Final Report

Feasibility Study on Production, Cultivation and Processing of Sea Buckthorn in Karnali Province

Submitted to

Karnali Province Government

Ministry of Industry, Tourism, Forests and Environment

Forest Research and Training Center

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Submitted by

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June, 2024

Abstract

Medicinal and aromatic plants contribute remarkably on economy of local people and government in Karnali Province, Nepal. Sea buckthorn (*Hippophaerhamnoides*) is identified as valuable non timber forest products of this province for long time. It has medicinal and nutrition value. Riverbank of High Mountain are suitable habitat of this species. This study was conducted to analyze the feasibility on production, cultivation and processing of sea buckthorn in Karnali Province, Nepal. First of all, this study collected the information from staff of Division Forest Offices, collectors and local traders to know the potential habitats, existing harvesting practices and marketing status of the sea buckthorn in Karnali Province. Then filed visit survey was conducted to understand the ground reality about the sea buckthorn. Moreover, presence locations were collected for the habitat suitability modeling. Although, field survey was concentrated to Jumla and Kalikot Districts, information was collected from whole province for this study.

Climate-related, topography-related, vegetation-related, and human-related variables were collected from open sources. Maximum Entropy (MaxEnt) software was used to model the distribution/suitable habitat of this species. Furthermore, the jackknife and response curves were used to identify the influencing environmental factors to the habitat suitability of the sea buckthorn. This study identified 212.11 km^2 area as distribution area/suitable habitat of this species in Karnali Province. Riverside of

Jumla, Humla, Mugu, Dolpa, and Kalikot Districts are best habitat of the sea buckthorn. Distance to water, annual mean precipitation, annual mean temperature, and elevation are influencing the habitat suitability of sea buckthorn in the study area. Production, cultivation and processing are identified as feasible in this province but it requires the effective and smart management. Distribution of tents to collected the sea buckthorn berries and buyback guarantee of collected products are recommend for the effective conservation, harvesting and marketing of the sea buckthorn products

Acknowledgement

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1. Introduction

1.1 Background

Sea buckthorn (*Hippophaerhamnoides* L.) is a plant with various nutritional and medicinal properties. It contains vitamins, carotenoids, polyphenols, fatty acids, and phytosterols, which have antioxidant, anticancer, anti-hyperlipidemic, anti-obesity, anti-inflammatory, antimicrobial, antiviral, dermatological, neuroprotective, and hepatoprotective effects(Dubey et al., 2023). Sea buckthorn can be used as a functional food or a dietary supplement for the prevention and treatment of chronic diseases. Similarly, sea buckthorn and its bioactive ingredients may have potential in the management of gynecological problems such as uterine inflammation, endometriosis, and easing symptoms of vulvovaginal atrophy in postmenopausal women (Mihal et al., 2023). It is a pioneer tree species for soil improvement, wind and sand control, and soil and water conservation (Wang et al., 2022).

This hardy shrub, often found in the cold, arid regions of Europe and Asia, is treasured for its bright orange berries, which are a rich source of vitamins, antioxidants, and essential fatty acids. The berries are particularly high in vitamin C, making them a powerful immune booster and a natural remedy for combating oxidative stress. Additionally, sea buckthorn oil, extracted from both the fruit and seeds, is celebrated for its skin-healing properties. Anti-inflammation is the most important applicable ingredient of this miracle berry (Ahani & Attaran, 2022). It is frequently used in

skincare products to treat conditions such as burns, eczema, and wounds, thanks to its anti-inflammatory and regenerative effects. Beyond its health benefits, sea buckthorn also plays a crucial role in environmental conservation. Its robust root system helps prevent soil erosion, and the plant itself acts as a windbreak in fragile ecosystems. Furthermore, this species can also be used in human and animal nutrition (Christaki, 2012). The increasing popularity of natural health supplements and organic skincare has sparked a surge in demand for sea buckthorn, prompting sustainable cultivation practices to meet this growing interest. As research continues to unveil its diverse benefits, sea buckthorn is poised to become a cornerstone of natural health and environmental sustainability.

Sea buckthorn production in Karnali Province, Nepal, presents a unique set of challenges that affect the cultivation, harvesting, and marketing of this valuable plant. Despite its potential as a source of economic growth and sustainable agriculture, several issues hinder its full development in the region.

Firstly, the rugged terrain and remote locations of Karnali make sea buckthorn cultivation difficult. The lack of proper infrastructure, such as roads and irrigation facilities, limits access to optimal growing areas and makes it challenging to transport harvested berries to processing centers. This isolation also means that farmers often rely on traditional farming techniques that may not maximize the plant's yield or quality.

Secondly,harvesting sea buckthorn is labor-intensive and time-consuming. The plant's thorny branches and the high altitude at which it grows pose significant physical challenges to workers. Inadequate harvesting equipment and techniques further reduce efficiency and increase the risk of injury to laborers. Moreover, the seasonal nature of the harvest means that labor must be mobilized quickly and effectively, which can be problematic given the limited availability of skilled workers in the region.

Thirdly, the post-harvest handling of sea buckthorn berries is fraught with difficulties. The berries are highly perishable and require careful handling to prevent spoilage and maintain quality. The absence of adequate storage and processing facilities leads to significant post-harvest losses. Additionally, a lack of training in post-harvest management results in improper handling, which compromises the berries' quality and reduces their market value.

Finally, the marketing of sea buckthorn in Karnali faces substantial obstacles. The remoteness of the province hinders access to larger markets, both domestic and international, making it difficult for farmers to sell their produce at competitive prices. Limited market awareness and insufficient promotion of sea buckthorn products also contribute to lower demand. The absence of organized market structures and support systems, such as cooperatives or associations, exacerbates these challenges, leaving individual farmers with little bargaining power and limited opportunities to scale up production.

1.2 Objective

The general objective of the study was to conductfeasibility study on production, cultivation and processing of sea buckthorn in Karnali Province. Objectives were categorized into four categories as follows

- ➢ To assess the ecological suitability of sea buckthorn: to investigate the environmental and climatic conditions of Karnali Province to determine the compatibility of sea buckthorn cultivation.
- ➢ To analyze the economic feasibility: to evaluate the financial viability of investing in sea buckthorn production, considering initial costs, operational expenses, and potential returns.
- ➢ To analyze market: Examine current market dynamics, identify consumer preferences, and assess the demand for sea buckthorn-based products at local, regional, and national levels.
- ➢ To identify sustainable practices: to propose environmentally sustainable cultivation and processing methods to ensure minimal ecological impact and long-term viability.

1.3 Rationale of the study

The rationale behind conducting a feasibility study on the production, cultivation, and processing of sea buckthorn in Karnali Province, Nepal, is multifaceted. Firstly, Karnali Province, characterized by its unique geographical and climatic conditions, presents an ideal environment for the cultivation of sea buckthorn, a hardy plant known for its adaptability to harsh terrains and high altitudes. Sea buckthorn, with its rich nutritional and medicinal properties, holds significant potential for both local consumption and export, thereby contributing to the regional economy. The feasibility study aims to assess the viability of establishing a sustainable sea buckthorn industry in this underdeveloped region, which could lead to increased agricultural diversity and income opportunities for local farmers. Additionally, sea buckthorn cultivation and processing can promote environmental sustainability by preventing soil erosion and enhancing soil fertility, thus aligning with the goals of sustainable development. The study will also evaluate the market potential, cost-benefit analysis, and logistical considerations, ensuring that any proposed initiatives are economically viable and beneficial for the local community. Ultimately, this feasibility study seeks to provide a comprehensive understanding of the opportunities and challenges associated with sea buckthorn cultivation in Karnali, paving the way for informed decision-making and strategic planning to harness the economic and ecological benefits of this valuable crop.

1.4 Limitation of the study

Despite its comprehensive approach, this study on the production, cultivation, and processing of sea buckthorn in Karnali Province, Nepal, faces several limitations that may affect the breadth and applicability of its findings. First and foremost, the study is restricted by limited access to detailed and up-to-date local data, which is crucial for accurately assessing the region's potential and market dynamics. The geographical remoteness and rugged terrain of Karnali make field data collection challenging, potentially leading to incomplete or less representative data. Furthermore, the study's focus on a specific timeframe may not account for seasonal and long-term climatic variations that significantly impact productivity and feasibility.

Additionally, the study's reliance on existing literature and secondary data sources may introduce biases and limit the depth of insights, as these sources might not fully capture the current on-ground realities or the socio-economic context unique to Karnali. There are also inherent challenges in projecting future market conditions and economic viability, especially in a region where infrastructure and market access are underdeveloped and subject to rapid changes.

Moreover, the study does not extensively cover the social and cultural factors that could influence local community acceptance and participation in sea buckthorn cultivation and processing.

Albeit, this the common level review, greater part of biophysical and information were gathered from Jumla and Kalikot Regions. Additionally, the majority of field visits for the social survey were made to these districts. Phone interviews and other indirect sources were used to gather information from other districts. The required data were analyzed from divisional forest office annual reports and other study reports. For the purpose of the study, collectors and traders of the sea buckthorn were the subjects of indirect interviews.

This study was led with exceptionally restricted financial plan so information were gathered from a few piece of the region and just some local area. Another constraint was the restriction on time. This study was unable to obtain multi-season field data due to time constraints. During the pre-monsoon season and the spring, field data were collected for this study. Sincerely, this season is not ideal for collecting field data for sea buckthorn. As a result, the information pertaining to the seasonal variation could not be gathered by this study.

2. Study area

2.1 Location of Karnali Province

Karnali, Nepal's largest province, covers an enormous 30,211 km^2. It consists of ten districts: Dailekh, Dolpa, Humla, Jajarkot, Jumla, Kalikot, Mugu, Rukum (west), Salyan, and Surkhet. It is bounded by Lumbini Province to the southeast and south, Sudurpashchim Province to the west, and the Tibet Autonomous Region of China to the north. (**Figure 1**). Whole Karnali Province is the study area of this study.
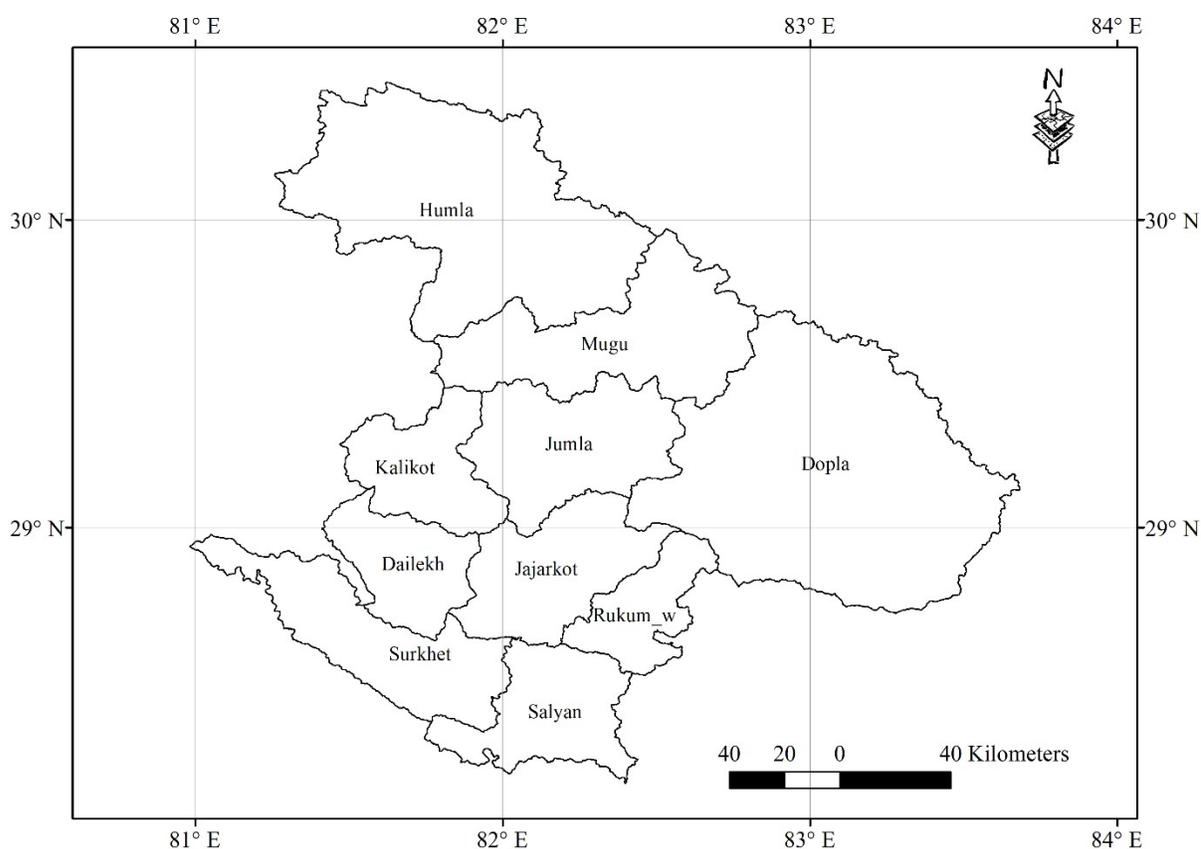
Figure 1: Karnali Province

2.2 Elevation

The Karnali Province has a wide range of elevations. Digital elevation model (elevation of the 30 m X 30 m pixel value) covers this province from 214 m to 7, 318 m. **Figure 2** depicts the province's low and high elevations in the southern and northern regions. The most noteworthy pinnacle point of the Region is ChurenHimal (7348 m). Limi Valley is located above 4,000 meters in the province's Humla District.
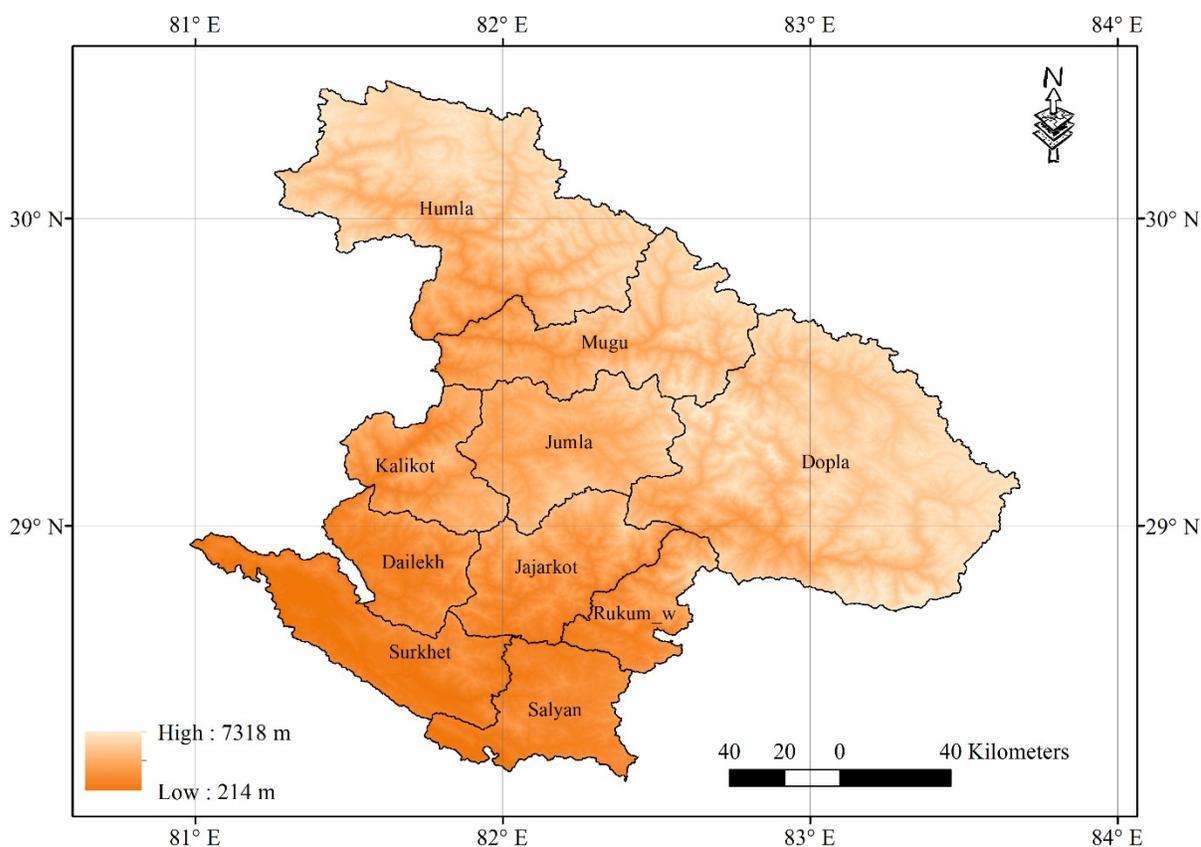
Figure 2: Elevation range of Karnali Province

2.3 Slope

Karnali Province has a variety of slopes from 86.84 degrees to flat ground (**Figure 3**). The Surkhet District is primarily made up of flat ground. The province's northern slope is getting steeper.
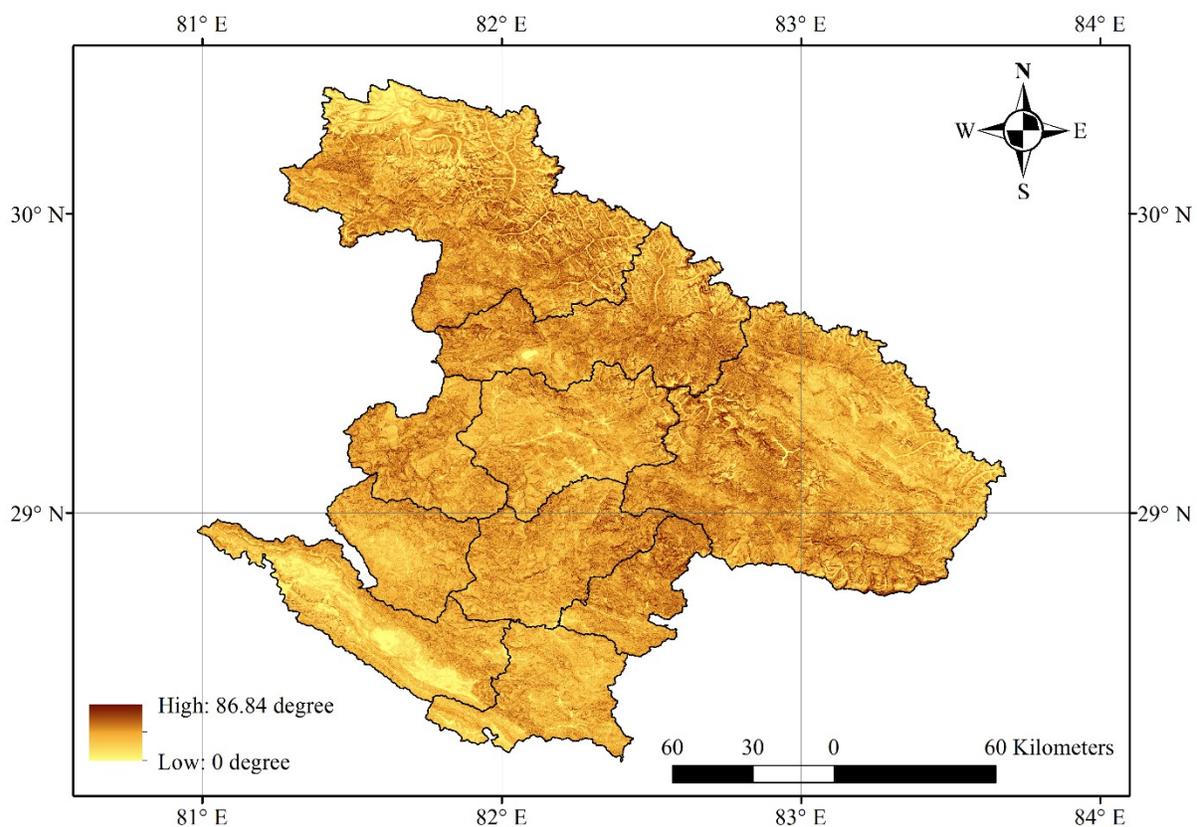
Figure 3: Slope range of Karnali Province

2.4 Climate

This province has a diverse climate due to its wide range of elevations. The province's annual mean temperature ranges from -25.26 to 23.88 degrees Celsius (**Figure**

4).Surkhet and Salyan Districts are hotter than other district. Upper part of the province is very cold.
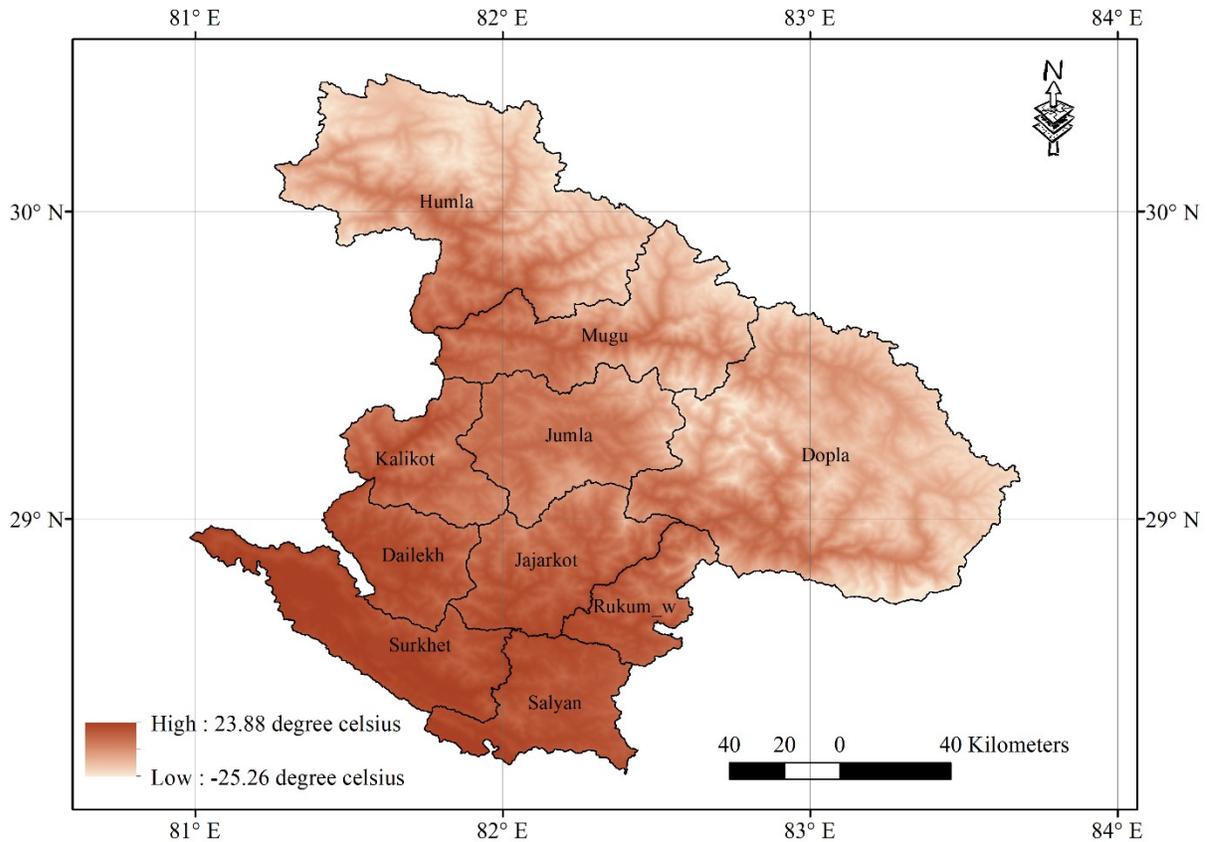
Figure 4: Annual mean temperature of Karnali Province

Moreover, the precipitation of the Karnali Province is also very diverse. Karnali Province is drier province. The precipitation received by this province is below the national average. Annual mean precipitation of this province range from 270 mm to 1,650 mm (**Figure 5**).
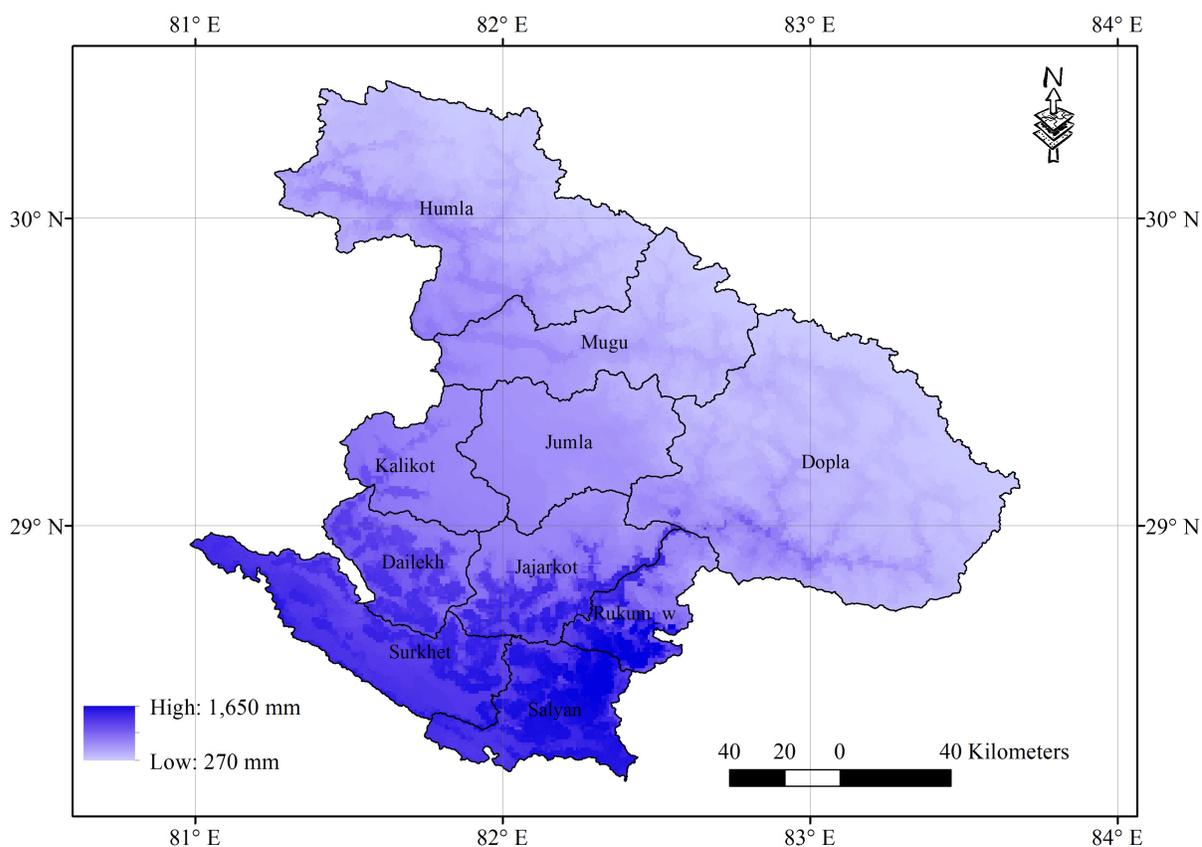
Figure 5: Annual mean precipitation of Karnali Province

2.5 River / stream / waterways

Karnali Province is rich in rivers and streams. Karnali, HumlaKarnali, MuguKarnali, SaniBheri, ThuliBheri, Seti, Budhiganga and Tila are famous rivers of this province. Waterways of Karnali Province are shown in figure 6.
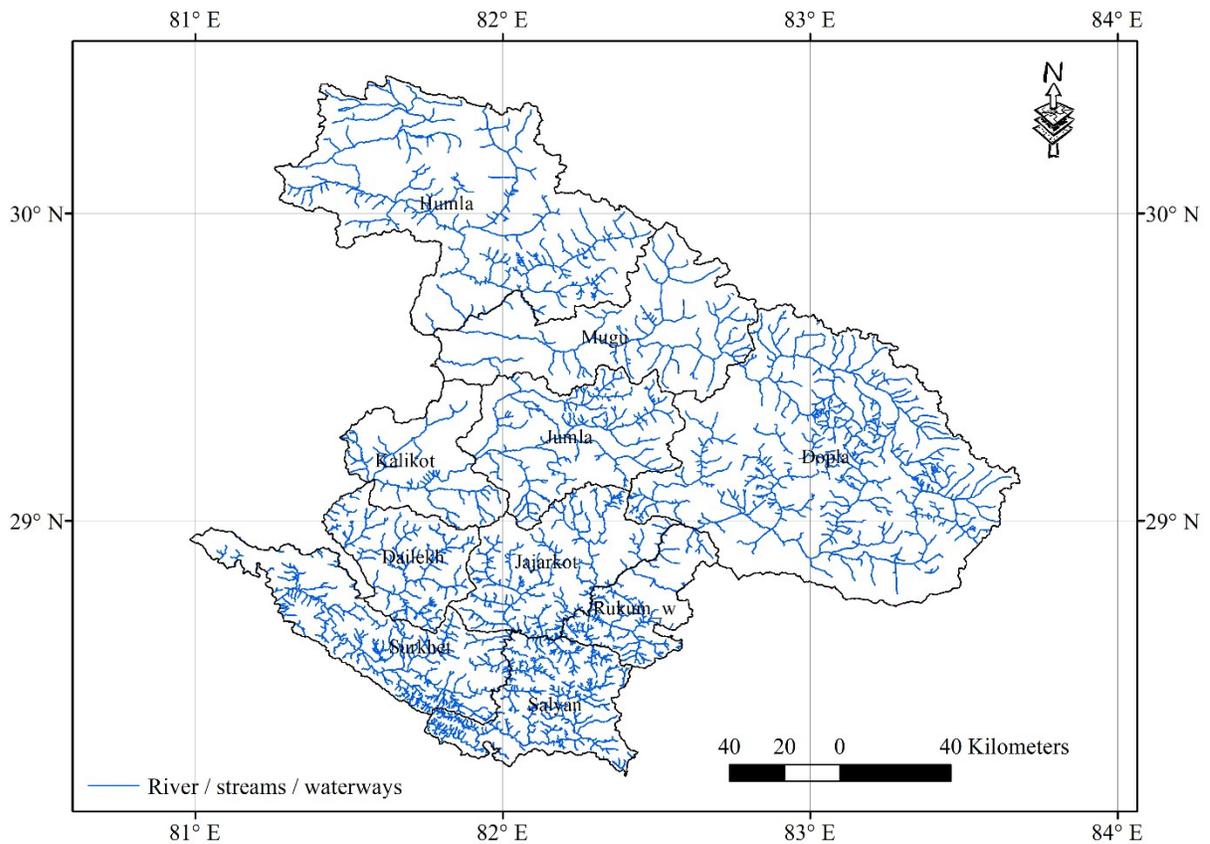
Figure 6: Rivers / streams / waterways of Karnali Province

2.6 Road network

Karnali Province is developing province of Nepal. In comparison to other provinces, it is less developed province in terms of infrastructure development. Similarly, this province has poor red network. Only few kilometer road is constructed in Dolpa, Humla and Mugu Districts. Surkhet, Salyan, Dailekh and Rukum West has good road network (**Figure 7**).
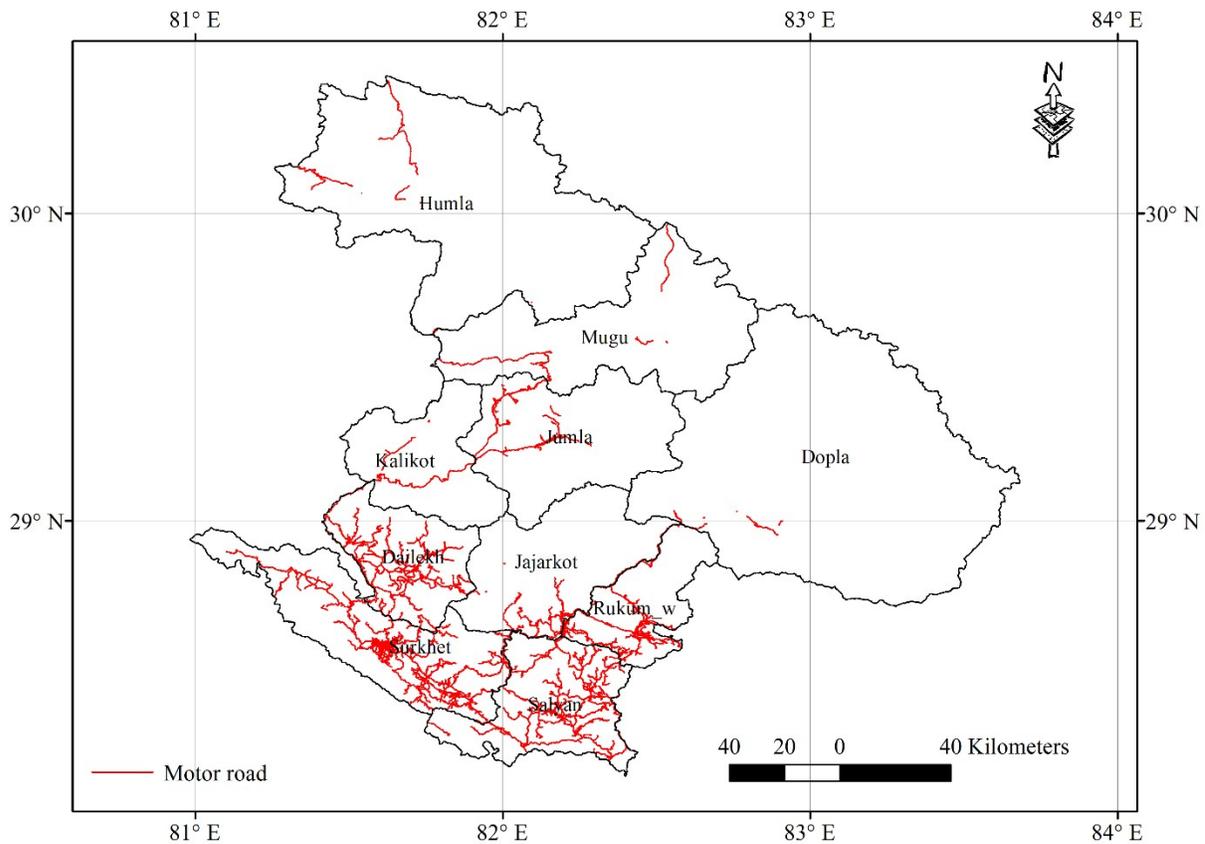
Figure 7: Road network of Karnali Province

2.7 Land use land cover

This province is covered by vegetation, shrub land, grassland, snow/glacier and other type of land cover.More than half the province's land surface (51%) is covered by vegetation, which includes forest (30%), shrub land (3%) and grassland (18%) (Acharya & Paudel, 2020; Uddin et al., 2015). Most of the area is covered by snow/glacier and bare area in upper parts of the province (**Figure 8**). Lower parts of this province is covered by agriculture lands and broadleaved forests. Needle leaved forest are presented in the middle parts of the province.
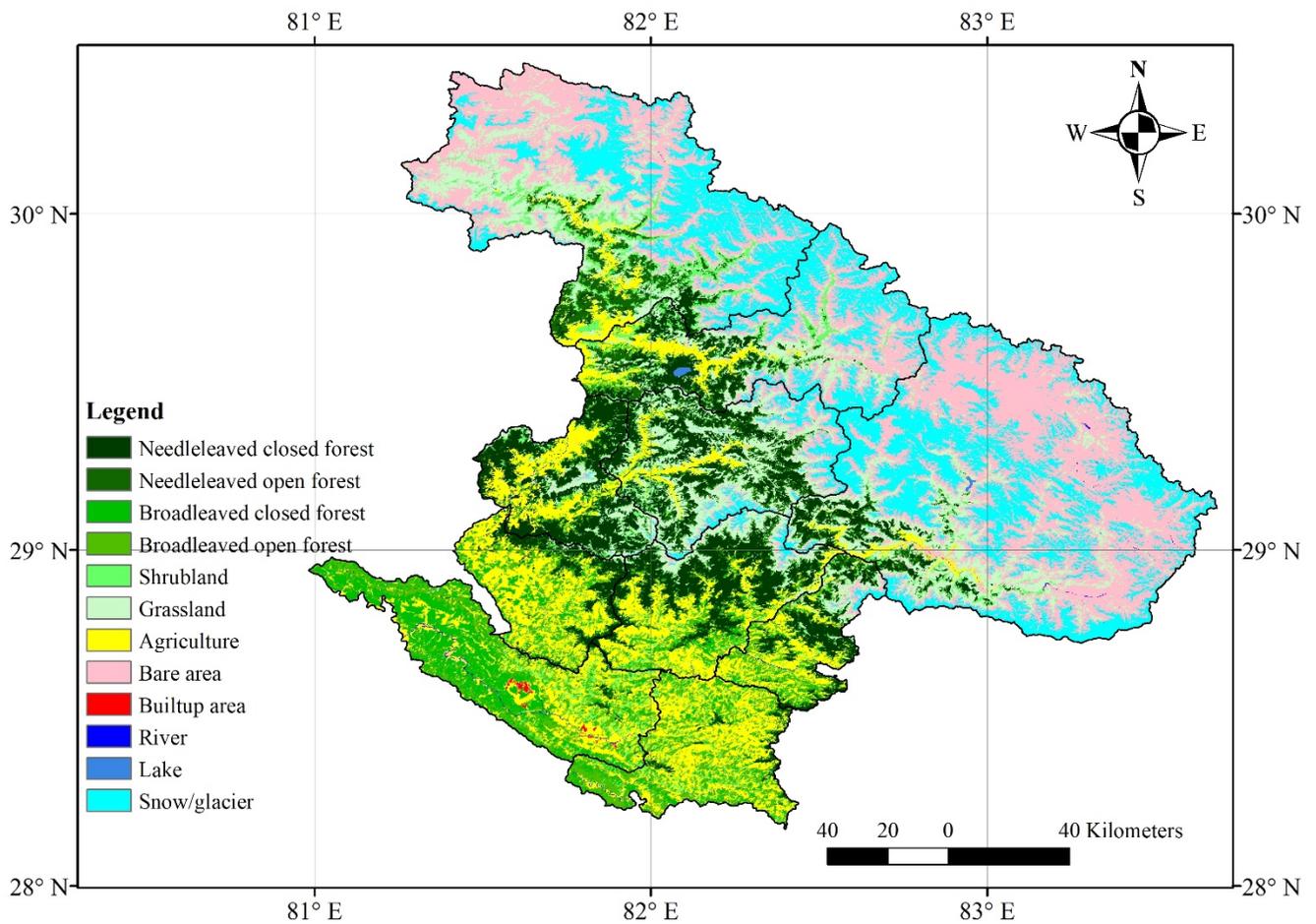
Figure 8: Land Cover of Karnali Province
©ICIMOD/Uddin et.al.2015.

2.8 Forest cover

The province's Humla, Mugu, and Dopla Districts have little forest cover. Nonetheless, the districts of Surkhet and Salyan have comparatively more forest cover. The forest cover in the remaining districts is moderate (**Figure 9**).
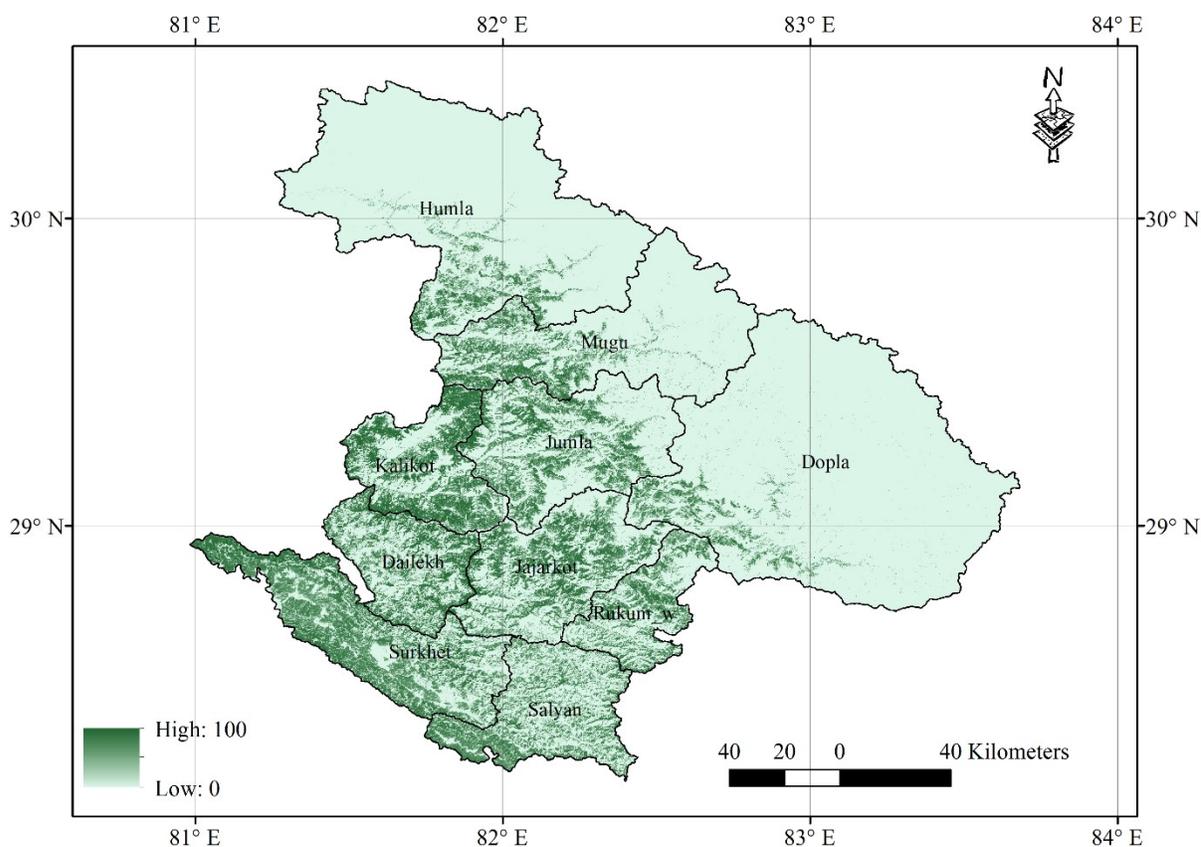
Figure 9: Forest cover of Karnali Province

2.9 Medicinal and aromatic plants (MAPs) of Karnali Province

MAPs in KarnaliProvince created monetary result identical to NPR 160738 million (USD 1.39 billion) or 1.03% of Gross domestic product of KarnaliProvince and 0.02% of the Gross Domestic Product of Nepal in the financial year 2019/2020 (Aryal et al., 2023). According to Raut et al., (2022)the Karnali and Far West Provinces account for 46% and 50% of Nepal's Ganoderma, respectively. Besides, wild morels

(*Morchella*spp.) are commercially harvested and extensively exported from west Nepal, particularly Karnali Province, which accounts for 58% of the nation's output (Raut et al., 2019).

3. Materials and methods

3.1 Data collection

3.1.1 Collection of presence points

First of all, possible habitats of sea buckthorn were identified by the help ofstaffs of the Divisional Forest Offices, member of the community forests users groups, key informants, collectors and traders. The study team visited all potential habitats of this species during the spring to pre-monsoon season of 2024 throughout the study area. The study team conducted intensive survey in Jumla and Kalikot Districts. Global Positioning System (GPS) points, photos and other details of sea buckthorn were collected during the field survey.

3.1.2 Collection of social information

Through consultation with Divisional Forest Office staff, community forest users, key informants, collectors, and traders, potential habitats for the sea buckthorn plant were identified. Then, these region were visited to gather the accompanying data connected with

➢ Location of habitat of sea buckthorn

➢ Suitable habitat type and climate for this species

➢ Collection season of this species

➢ Uses of this species

➢ Existing practices of collection of sea buckthorn fruits/berries

- Cost and time for sea buckthorn plantation

- Problems related to the harvesting of sea buckthorn fruits/berries

- Cost to establish factory to process the sea buckthorn fruits/berries

- Marketing status of sea buckthorn fruits/berries and other products derived from it

- Existing practices and problems associated with marketing of sea buckthorn fruits/berries and other products derived from it

- Economic contribution of this species in national and local economy

3.1.3 Collection of environmental variables for modelling
3.1.3.1 Climate-related variables

The most significant factor in the plant species' distribution is the climate. For this study, climatic factors were downloaded from the WorldClim data set (http://worldclim.org/). For the purpose of modeling, annual mean temperature and annual mean precipitation were used (**Table 1**).

3.1.3.2 Topography-related variables

The Digital Elevation Model (DEM) with a resolution of 30 meters was downloaded from the USGS website (https://earthexplorer.usgs.gov/). ArcGIS software was used to calculate slope and aspect from the DEM (ESRI, 2017). Furthermore, the Geofabrik website (https://www.geofabrik.de/data/shapefiles.html) served as the source for the shapefiles of waterways. The ArcGIS software was then used to create the distance

raster file (ESRI, 2017). The topographical variables were used for the habitat modeling of the species for 20 years (Osborne et al., 2001).

3.1.3.3 Vegetation-related variables

The distribution of any plant species is determined by factors related to the vegetation. For example, a few species categories are light demanders, while others are shade demanders. Therefore, robust modeling necessitates the inclusion of vegetation-related variables to predict this species' habitat and distribution.

For the purposes of modeling, this study used of the Enhanced Vegetation Index (EVI) and forest cover. Forest cover prepared by Hansen et al. (2013) was downloaded from the Global Forest Change (GFC) website and used for the modeling. Also, EVI time-series information for 2018 and 2019, from images acquired via Landsat 8 were utilized for the modelling. The EVI was determined/refined with the assistance of the Google Earth engine.

3.1.3.4 Human-related variables

This study incorporated human-related variables into the model. Human-related variables were distance to roads (used by vehicle), distance to settlement, and land use. The shapefile of roads were obtained from the Geofabrik website (https://www.geofabrik.de/data/shapefiles.html).Similarly location of settlement were obtained from Department of Survey, Nepal. Distance raster files of roads

andsettlement were created using ArcGIS (ESRI, 2017). Land cover and land use (LULC) data were downloaded from the International Centre for Integrated Mountain Development website (ICIMOD; http://www.icimod.org) (Uddin et al., 2015) and used for modelling purpose.

Table 1: Environmental variables for modelling the suitable habitat of seabuckthorn

Source	Category	Variable	Abbreviation	Unit
WorldClim	Climate-related	Annual mean temperature	mean_temperature	Degree centigrade
		Annual mean precipitation	mean_precipitation	cm
USGS	Topography-related	Elevation	elevation	m
		Slope	slope	Degree
		Aspect	aspect	Degree
GEOFABRIK		Distance to water	dist_water	m
Landsat	Vegetation-related	Annual mean EVI	mean_evi	Dimensionless
GFC		Forest cover	Forest	Dimensionless

		Distance to motor road	dist_motord	m
GEOFABRIK				
Department of Survey	Human-related	Distance to settlement	dist_build	m
ICIMOD		Land use/land cover	lulc	m

3.2 Data analysis

3.2.1 Modeling the suitable habitat of sea buckthorn

Using species occurrence points and environmental variables, the Maximum Entropy (MaxEnt) was used to predict the species' distribution (Elith et al., 2006; Phillips and others, 2006). This is an established and widely used tool for predicting the distribution of the species in Nepal (Aryal et al., 2016; Bista et al., 2018; Karki & Panthi, 2021; KC et al., 2019; Panthi et al., 2019; Sharma et al., 2020; Shrestha & Bawa, 2014; Thapa et al., 2018). Ten replicates and 1000 background points were used in the modeling to model (Barbet-Massin et al., 2012) the sea buckthorn distribution in Nepal's Karnali Province.

3.2.2 Accuracy assessment of the model

An essential step in validating the models and comprehending their performance is the accuracy assessment. For the purpose of modeling this species, 30% of the occurrence points of sea buckthorn were used as a testing or validation dataset, while 70% of the occurrence points were allocated for the training dataset. The two approaches were used to evaluate the models. There was a threshold-independent and threshold dependent methods. In the threshold independent method, the area under the receiver-operator curve (AUC) of models was obtained directly from the model (Phillips et al., 2006; Wiley et al., 2003). Model performance (discrimination capacity) increases with the AUC. The AUC <0.7 denotes poor model performance, 0.7–0.9 denotes moderately useful model performance, and >0.9 denotes excellent model performance (Pearce & Ferrier, 2000). Although AUC is a classical and widely used model evaluation parameter, it is criticized by researchers (Lobo et al., 2008). Therefore, threshold-dependent accuracy evaluation: For the purpose of evaluating the model, True Skill Statistic (TSS) and Kappa were calculated (Merow et al., 2013). The worth of TSS (TSS Sensitivity + Specificity − 1) ranges from - 1 to 1, where esteems under 0 demonstrate a presentation no better than random and 1 shows an ideal attack of the model (Allouche et al., 2006).Similarly, higher the Kappa, better the model performance is. TSS and Kappa were determined for all model results (0-9 replications), and the averages were calculated (Jiang et al., 2014; Panthi et al., 2019). The threshold to maximize the sum of sensitivity and specificity was used to calculate

the TSS and Kappa and transform the MaxEnt model's continuous probability map into a binary suitable/unsuitable map (Liu et al., 2013).

4. Results and discussion

4.1 Distribution / habitat suitability of sea buckthorn

Result of the MaxEnt model showed that riverside ofJumla, Humla, Mugu, Dolpa, Kalikot District are best habitat of the sea buckthorn (**Figure 10**). Riverside of Rukum West, Jajarkot and Dailekh Districts are less suitable habitat of this species. There is no any suitable habitat in Surkhet and Salyan Districts of Karnali Province.
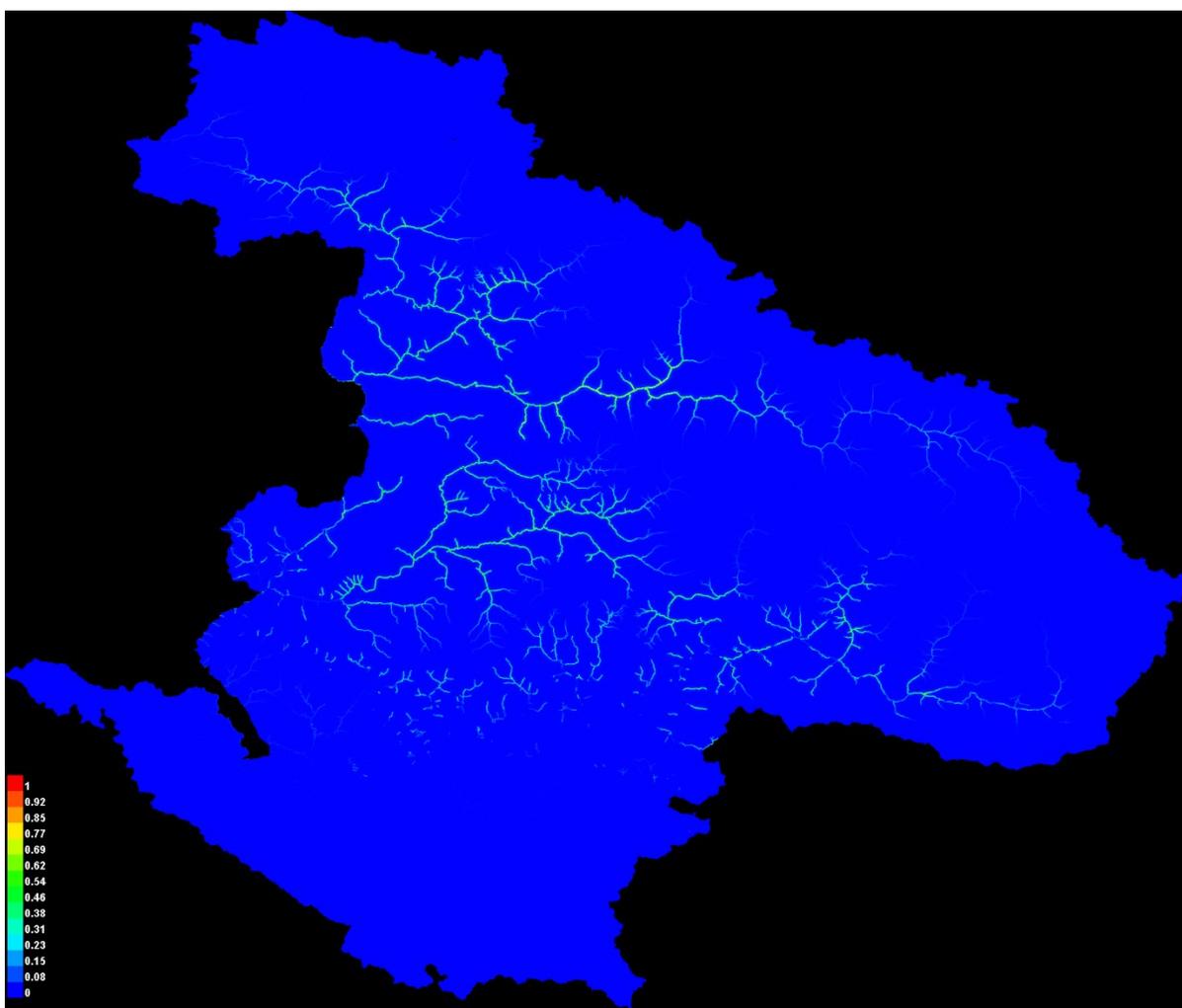
Figure 10: Habitat suitability map of sea buckthorn in Karnali Province

In total 212.11 km^2 area was identified as distribution area/suitable habitat of this species in Karnali Province (**Figure 11**).
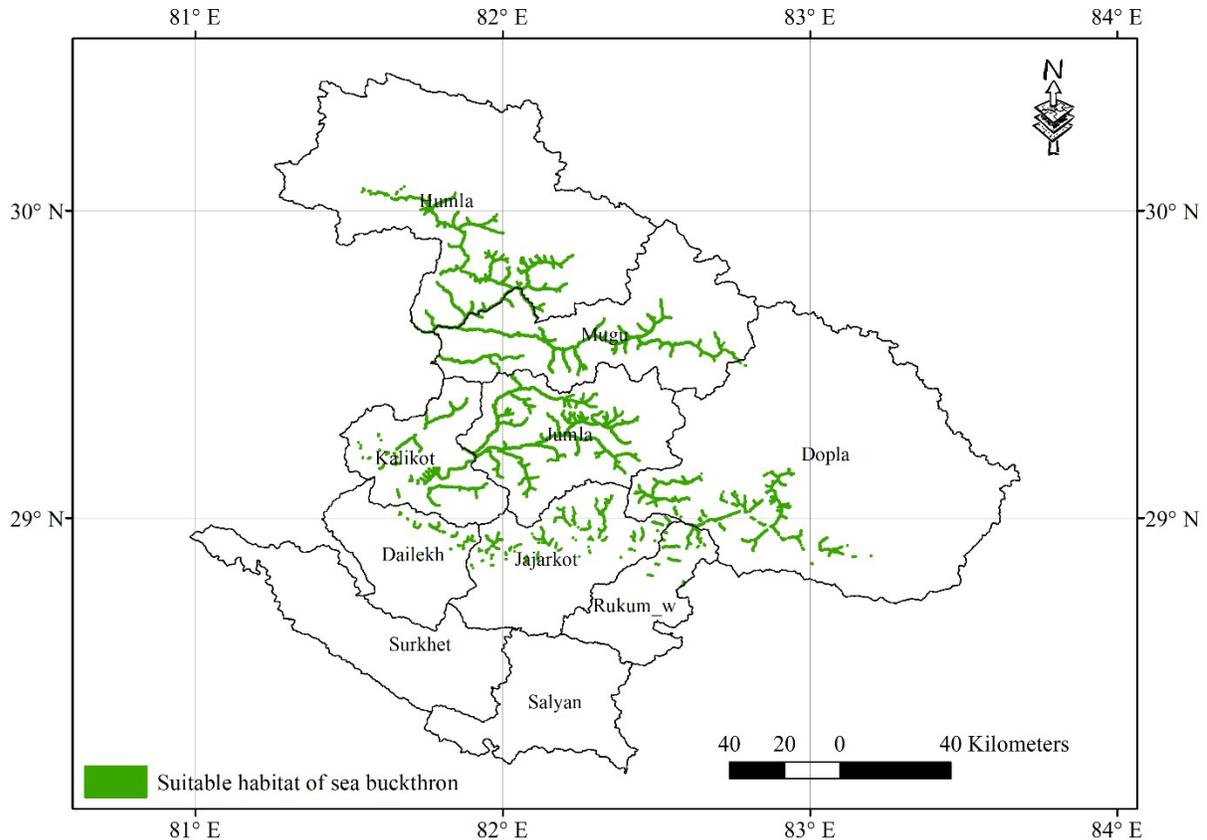
Figure 11: Distribution/suitable habitat of sea buckthorn in Karnali Province

Threshold 0.315 was used to convert the continuous MaxEnt output into the binary map. The model has good accuracies (TSS=0.900, AUC=0.963, Kappa=0.939). Details of accuracies of every 10 run are shown in table 2.

Table 2: Accuracies of the models

Replicates	Threshold	AUC	TSS	Kappa
0	0.260	0.979	0.997	0.917
1	0.410	0.988	0.999	0.971
2	0.110	0.977	0.992	0.806
3	0.310	0.978	0.999	0.971
4	0.265	0.980	0.997	0.917
5	0.395	0.980	0.999	0.971
6	0.190	0.981	0.995	0.869
7	0.260	0.983	0.999	0.971
8	0.490	0.983	1.000	1.000
9	0.457	0.985	1.000	1.000
Average	0.315	0.981	0.998	0.939
Std	0.121	0.003	0.003	0.062

4.2 Ecological suitability of the sea buckthorn

Distance to water, annual mean precipitation, annual mean temperature and elevation are influencing the distribution of sea buckthorn in study area. This means these variables are more responsible for the ecological suitability. Rest of the variables are

less influencing (**Figure 12**). In figure 12, variables having short light bar are more important than long light bar. Because, if that variable is not used for the modelling, the regularized training gain of the model will be dropped to that light bar. In figure 12, dist_water has shortest light bar. Therefore,distance to water is the most important variables to model the distribution of sea buckthorn.
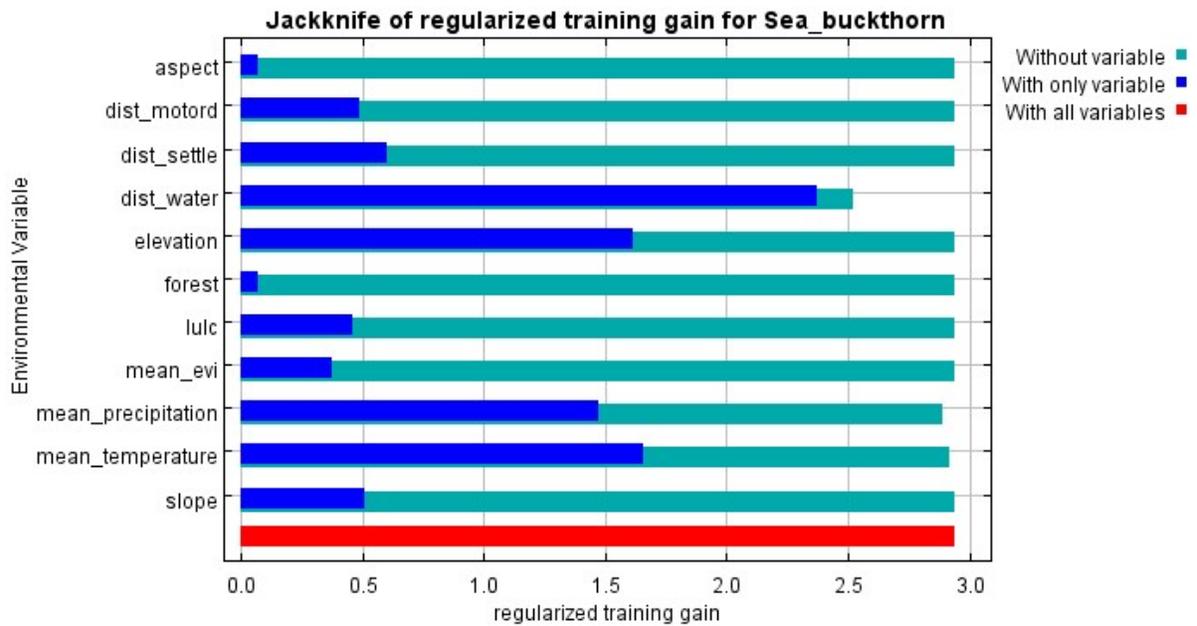
Figure 12: Environmental factor influencing the habitat suitability of sea buckthorn

Distance to water is the most influencing factor to the habitat suitability of sea buckthorn. Suitable habitat is located near to the water bodies (**Figure 13**). This species prefers to grow exactly at the riverside. The area is becoming unsuitable with increasing the distance from water.
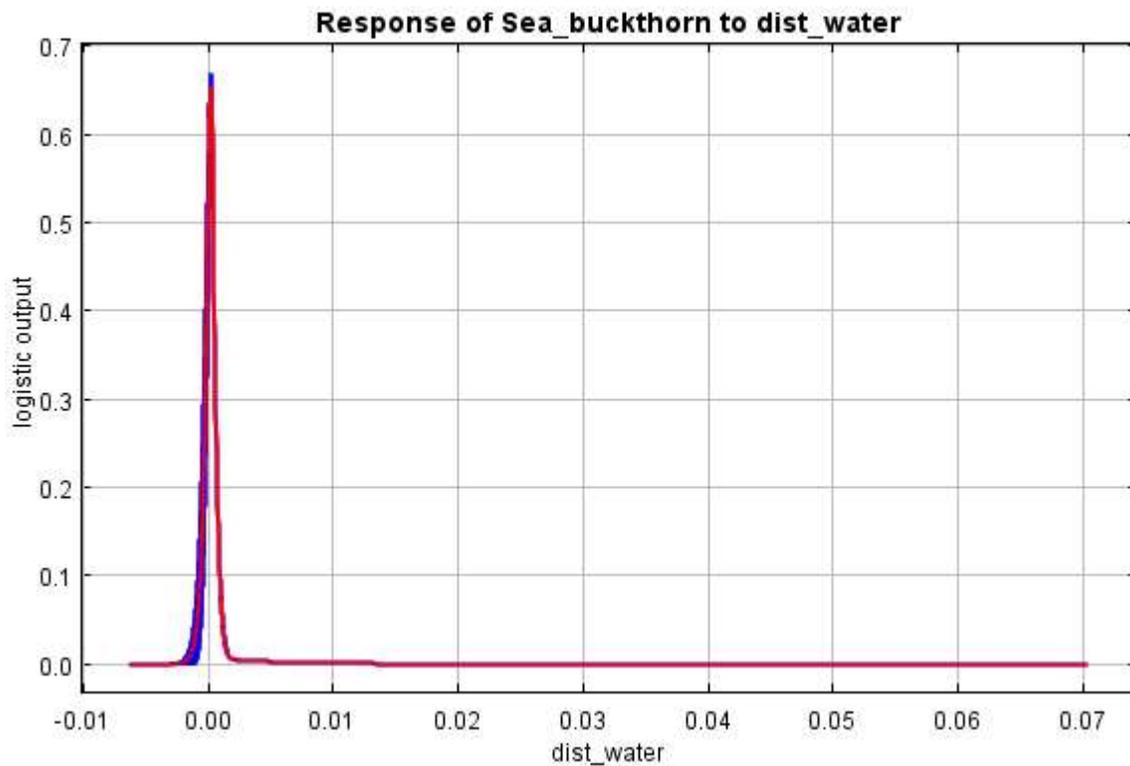
Figure 13: Response of habitat suitability of sea buckthorn to distance to water

Annual mean precipitation is also most influencing factor to the distribution of the habitat suitability of sea buckthorn.   650 mm annual mean precipitation is ideal required precipitation for the suitable habitat of this species (**Figure 14**). Precipitation less than 500 mm and more than 830 mm is not suitable for the distribution of sea buckthorn in the study area.
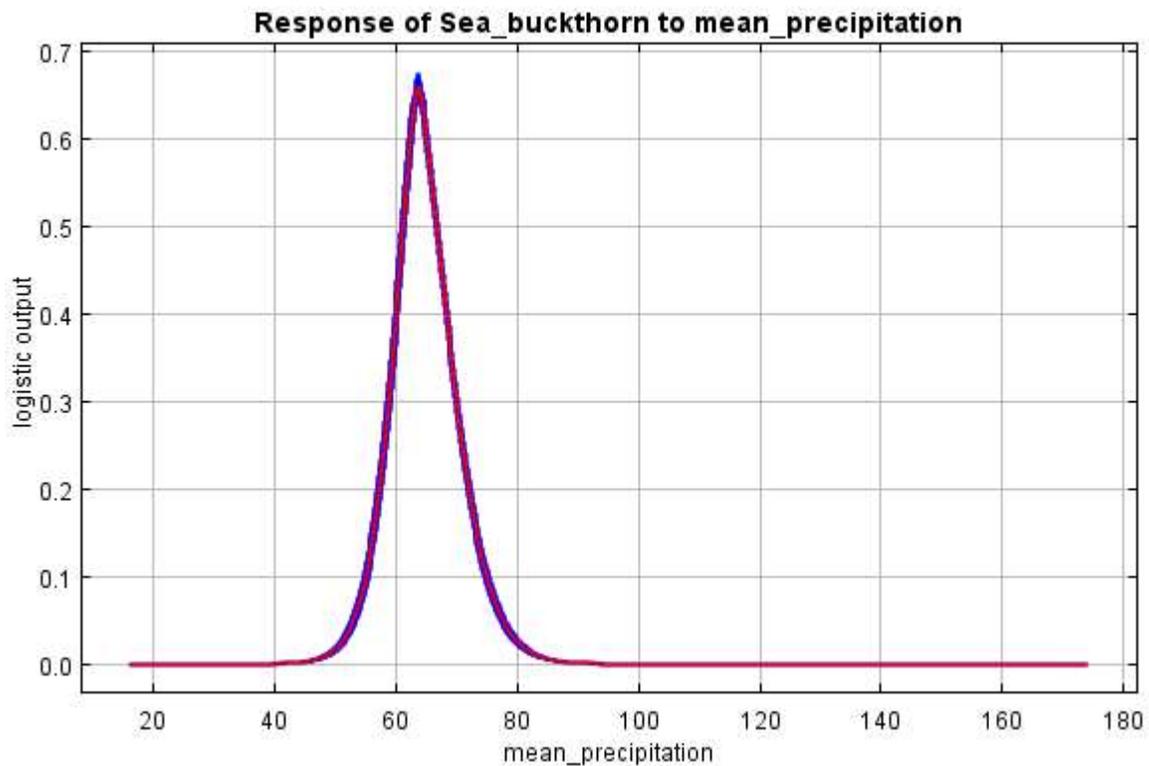
Figure 14: Response of habitat suitability of sea buckthorn to annual mean precipitation

Another influencing factor to habitat suitability of sea buckthorn in the Karnali Province is annual mean temperature. 13 degree centigrade annual mean temperature is ideal required temperature for the suitable habitat of the sea buckthorn (**Figure 15**). Temperature less than 6 degree centigrade and more than 18 degree is not suitable for the distribution of sea buckthorn in the study area.
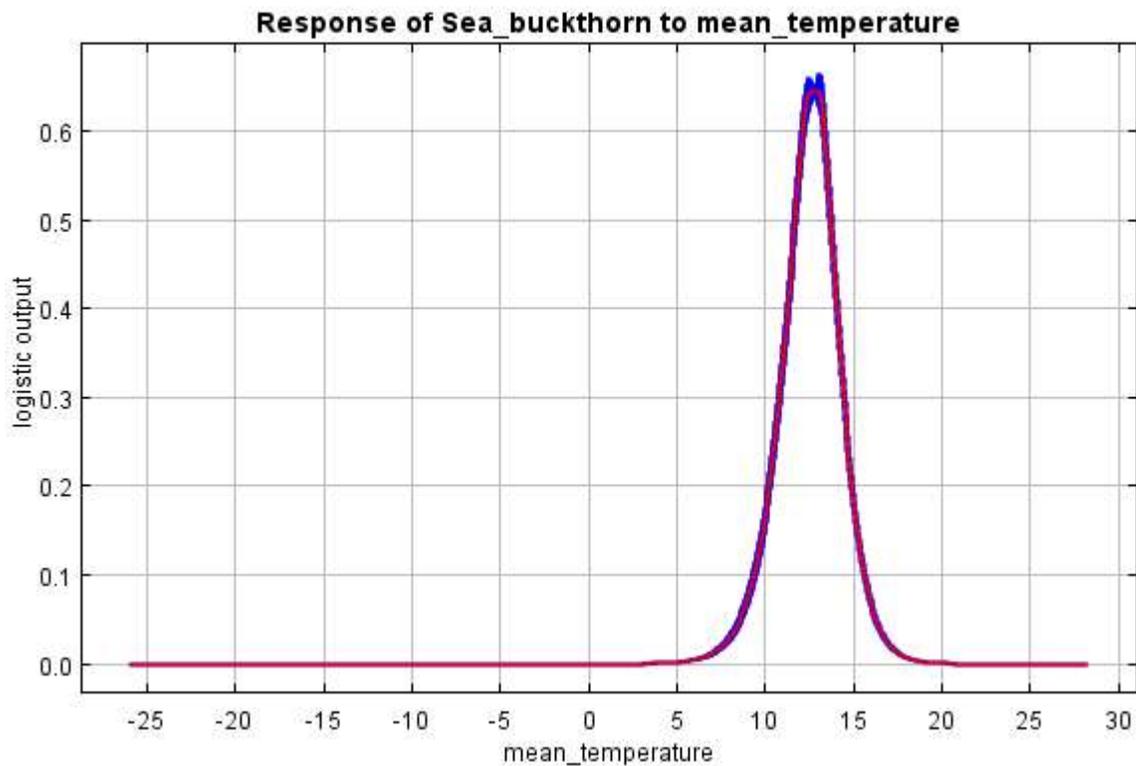
Figure 15: Response of habitat suitability of sea buckthorn to annual mean temperature

Elevation is also influencing to the habitat suitability of sea buckthorn in the study area. 3,550 m elevation is ideal for the best habitat of sea buckthorn. Habitat having below 1,800 m and above 4,200 m elevation is not suitable for the distribution of this species in the study area (**Figure 16**).
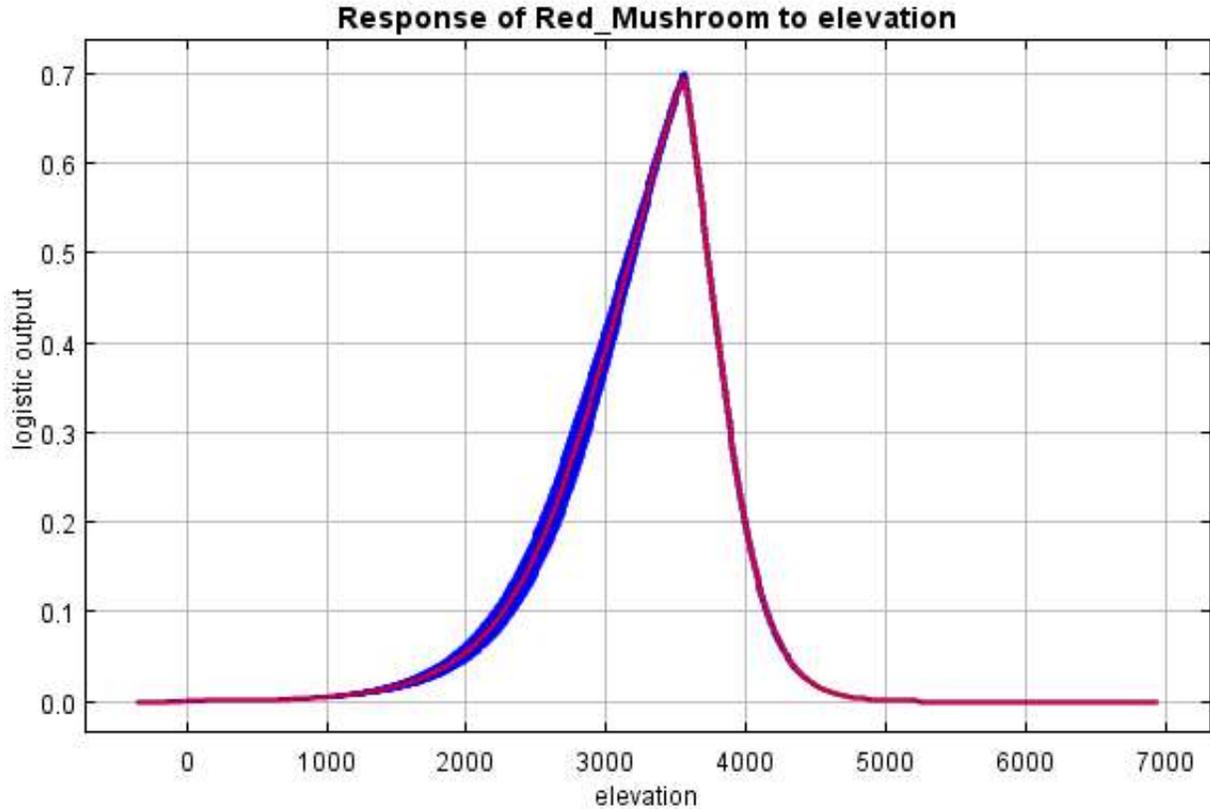
Figure 16: Response of distribution of sea buckthorn to elevation

4.3 Economic feasibility of sea buckthorn production

4.3.1 Initial cost for sea buckthorn production

First of all seedlings of the sea buckthorn should be prepared in the nursery. Normally,

one seedling can be produced within 100 rupees. Then, it can be planted at riverside of

the identified habitat. One seedling can be planted in 100 rupees. If any person plant

1600 seedling in one hectare, total NRs 32,000 should be invested for planting only.

Fencing is essential for the grazing prone area. Furthermore, one lakh rupees should be invested to establish the juice factory to produce the sea buckthorn juice.

4.3.2 Operational expenses

Seedlings can provide the berries after 3 years of plantation. So, they should be cared without any return. Irrigation during the dry season is pre-requisite for this species. To care the seedlings at least 5,000 rupees is required for a month. In total NRs 60,000 is necessary to care the seedling of one hectare. On the basis of local peoples' assumption, NRs 2,000 is required to grow 1 seedling to berry tree. For harvesting the berries, to prepare juice and manage the factor additional costs are essential.

4.3.3 Potential returns

After three year, seedlings start to provide the return. Cost of one *mana* berries is NRs 400 in village and 500-700 in local market. Price of juice depends on the size of glass and other additives used. In general, one liter pure juice can be traded at NRs 1,000.

Financial feasibility is more depend on the management skills and market fluctuation rather than discrete and existing factors. Here is not any guarantee about the financial feasibility but it is sure that, production, processing and trade of sea buckthorn products can be financially feasible under the effective and smart management.

Overall, sea buckthorn production is financially feasible under the effective management.

4.4 Market analysis of sea buckthorn products

4.4.1 Current market dynamics

Majority of people are collecting the sea buckthorn berries for their domestic purpose. But in some cases they sell it to local traders. Traders transport berries to Nepalgunj and Kathmandu. Sometimes, traders make crude juice and send into the market. Major phenomenon of the market is there is uncertainty. Sometime people can't sell even in minimum price due to unwillingness of traders to buy.

4.4.2 Consumer preference

Local consumer want to use the berries of sea buckthorn for domestic and traditional purpose. It can be used a sour test for pickle. Massage by juice of sea buckthorn can be useful to reduce the wound pain. These berries can be used as medicine to cure the germs of stomach of domesticated animals. But urban people perfer to drink the sea buckthorn juice.

4.4.3 Demand of sea buckthorn-based products

Demand of this product is in normal condition. Local people demand it for dietary supplement. Juice of sea buckthorn is demanding product from national and international market. Because, it is organic product of Himalayan region and it has also medicinal value. The demand for Sea buckthorn has explosive growth in China

(Mei et al., 2023). But people of Karnali Province are facing fluctuating market demand. Sometimes, traders buy the products from collectors but sometime the products remain unsold.

4.5 Sustainable cultivation, harvesting and processing practices of sea buckthorn

4.5.1 Sustainable cultivation

Normally sustainable cultivation is associated with conservation of existing plants and plantation of new seedlings. First of all, identified habitats of sea buckthorn should be conserved. Additionally, the existing plants should be conserved. In Himalayan regions, here are lots of small streams and marshy lands. Individuals, community forest and governmental organization should plant the seedling at the suitable places. Before that, Division Forest Office should produce the seedling of sea buckthorn.

4.5.2 Sustainable harvesting

Sustainable harvesting is important to conserve and manage the plant species. Sea buckthorn berries should be picked by hand or by shaking the trees and branches. Breaking and cutting the branches and trees for harvesting of the berries should be prohibited.

4.5.3 Sustainable processing

Sustainable processing involves selecting and applying the right techniques, tools, and methods to achieve desired outcomes efficiently and effectively. Here processing of the sea buckthorn berries with minimum wastage is recommended. For example, by product of the juice can be used as pickle or food for the domesticated animal.

5. Conclusion

This study was conducted in Karnali Province to analyze the feasibility on production, cultivation and processing of sea buckthorn. This study identified 212.11 km^2 area as distribution area/suitable habitat of this species in Karnali Province. Riverside of Jumla, Humla, Mugu, Dolpa, Kalikot are best habitat of the sea buckthorn. Threshold 0.315 was used to convert the continuous MaxEnt output into the binary map. The model has good accuracies (TSS=0.900, AUC=0.963, Kappa=0.939). Distance to water, annual mean precipitation, annual mean temperature, and elevation are influencing the habitat suitability of sea buckthorn in the study area. This species prefers to grow exactly the riverside. The area is becoming unsuitable with increasing the distance from water. 650 mm annual mean precipitation and 13 degree centigrade annual mean temperature is ideal requirement for the suitable habitat of this species. 3,550 m elevation is ideal for the best habitat of sea buckthorn. Habitat having below 1,800 m and above 4,200 m elevation is not suitable for the distribution of this species in the study area. Local consumer want to use the berries of sea buckthorn for domestic and traditional purpose. It can be used for sour test for pickle and vegetable. Massage by juice of sea buckthorn can be useful to reduce the wound pain. These berries can be used as medicine to cure the germs of stomach of domesticated animals. Urban people prefer to drink the sea buckthorn juice.

Cost of one *mana* berries is NRs 400 in village and 500-700 in local market and cost to grow one seeding to tree is NRs 1,500 to 2,000.   Overall, sea buckthorn production is financially feasible under the effective management.

6. Recommendation

This project was conducted to do feasibility study on production, cultivation and processing of sea buckthorn in Karnali Province, Nepal. Riverside of the Karnali Province were identified as good habitats of sea buckthorn. This study recommends to produce the seedling of this species and plant at the identified suitable habitat. Division Forest Offices should play major role for seedling production. Private land owner, community forests and governmental organization and other stakeholders should plant seedling on suitable area belong to their jurisdiction. Major problem identified during the study was difficult to harvest the berries. It is better to prune and pollard the trees to maintain smaller size. Smaller size trees are comfortable to harvest the berries. Shaking the tree branches are good ways to harvest the sea buckthorn berries. For this action, large tent should be distributed. People can spread the tent on ground and shake the branches. Then berries can be collected from the tent.

Collection of sea buckthorn berries from large and talltrees are risky action. Collector can fell from the tree. Serious injury or death can be consequence of this action. Use of ladder and rope can be solution of this problem. Any risky activities should be prohibited. Sometimes, collectors can't sell product even in low price. Therefore, buyback guarantee by authorized organization is highly recommended.

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8. Appendix

GPS points collected for modeling

S.N.	Species	X coordinate	Y coordinate

1	Sea buckthorn	82.11054	29.24469
2	Sea buckthorn	82.09847	29.23793
3	Sea buckthorn	82.01861	29.22873
4	Sea buckthorn	81.98611	29.22722
5	Sea buckthorn	81.9646	29.2311
6	Sea buckthorn	81.9533	29.22799
7	Sea buckthorn	82.04144	29.20032
8	Sea buckthorn	82.04473	29.2287
9	Sea buckthorn	82.06158	29.19015
10	Sea buckthorn	82.0643	29.17316
11	Sea buckthorn	82.07346	29.15162
12	Sea buckthorn	82.07652	29.13953
13	Sea buckthorn	82.08626	29.10031
14	Sea buckthorn	82.37378	29.20519
15	Sea buckthorn	82.40177	29.21029
16	Sea buckthorn	82.37583	29.18276
17	Sea buckthorn	82.41293	29.31217
18	Sea buckthorn	82.40261	29.31225
19	Sea buckthorn	82.40722	29.30958
20	Sea buckthorn	82.19605	29.26892

21	Sea buckthorn	82.21274	29.27036
22	Sea buckthorn	82.28117	29.25908
23	Sea buckthorn	82.31442	29.24613
24	Sea buckthorn	82.34615	29.21284
25	Sea buckthorn	82.30624	29.30638
26	Sea buckthorn	82.31059	29.30861
27	Sea buckthorn	82.32883	29.30457
28	Sea buckthorn	82.34967	29.29545
29	Sea buckthorn	82.39278	29.30986
30	Sea buckthorn	82.12377	29.40886
31	Sea buckthorn	82.18809	29.27205
32	Sea buckthorn	82.20944	29.28119
33	Sea buckthorn	82.10625	29.24045
34	Sea buckthorn	82.39789	29.31128
35	Sea buckthorn	82.1104	29.41844
36	Sea buckthorn	82.12644	29.40703
37	Sea buckthorn	82.17333	29.26676
38	Sea buckthorn	82.05985	29.18126
39	Sea buckthorn	82.16546	29.26868
40	Sea buckthorn	82.32637	29.30032

41	Sea buckthorn	82.14397	29.25849
42	Sea buckthorn	82.12437	29.23854
43	Sea buckthorn	82.20467	29.27528
44	Sea buckthorn	82.13976	29.23365
45	Sea buckthorn	82.16954	29.22406
46	Sea buckthorn	82.13414	29.2507
47	Sea buckthorn	82.2163	29.29279
48	Sea buckthorn	82.24629	29.31207
49	Sea buckthorn	82.2341	29.30962
50	Sea buckthorn	82.32941	29.22843
51	Sea buckthorn	82.30779	29.19974
52	Sea buckthorn	82.36834	29.18772
53	Sea buckthorn	82.01675	29.40851
54	Sea buckthorn	82.03217	29.40025
55	Sea buckthorn	82.04539	29.3932
56	Sea buckthorn	82.13906	29.40071
57	Sea buckthorn	82.14457	29.39584
58	Sea buckthorn	82.26413	29.31384

Photo Plates during Field works and Discussions

Photo 1: Collection of social data related to sea buckthorn

Photo 2: Natural habitat of sea buckthorn

Photo 3: Natural habitat of sea buckthorn

Photo 4: Presence points collection of sea buckthorn