the country for the Khamu/Chuli-Based Industry: There is lack of knowledge, skills and technology not only in Karnali province but also in the country for the processing of Khamu/Chuli seed for producing oil. At the same time, neighbouring country India and European countries, they have both traditional and modern technologies for producing oil and biochar from Khamu/Chuli. India, European countries are main market for the essential oil.

This is the main hurdle to get local consent for the establishment of Khamu/Chuli processing Industry in Karnali Province.

No detailed survey of Khamu/Chuli available in Karnali Province: Till now detailed survey of Khamu/Chuli has not been conducted by any agency in Nepal. It requires detailed forest or farmland survey to estimate the amount of Khamu/Chuli available for the Khamu/Chuli based industries.

Risk of uncertainly: There is no information on amount of natural resources (raw materials) available for the long-term investment, investment amount and sources, factory gate price of raw material (Khamu/Chuli), cost of production, demand, supply, market, price of Khamu/Chuli oil and external factors such as environmental risks. Thus, investors want to ensure these elements before invest in such industry.

Experiences in NTFP Processing: Numbers of processing plants were started in Karnali zone for the processing and/or semi-processing of valuable medicinal and aromatic plants, non-timber forest products mainly through the community forestry user groups. For example, Dalechuk (Sea buckthorn) processing was started in Mugu district. Jatamansi (*Nardostachys grandiflora*) processing was initiated in Jumla. But there are not any visible results. Public-Private-Partnership Model may be potential for the investment. This is the first initiative to explore the feasibility of Khamu/Chuli oil. Traditional Khamu/chuli processing was initiated and is running at district headquarter (SIMKOT) of Humla district.



Photo 5: Heap of oil cake (locally called PINA) at Suwarna Simkot Khadhya Udhog, Karnali Province

Remoteness and poor road access: In past, there was lack of road access particularly in Karnali zone that hindered the establishment of industries over there. Now there is somehow road access in the Karnali Province but road condition is not good for the transport of heavy machinery for the establishment of industries, raw materials and export of finished goods.

Regularity in electricity supply: Continuous electricity supply is one of the key factors for the production and maintenance of quality of essential oil from Khamu/Chuli. But even in the province headquarter there is no continuous supply of electricity for the industry.

Poverty: Karnali Province is rich in natural resources but the lowest in the socio-economic indicators mainly due to remote geographical condition and lack of knowledge, skills, technologies and resources to harness the ecosystem resources. Yarsagumba (*Cordyceps*) is single product that is supporting to the local economy in some district of the province.

Unemployment and high seasonal migration: Unemployment is prevalent all over the country but Karnali Province is very specific due to limited area for agriculture production.

Thus, there is high seasonal migration mainly in cold season from Karnali Province to Surkhet, Kathmandu, Nepaljung and or India, other parts of country and foreign countries.

Experienced Expatriate Advice in the feasibility and establishment of Khamu/Chuli-based industry in Karnali Province: It is strongly recommended to take the expatriate advice in the feasibility and establishment of Khamu/Chuli-Based Industry in Karnali Province.

Traditional oil extraction Following steps are taking into action during traditional oil extraction methods in Karnali province

- collect the fruits and or seed
- soften the seed sheel
- Separate kernel (mijula) from sheel
- Dry kernel in sun and store
- Crush/Grind the kernel
- Steam the grounded kernel
- Expel oil from traditional wooden *duno* with pressing hands
- Filter and purify the oil



Photo 6: Traditional oil extraction method (wooden duno) (Photo by Rabindra Roy)

5.1.4 Oil processing plant:

The best location for an oil extraction mill is selected considering the following factors:

- Near to the greater source of raw materials.
- Closeness to the agricultural land to sell oilcake by-product.
- Low cost of transport.
- Availability of electricity.
- Building rent availability
- Cost of labour and land.

Figure 1 shows a general layout of the building required for oil processing;

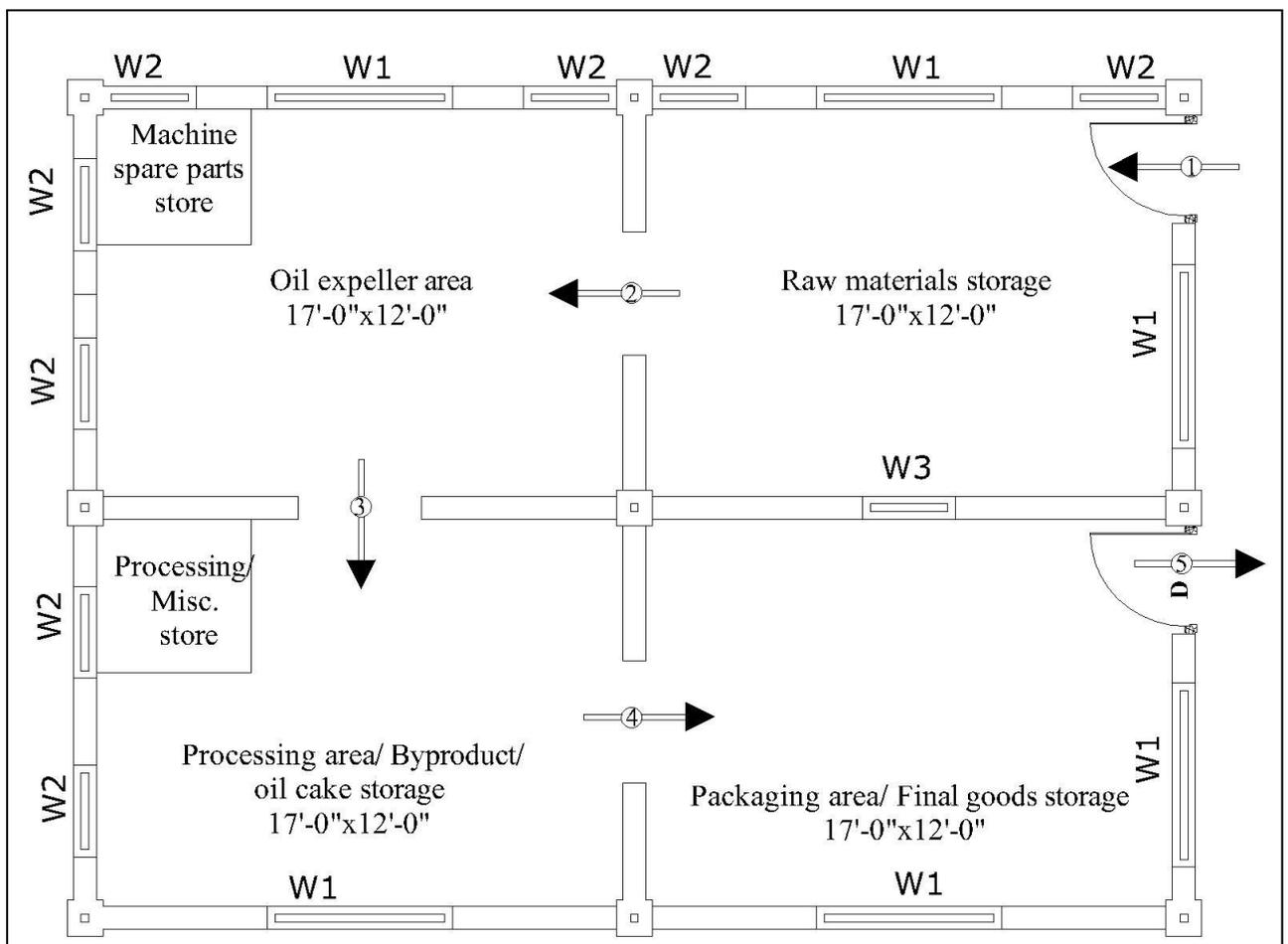


Figure 1: General layout of the building required for oil processing

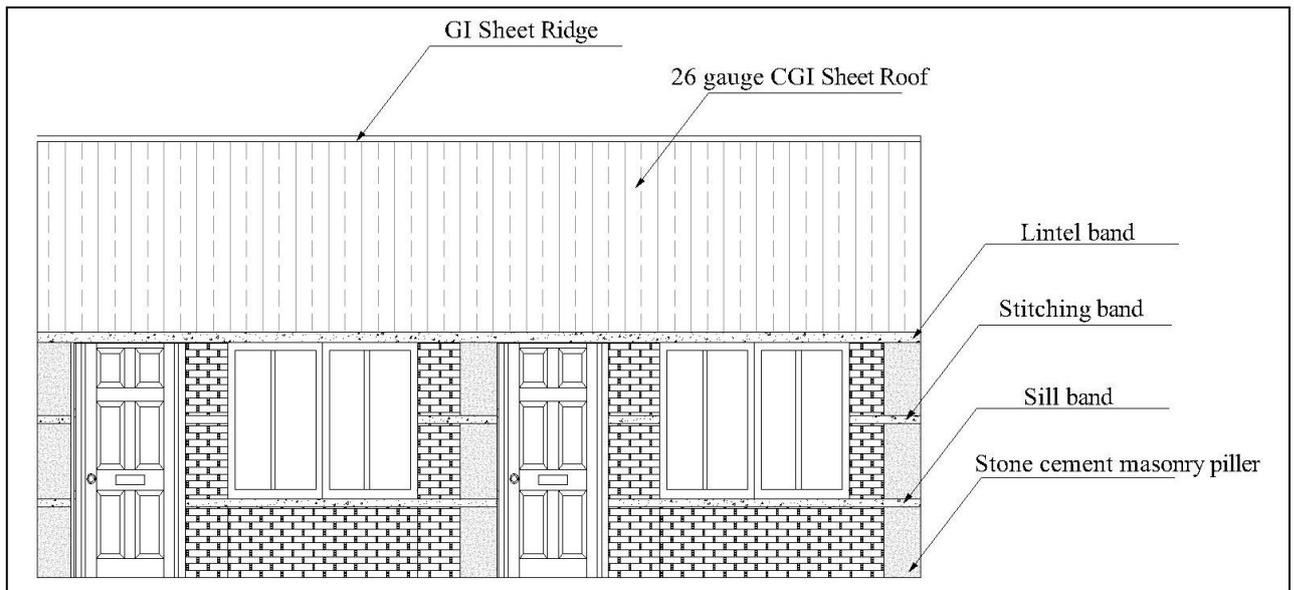


Figure 2: Front view of general oil-processing unit

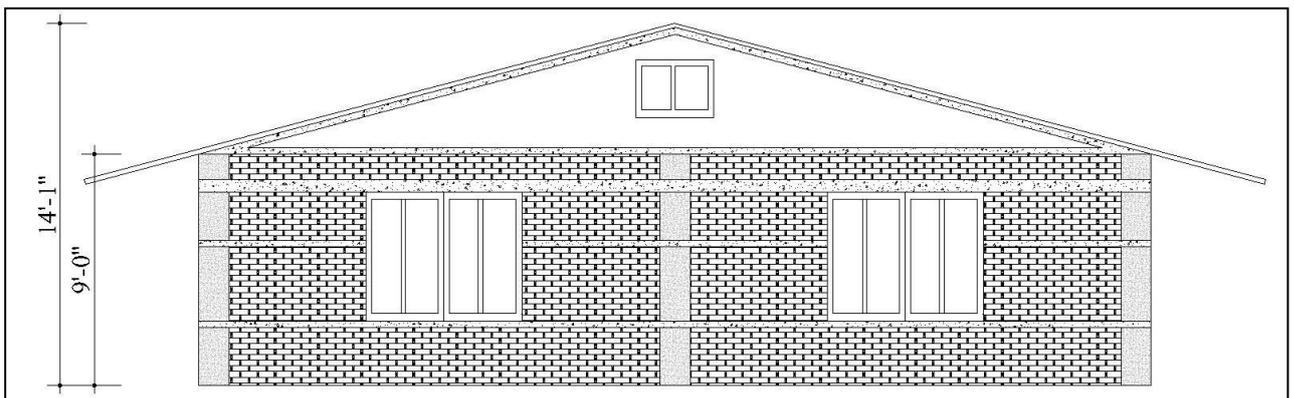


Figure 3: Side view of a general oil-processing unit

Following steps are to be followed in Oil extraction plant;

Step1: Collection, drying and storage of raw materials.

Step2: Transferring cleaned/conditioned seeds into the oil extraction machine.

Step3: Filtering the oil obtained from Oil extraction machine and storage of byproduct.

Step4: Packing of processed oil for sell and its storage.

Step4: Selling of oil.

5.1.5 Oil Extraction machine:

There are different types of oil extraction machine available in the market (i.e., China, India etc.). However, a good oil extraction mill should have following features for the ease of operation and maintenance:

- Easy and fast installation. Modular type machines are easier to assemble.
- Its weight should be as small as possible so that it can be shift from one place to another place when needed.
- Machine parts should be common and available in the market.
- Should have a simple operation procedure to reduce the people required for operation.
- Plant should have short payback time but long lasting.
- Noise and vibration produced during its operation should be less.

A common working principal of most of oil extraction machines for a small-scale oil production is shown in **Figure 4**;

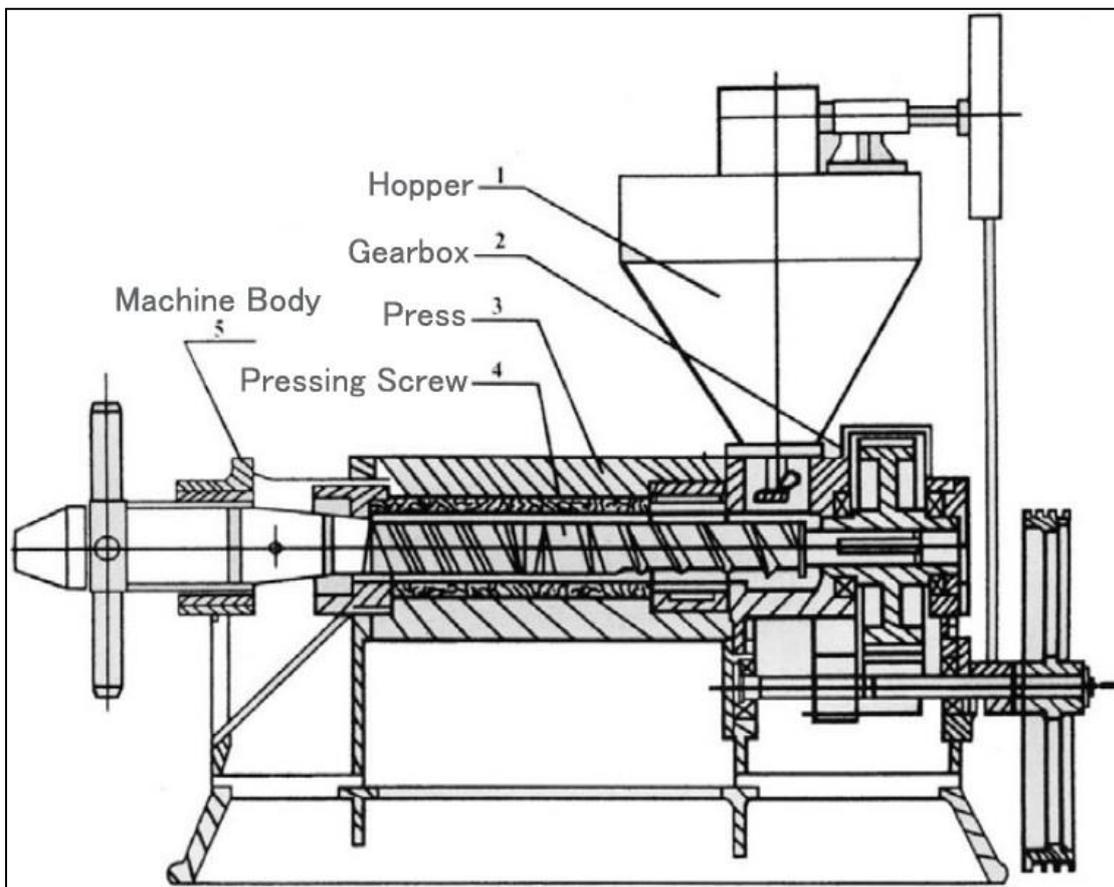


Figure 4: Oil extraction machine and working principle (Alibaba.com)

When the oil expeller is running, the processed seed enters the pressing chamber from the hopper. Screw shaft rotates in the cage, which pushes the oil materials into the pressing unit. The raw material keeps running all the time in pressing unit. Under the high pressure of pressing unit, there is a great frictional drag between the raw material and the screw shaft. When the screw shaft is rotating, it squeezes raw materials with great force and rolls over outward. Heat is produced due to high pressure and relative motion between oil material and shaft, which is utilized for breaking the molecular structure of protein in the material to improve the oil extraction rate.

5.1.6 Financial analysis:

Suitable area for cultivation of Chuli and Khamu in different districts of Karnali Province is calculated based on the survey data and species suitability map. Only 1% of the suitable area, which is very less and possible to implement is assumed as cultivation area for economic analysis. Yields from tree are based on the social survey of local people producing oil from traditional method.

Table 9: Yield from cultivation area

Description	Quantity	Unit
Area suitable for cultivation of Khamu and Chuli	5681.828	SqKM
Area surveyed	148000	m ²
No of plots surveyed	296	nos
No of trees studied	887	nos
Khamu trees	533	nos
Chuli trees	354	nos
Avg. area for the occurrence of one tree	166.85	m ²
Estimated cultivation area (1% of suitable area)	56818280	m ²
Total no of trees	340525.8	nos
No of Khamu trees	204623	nos
No of Chuli trees	135903	nos
Average yield from one Khamu tree (From survey data)		
Fruits	50	Kg
Seeds	17.5	Kg
Oil	9	Ltr
Average yield from one Chuli Tree (From survey data)		
Fruits	75	Kg
Seeds	22.5	Kg
Oil	11.5	Ltr
Total quantity of oil can be produced by Khamu from cultivation area	1841607	Ltr

Total quantity of oil can be produced by Chuli from cultivation area	1562885	Ltr
Total quantity of oil obtained	34,04,492	Ltr

5.1.6.1 Annual oil consumption in Karnali Province (study area):

Table 10: Annual oil consumption

Description	Quantity	Unit
No. of HH in Karnali province (5 study districts) (CBS)	84282	HH (No.)
Avg. oil consumption per HH per day	0.085714286	Ltr
Annual avg. oil consumption per HH	31.28571429	Ltr
Total annual oil consumption in Karnali province (5 study districts)	2636822.571	Ltr

The data of average number of Households (HHs) in Karnali Province is derived from national census 2021, and an average family of 5 (~ 4.61) members. Average price of edible refined oil in Karnali Province (study district) is 400NPR/Ltr which shows that annual expenses of Karnali Province on cooking oil is about 1,054,729,029.57 NPR. Oil extraction rate is based on the oil production from the traditional method. So, that rate can be considered as oil production from oil processing machine in the worse scenario. However, improved oil processing technology has already shown the much higher yield than that from traditional method, and the oil production rate in the best-case scenario will be much higher. If cultivation of Khamu/Chuli is done only in 1% of the suitable area and processing plant run properly, oil import in the Karnali province can be reduced to zero (the ratio of production to consumption would be 1.29). Additionally, use of local human resource from plant cultivation to oil processing can increased the employment generation of the province. The oil cake can be used as compost manure to the farmland and seed coat can be used as Charcoal. Hence it helps to minimize the public dependency to forest areas.

5.1.6.2 Expenses and returns:

If a small scale oil processing unit (one unit) is installed in a district (for example) from the available raw materials. The annual average expenses and return is calculated in Table 11, 12

and Table 13. This is just an example of how the industry will perform in a long run in a sustainable manner.

Table 11: Annual expenses and return

Initial Investment	Rate	Unit	Total Per annum/Season
Land Cost (NPR)	1000000	Initial	1000000
Building cost (NPR)	1500000	Initial	1500000
Machine Cost (NPR)	500000	Initial	500000
Total Initial investment (NPR)			3000000
Recurring cost			
Labor cost (NPR)	varied	Per month	940000
Electricity/Fuel cost (NPR)	15000	Per month	60000
Maintenance cost (NPR)	5000	Per month	25000
Cost of Mijula (NPR)	180	Per Kg	6480000
Cost of empty Bottle (NPR)	20	Per bottle	432000
Miscellaneous expenses	10000	Per month	50000
Total Recurring Cost			7987000
Return			
Oil extraction rate	400 kg	Per day	
Mijula needed in one season	36000	kg	36000
Oil yielded from one Kg Mijula	600 ml	Per Kg	
Total Oil production in one season	21600	litre	21600
Price of Oil	500	NPR	
Total return from Oil	10800000	NPR	10800000
Oil cake yielded from one Kg Mijula	0.5	Kg	
Oil Cake yielded in one season	18000	Kg	18000
Price of Oil Cake	20	NPR	
Total return from Oil cacke	360000	NPR	360000
Total Return Per Season	11160000	NPR	11160000

Table 12: Yearly net cash flow

Machine yield capacity reduction rate (%)	5.00	p.a.						
		1st year	2nd year	3rd year	4th year	5th year	6th year	7th year
Expenses per year (NPR)	10987 000	79870 00	79870 00	79870 00	7987 000	7987 000	7987 000	0
Return Per Season/year (NPR)		11160 000	10602 000	10044 000	9486 000	8928 000	8370 000	7812 000

	-							
Yearly Cash flow	10987 000	31730 00	26150 00	20570 00	1499 000	9410 00	3830 00	7812 000

Table 13: Financial indicators of the project

IRR (%)	14%
NPV at discounted rate of 15% (NPR)	1306605.36
Present value (PR) at 10% discounted rate	12424265.89
Initial Investment (NPR)	10987000
Benefit cost ratio	1.13
Payback start year	3rd year

5.1.6.3 Fixed Cost:

This project aims to change the livelihood of the province (district in which an oil processing unit is established). Therefore, permanent fundamental infrastructures are essential to diversify the livelihood sources. Cost analysis is done considering a single oil extraction machine and its production. However, more number of machines can be installed to obtain the desired quantity of oil. Since land is very cheap near agricultural area of the province, rough estimate of 1,000,000 NPR will be enough to buy the space required for building physical infrastructures. To make the construction labor intensive and environment friendly, locally available materials such as stone, mud, wood and local masons can be used. CGI sheet will be used for roof. This will generate employment and reduce the cost of construction. Quantity and cost estimate shows that 1,500,000.00 NPR is enough to construct fundamental infrastructures required for one oil extraction machine. Only oil expeller area can be enlarged if the number of oil extraction machines are increased. About 20 percent of the present cost of building construction will be increased to expand the oil expeller area for each extra extraction machine. After consulting with different international and national suppliers (*Source: Everest Tori Mill Kathmandu, Alibaba.com, Dir.Indiamart.com and myandegroup.com*), it is found that the cost of a most common oil extraction machine is 500,000.00 NPR including the transportation up to all districts in the province. Altogether the estimated fixed cost to run a single oil extraction machine is calculated to be 3,000,000 NPR.

5.1.6.4 Recurring Cost:

Costs needed each time when oil extraction machine runs are analyzed under recurring cost. Our yield is obtained from considering three months as a season to produce oil. Nevertheless, most of recurring expenses are calculated for four months to reduce the risk and provide flexibility on expenses. An unskilled labor will be hired to take care of plant throughout the year and collect Mijula and sell oil during when needed. H/She will be paid on annual basis. Four skilled labors/ operators will be hired during the production season. The estimated sum of Electricity/Fuel cost, Machine maintenance cost, Miscellaneous expenses, Labor wages, including the cost of empty bottles and Mijula for one year comes out to be 7,987,000 NPR. Chuli/Khamu are now being cultivated for the fruit only. The cost of Mijula is given higher to add the value of Chuli/Khamu and encourage local people to

cultivate Chuli/Khamu and generate employment. About 81% of total recurring cost of this project will be spend on the collection of Mijula only.

5.1.6.5. Project Return:

As it is already mentioned, yield of a single extraction machine only is considered for the financial analysis. However, project return from more than one machine would be much higher than that from a single machine, as most of the costs would not increase proportionally. Different literature reviews and product (oil extraction machine) details show that average extraction rate of a commonly used extraction machine is about 60-80 Kg/hour and its operation hour is 6-10 hours (*Source:Alibaba.com, Dir.Indiamart.com and myandegroup.com*). To reduce the possible risks, we have considered the 66.67 Kg/hour as an extraction rate of machine and 6 hours per day as production capacity of the machine. The yield of the machine is taken to be 600 ml which is 100ml more than the oil obtained from the traditional method (*Source: Mukundra Rokaya, Suvarna Simikot Khaadhya Udhyog, Humla*). If one machine runs for 3 months, the total oil production in season will be 21600 liter. Price of one liter of Khamu and Chuli's oil in Karnali Province is 500NPR per liter and it is being sold at 1400NPR in Pokhara and Kathmandu (*Source: Mukundra Rokaya, Suvarna Simikot Khaadhya Udhyog*). Oil cake is the byproduct obtained during oil extraction. It can be used as manure for agricultural products and animal feeds. Therefore, oil cake can be sold at a reasonable price (20NPR in the calculation). Total return in the first year would become 11,160,000 NPR whereas 5% deduction is made in each subsequent year as machine lose its yielding capacity with the passage of time.

To know the financial viability of the project, annual cash flow of the project is calculated for 7 years as shown in **Table 12 and Table 13** and different analyses have been made (**Table13**). The present value of the project returns at the discounted rate of 10% is 12424265.89 NPR and the net present value of the project at a discounted rate of 15% is 1306605.36 NPR. IRR of the project is found to be 14% and benefit cost ratio at a discounted rate of 10% is 1.13. Project cashflow is created in such a way that the cash inflow will be invested for the recurring cost for the next year. If no recurring expenses are invested for the next year and total cash inflow is taken as project return, the project will have the payback period of three years. Many commercial banks offer annual interest rate of 9-11% for the fixed deposit. Benefit cost ratio higher than unity at a discounted rate of

10% shows that project has better returns than that is obtained from fixed deposit. This project also creates local employment and improve the living standard of people in Karnali Province. So, the project seems feasible financially as well as socially.

5.1.7 Location criteria for oil processing industry

5.1.7.1 Feasible industrial locations:

For the feasible industrial location, following eight indicators should be taken into account. Here higher weight is given to resource base areas later followed by connectivity and power supply. All the rest of other criteria have given equal to 10 weights. With observation of the researcher's criteria, the possible assumed industrial sites have been put into the list of examinations. It is not research bias that the resource base has given much weight over the market accessibility but in order to decentralize the industrial process and development. The area near by natural habitat is the best-suited place. The weight is not given by the team to avoid bias and the entrepreneur using his or her own knowledge and experiences should give it. These indicators must be considered while establishing processing unit.

- 1) Resource base area (20)
- 2) The road accessibility (15)
- 3) Power and electricity (15)
- 4) Land availability (10)
- 5) Working manpower and nearby settlement (10)
- 6) Market proximity (10)
- 7) Regeneration and plantation areas (10)
- 8) Natural hazards and environmental safety (10)

Indicators or Feasibility Location (Example)

Table 14: Feasibility indicators examples

S.N.	Indicators	Possible District						
		Jumla	Mugu	Kalikot	Humla	Dolpa	Jajarkot	Rukum(W)

1	Resource base							
2	The road accessibility							
3	Power and electricity							
4	Land availability							
5	Working manpower and nearby settlements							
6	Market proximity							
7	Regeneration and plantation areas							
8	Natural hazards and environmental safety							
Total							Not Potential Districts	

Role of the government establishing the Khamu/Chuli processing industry and entrepreneurship;

- a) The provincial government in coordination with the federal government should do all efforts for the betterment of infrastructure such as roads, electricity, water and sewage.
- b) Local government has a major role to provide land for industrial establishments free of charge so that investors could be motivated.
- c) Local governments should focus more on small oil extraction industries and nurseries.
- d) The provincial government should fulfil the responsibility of building road links up to the industrial site, water through pipeline or pumping and safer sewage and electricity lines up to the industrial point.
- e) Tax free, low interest loan, energy subsidy etc
- f) Support constructively on environmental issues
- g) Support for marketing

5.1.8 Market analysis

Apricot kernel oil price in India is about 800-1200 IC per liter. India and China (specialy Tibet) are the major markets for Khamu/Chuli oil. Thus, its price, market and marketing process has been further analyzed in Nepal. This will be a new product in Nepal. For example, price of Khamu/Chuli oil is USD 31\$ per 100ML by salvia company at Amazon.com. Thus, competitive production cost at industrial level is important for the market and marketing of the products.

Market for essential oil's (EO) data in 2017, the worldwide production of EO's was estimated as 1,50,000 tonnes i.e. triple in volume since 1990's (Cinzia Barbieri et al, 2018). Therefore, the demands of EO's are increasing drastically in fragrance industries (29%), household (16%), food and beverages (35%), cosmetics, aromatherapy and pharmaceuticals

(15%). The demands of EO's, major leading importers and exporters are: The Netherlands, Germany, France, UK, Italy, Belgium, Spain and other European countries.

In Nepal, the Khamu/Chuli oil has been extracting in indigenous way and only some small plants have started to extract oil very recently with traditional compress/pressing technology. In previous years, the price of Khamu/Chuli oil was between 500 to 600 NPR per liter in the villages. The price of its oil in Pokhara and Kathmandu is 1400 NPR per liter including transportation.

CHAPTER: 6

6.1 Conclusion and Recommendations

6.1.1 Key findings:

- A particular study on Khamu/Chuli in Karnali province has not been carried out yet. Nonetheless, some socio-cultural references can be found.
- Approximately 568,182.8 hectares, accounting for about 26.69% of the entire land area, is identified as the most suitable region for cultivating Khamu and Chuli in the study area.
- The potential area for the Khamu and Chuli production is found higher in Jumla (53.39% i.e. 136214.6 ha) followed by Mugu (35.97% i.e. 115812.9 ha) and Kalikot (31.58% i.e. 51463.43 ha) district. Dolpa and Humla districts have the least suitable areas for production, with percentages of 10.40% (82315.37 ha) and 17.67% (105462 ha) respectively.
- However, commercial cultivation of Khamu/Chuli is not done yet because of no market potentiality. Nevertheless, the district is going to be linked with the national road network and its accessibility makes people motivated to cultivate the fruit in large scale in Karnali Province.
- Khamu/Chuli has significance in the history and life of the people living in the upper Karnali region. In this study, we found Khamu and Chuli are found in the upper hills and mountainous zones of the province, mostly in between 1500 and 3500 meter above the mean sea level.
- Average price of edible commercial refined oil in the study area is found 400NPR/Ltr, which shows that annual expenses of Karnali province (five districts) on cooking oil, is about 1,05,47,29,028.57 NPR. If cultivation of Khamu/Chuli has done only in 1 % of the suitable area and processing plant run properly, cooking oil import in the study area could reduced to zero.

- A total quantity of 34,04,492.00 liter oil could be obtained if only one percent (5682 ha) of the suitable land area is cultivated with Khamu and Chuli in the study area.
- Khamu/Chuli-based industry can help bring ample economic opportunities for many youths in the communities. The extraction of oil is cost beneficial with greater market prospects.
- Extracting oil can be sustainable in terms of environment. As we do not have to harm to tree, we can only utilize the fruit, which can be obtained in sustainable manner.
- The oil production of a single machine; that is assumed to run for 3 months in one season will be 21600 liter. Considering the sell of cooking oil and oil cake, project return in the first year would become 1,11,60,000 NPR whereas 5% deduction has made for each subsequent year assuming the reduction of machine yielding capacity with the passage of time.
- Use of local human resource from plant cultivation to oil processing can increase the employment generation of the province. The oil cake can be used as compost manure to the farmland and seed coat can be used as Charcoal. Hence it helps to minimize the public dependency to national forest areas.
- Analysis of the time value of money (Net Present Value, IRR, Benefit-cost ratio, Comparison with opportunity cost) shows that the project is financially risk free. This project has many dimensions to generate local employment and improve the living standard of Karnali Province. So, the project seems feasible financially as well as socially once it is implemented in a district as a pilot project.
- In Nepali market, the Khamu/Chuli oil extracted in indigenous way and only very recently, some small plants have started to extract oil with squeeze-based technology.
- The price of Khamu/Chuli oil was between 500 to 600 NPR per litre in the villages in previous year. The price of its oil in Pokhara and Kathmandu is about 1400 NPR

per liter including transportation. Apricot kernel oil price in India is about 800-1200 IC per litre.

6.1.2 Recommendations:

- The provincial government in coordination with the federal government should do all efforts for the betterment of infrastructure such as road, electricity, water and sewage. Building road links up to the Khamu/Chuli industrial site, water through pipeline or pumping and safer sewage and electricity lines up to the industrial point should be the major responsibility of the provincial government.
- The industry and consumer welfare office, Karnali Province should take prior responsibility for the promotion of such industry in the district. The office could support in machinery, trainings and other start-up funds to immerging entrepreneurs.
- Local governments should play a major role to provide land for industrial establishments free of charge to motivate the investors. They should coordinate the matter with the central and provincial government and the communities.
- Local governments should focus more on small oil extract industries and nurseries with incentives in the areas of mixed Khamu/Chuli.
- Tax free, low interest loans, energy subsidy should be provided by the Provincial government through the fast track.
- The provincial government should support constructively on environmental issues; For instances doing IEE, EIA
- Support for marketing of Khamu/Chuli products is necessary such as by providing free space in provincial capital, using the production in government offices etc.
- The government should provide some incentive to the farmers and community willing to plant Khamu/Chuli tree. The seedling nursery of these species can be raised and promoted in District Forest Office nurseries.

- The government should provide technological support for the traditional processing of Khamu/Chuli oil.
- The Division Forest Office or the District Industry and Consumer Welfare Office in Humla should prioritize the development of this particular oil processing industry, considering that the local community is already engaged in running such businesses. It is essential for the government to provide assistance for the technological advancement of these industries.

REFERENCES:

- Arakelyan, B. (1968). "Excavations at Garni, 1949–50", p. 29 in Contributions to the Archaeology of Armenia. Henry Field (ed.).
- Davidson, Alan (1999). The Oxford Companion to Food (1 ed.). Oxford: Oxford University Press. p. 588. ISBN 0-19-211579-0.
- DCC, Karnali Province
- DIO, Karnali Province (district irrigation office)
- Dir.Indiamart.com
- Everest Tori Mill Kathmandu, Nepal
- Guo, Cai-ru & Wang, Zhen-long & Lu, Ji-qi. (2010). Seed germination and seedling development of *Prunus armeniaca* under different burial depths in soil. Journal of Forestry Research. 21. 492-496. 10.1007/s11676-010-0104-1.
- <http://headnepal.org>
- [http://www.fruitipedia.com/CHULLI APRICOT_Prunus spp.](http://www.fruitipedia.com/CHULLI%20APRICOT_Prunus%20spp)
- <https://chat.openai.com>
- [https://dccKarnali Province.gov.np/ne-brief-introduction](https://dccKarnaliProvince.gov.np/ne-brief-introduction)
- https://en.wikipedia.org/wiki/Prunus_armeniaca#/media/File:ArmenianStamps-407.jpg
- [https://www.amazon.com/KERNEL-Prunus-persica-Carrier Salvia/dp/B07HNF4NXX](https://www.amazon.com/KERNEL-Prunus-persica-Carrier-Salvia/dp/B07HNF4NXX)
- <https://www.balkep.org/prunus-persica.html>
- Jimenez-Lopez, C.; Carpena, M.; Lourenço-Lopes, C.; Gallardo-Gomez, M.; Lorenzo, J.M.; Barba, F.J.; Prieto, M.A.; Simal-Gandara, J. Bioactive Compounds and Quality of Extra Virgin Olive Oil. Foods 2020, 9, 1014. <https://doi.org/10.3390/foods9081014>
- Jump up to: a b c Geissler, Catherine (2009). The New Oxford Book of Food Plants. Oxford: Oxford University Press. p. 82. ISBN 978-0-19-160949-7.
- Knörzer, KH. 3000 years of agriculture in a valley of the High Himalayas. Veget Hist Archaeobot 9, 219–222 (2000). <https://doi.org/10.1007/BF01294636>

- Layne, Desmond R.; Bassi, Daniele (2008). *The Peach: Botany, Production and Uses*. CAB International. ISBN 978-1-84593-386-9.
- myandegroup.com
- openjicareport.jica,NIT Report
- Rabindra Roy, Dietrich Schmidt-Vogt, Olav Myrholt "“Karnali Province Development Initiatives” for Better Livelihoods in the Face of Isolation and Conflict," *Mountain Research and Development*, 29(3), 211-219, (1 August 2009)
- Rafiq Ahmed Shah, Arti Sharma , V.K. Wali, Amit Jasrotia and Madhvi Plathia Division of Fruit Science, Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu, Chatha 180009, J&K, *Indian J. Hort.* 70(4), December 2013: 591-594
- Singh, Akath; Patel, R.K.; Babu, K.D.; De, L.C. (2007). "Low chilling peaches". *Underutilized and underexploited horticultural crops*. New Delhi: New India Publishing. p. 90. ISBN 978-81-89422-69-1.

Annex I: Questionnaire

Questionnaire for "Feasibility Study of the Khamu/Chuli production & processing Industry"

Supported by: Forest Research and Training Center, Karnali province

Research by: Alpine Nature Services Pvt. Ltd., Birendranagar, Surkhet

Name of Key informant:

District:

Municipality/Rural Municipality:

Ward No.:

Tole Name:

Responsibility:

Contact No.: If H/She agree

(Key informants: People's representatives of local level, representatives of community forest user group, local leader, local Medicine men/women, people who know about Khamu/Chuli)

1) Historical, cultural and religious aspect of Khamu/Chuli:

What kind of works was Khamu/Chuli used for traditionally and culturally?

- i. How many years may it take for a Khamu/Chuli tree for fully growing up and what may be its life-span?
- ii. Are there any old Khamu/Chuli trees in this place? Could you tell us about these trees?
- iii. Share the information if you have any.
- iv. What is Khamu/Chuli found here called in local language?

2) Socio-economic aspect

- i. Are there communities or people who survive by selling Khamu/Chuli oil, etc.?
- ii. What is the market value of Khamu/Chuli based oil, etc. in different places?
Such as: Per liter price at the place of production.....
Oil per Liter price in Nepalgunj.....oil per liter price in India.....

3) Location of Khamu/Chuli

- i. In which places Khamu/Chuli are found mostly?
- ii. How much area of forest/farmland, Khamu/Chuli has occupied approximately?
- iii. How far is Khamu/Chuli farmland from the road? How far is nearest settlement?
How many people reside here? Name of the village? Name of the surrounding settlements?
- iv. Do these settlements have access to road, electricity and water facilities?
- v. Do we have other varieties of Khamu/Chuli too?
- vi. What type of environment is this variety suited to? (Southern side/moist land/dry sunny place etc.)

4) Use of Khamu/Chuli

- i. How was/is Khamu/Chuli oil processed? What is it used for?
- ii. What are the medicinal properties of Khamu/Chuli? What kind of medicine are made from its wood, bark and leaf?
- iii. What is the price of other essential oil?

5) Sustainability and Environmental aspect

- i. What is the past and present situation of Khamu/Chuli? Has it been decreasing now than it was before?
- ii. What is the possibility of developing Khamu/Chuli forests from afforestation programs?
- iii. Is there any nursery established for growing Khamu/Chuli? Is there any culture of planting Khamu/Chuli trees?
- iv. Which place could be appropriate for the Khamu/Chuli nursery?

6) Industry Trade

- i. Are there any domestic or cottage industries to produce other products by using Khamu/Chuli at local level?
- ii. Was Khamu/Chuli oil exported to Tibet?

- iii. If there any are domestic or cottage industries, in which place and who operates them?
- iv. What was the business purpose of Khamu/Chuli? (Local level, within the country and abroad)?
- v. How much income is made from the business of Khamu/Chuli products?
- vi. What kind of industry can be made from Khamu/Chuli at present?
- vii. In which place can such industry be built?

7) Policy-level arrangements

- i. What kind of works has been done by the Local Level and District Forest Office for the protection and industry of Khamu/Chuli?

Date:

Annex II: Field photo snaps



Photo 8: Discussing with farmers about Khamu and Chuli at Dadafaya, Humla



Photo 7: Interaction with farmer



Photo 10: People collecting Chuli in Mugu



Photo 9: A Khamu/Chuli farm in Jumla



Photo 12: Khamu Blossoms in Dolpa

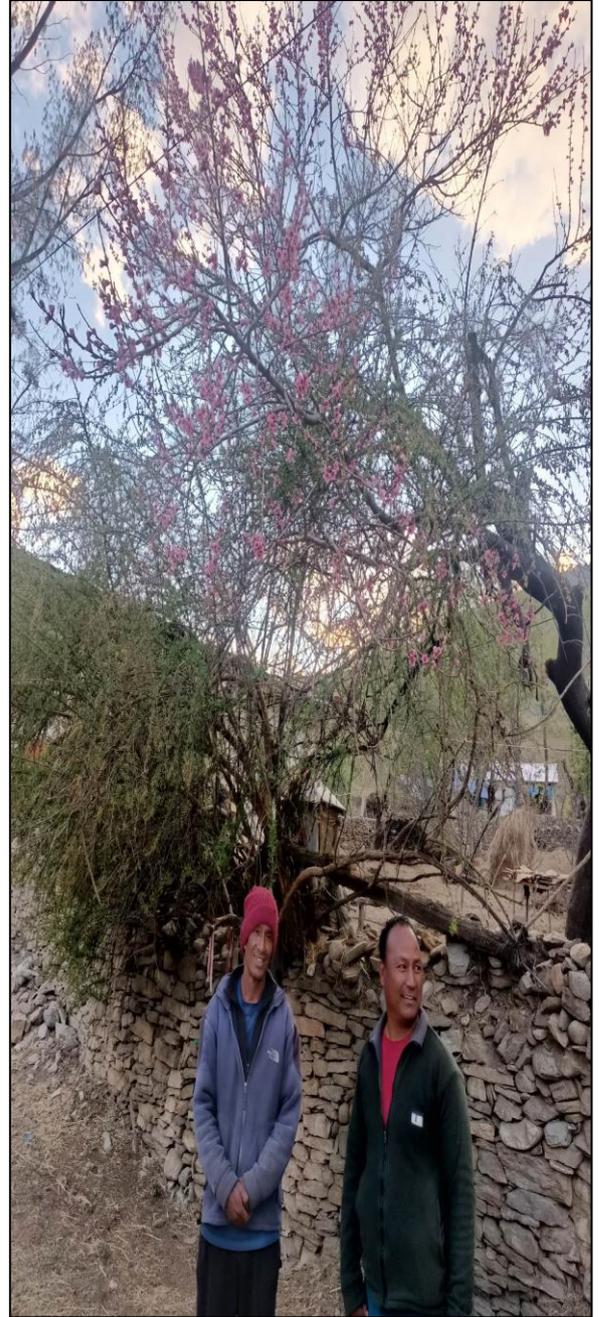


Photo 11: Interaction with locals in Jumla



Photo 15: Khamu tree with fruits near Chilkhaya, Kalikot



Photo 14: Old Chuli tree in Kalikot



Photo 13: A typical fruit farm in Kalikot



Photo 17: Khamu tree at 2598 meter altitude



Photo 16: Analysing tree morphology of Khamu at Pialgaun, Jumla



Photo 18: Traditional oil processing unit



Photo 21: Seed (Mijula) collection at industry



Photo 20: Khamu fruit



Photo 19: Khamu Oil



Photo 22: Aaru farm near Jumla headquarter

“THANK-YOU”