Seabuckthorn (*Hippophae salicifolia*) Management Guide

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I. INTRODUCTION

1. Introduction

Seabuckthorn, found in the icy heights of the Himalaya, is a deciduous, thorny willow-like plant species native to Europe and Asia. It is a pioneer species and prefers to grow in low humid, alluvial gravel, wet landslips and riverside with brown rusty-scaly shoots (Lu, 1992). It is also a multipurpose fast growing species which is serving as a measure of biodiversity conservation, soil conservation, medicines, food, fodder and fuel wood. It has an extraordinary capacity to grow and survive under adverse conditions (-40 to 40º C) and has extensive subterranean rooting system with strong soil binding ability useful for soil stabilization, river bank control and water retention (TISC, 2001). Seabuckthorn berry is a very rich source of vitamins and is called treasure of bio-activity substance because of its over 190 bio-activity substances possessing unique medicinal properties (Maertz, 2006). For these reasons, it is also called a wonderful plant (Lu, 1992).

For the farmers living in the mountains, seabuckthorn offers the opportunity to maintain a sustainable livelihood – providing healthy foods, variety of medicines and protecting their land from soil erosion (Lu, 1992; Ansari, 2003). The use of seabuckthorn illustrates how low input costs and careful planning can lead to quite substantial benefits; a good example of mountain perspective-oriented sustainable development. It thus qualifies as a unique option for the simultaneous management of several problems emanating from the fragility, marginality, inaccessibility and diversity characterising mountain areas (Lu, 1992).

2. Name and Taxonomical Position

Seabuckthorn (also commonly written as sea buckthorn) is a general term used for the shrub-tree *Hippophae Linn.*, belonging to the family: Elaeagnaceae, Order: Elaeagnales, Super order: Celastraneae, Subclass: Rosidae, Class: Magnoliopsida and Division: Magnoliophyta. In ancient Greece, leaves of seabuckthorn were used as horse fodder for improving weight and shiny hair, thus gaining the seabuckthorn genus a Graeco-Latin name '*Hippophae*' (Hippo – Horse; Phaos – to shine) (Lu, 1992). It is called Oblepikha in Russia, Sanddorn in Germany, Argousier in France, Espino Armarillo in Spain, Finbar in Sweden, Tindved in Denmark, Rokitnik in Poland, Yashildoo Chatsargana in Mongolia and Sebu in China. It is a traditional component of herbal medicines in Tibetan where it is called Star-Bu or Dhar-bu. In Nepal, *H. tibetana* is known as Tserken kyun in Manang, Tora in Mustang, Torwa/Tirchuk in Dolpa and Bhuichuk in Humla

and *H. salicifolia* is known as Tijicyun in Manang, Chichi in Thakali language in Mustang, Dalechuk in Dolpa, Tarachuk in Mugu, Jumla and Humla (TISC, 2001).

Classification within this genus is still controversial. A Swedish taxonomist Linnaeus, for the first time recorded this plant distributed in Baltic Coast and established the genus *Hippophae* using *H. rhamnoides Linn* as a mode in the plant family Elaeagnaceae. After that, several other species were found and named by many taxonomists. In 1971, a Finish taxonomist Arne Rousi divided *Hippophae* into three species based on morphological traits: *H. rhamnoides Linn., H. salicifolia D. Don* and *H. tibetana Schlecht*. *H. rhamnoides* was further divided into nine subspecies growing from Norway in Scandinavia to the Northwest of China: *carpatica, caucasica, fluviatilis, gyantsemis, mongolica, sinensis, turkestanica, yunnanensis* and *rhamnoides* (Rousi, 1971). In 1978, Chinese taxonomists, Liu Shengwu and He Tinnong, reported the fourth species – *H. neurocarpa* from the Qinghai Plateau, China. In 1988, Lian Yongshan upgraded *H. rhamnoides,* subsp. *gyantsensis* to an independent species. In 1995, Lian Yongshan again found one new species and two subspecies: *H. goniacarpa, H. goniacarpa subsp. litangensis* and *H. neurocarpa subsp. stellatopilosa* (Lu, 1999). Lian and Chen, in 2002 considered *H. litangensis* as an independent species. In 2003, Lian et al described a new subspecies *Hippophae rhamnoides wolongensis*. Therefore, based on these taxonomical studies, new taxonomic system should include seven species and eleven subspecies, which was also given in Species Records of *Hippophae*, Germplasm Resource Information Network (GRIN, 2007).

1) *H. goniocarpa*
2) *H. gyantsensis*
3) *H. litangensis*
4) *H. neurocarpa*
    - *i. Subsp. neurocarpa*
    - *ii. Subsp. stellatopilosa*
5) *H. salicifolia*
6) *H. tibetana*
7) *Hippophae rhamnoides*
    - *i. Subsp. carpatica*
    - *ii. Subsp. caucasica*
    - *iii. Subsp. fluviatilis*
    - *iv. Subsp. mongolica*
    - *v. Subsp. rhamnoides*

vi. *Subsp. sinensis*

vii. *Subsp. turkestanica*

viii. *Subsp. wolongensis*

ix. *Subsp. Yunnanensis*

The following table shows the distribution and the status of utilization of *Hippophae*:

The Distribution and Status of Utilization of *Hippophae*

Taxons	The Areas of Distribution	The Status of Utilization
1. H. rhamnoides. Subsp. rhamnoides	Scandinavian countries, Baltic Sea countries, Germany, Belgium, Netherlands, Ireland, Poland, U.K., France, Russia	Many varieties are cultivated in some European countries and Canada
2. H. rham. Subsp. sinensis	The North, Northwest, Southwest of China	Wild resources are used for ecological restoration and berries are processed for products. Some new varieties are in tests.
3. H. rham. Subsp. yunnanensis	Sichuan, Yunnan, Tibet of China	Wild resources are used for ecological restoration only.
4. H. rham. Subsp. mongolica	Siberia of Russia, Mongolia, Xinjiang of China	More than 60 varieties are cultivated in Russia, Mongolia, many East European counties. Many West European counties, Canada and China introduced the varieties for test.
5. H. rham. Subsp. turkestanica	India, Pakistan, Afghanistan, Turkmenistan, Kyrgyzstan, Uzbekistan, Kazakhstan, Iran, Turkey, Xinjiang , Tibet of China	Wild resources are used for ecological restoration and berries are processed for various products on commercial level in India for the production of food, medicine and cosmetics.
6. H. rham. Subsp. fluviatilis	Around Alps Mountains: Germany, France, Switzerland, Austria, Czech, Slovakia, Italy,	Most of wild resources are protected as forest species. Some berries are collected for processing products
7. H. rham. Subsp. carpatica	The Capathinan Mountains, Transsylvanian Alps,the valley	Most of wild resources are protected as forest species. Some

	and the mouths of the Donube and its tributary	varieties are cultivated for processing products
8. H. rham. Subsp. caucasica	The Caucasus Mountains, Georgia, Azerbaijan, Armenia, Ukraine, Romania, Turkey, Bulgaria, Iran, Russia.	Most of wild resources are protected as forest species. Some selected varieties are cultivated for test.
9. H. goniocarpa	Sichuan, Qinghai of China	Most of wild resources are protected as forest species. Very few studies have been done.
10. H. goniocarpa Subsp. litangensis	Sichuan, Qinghai of China	Most of wild resources are protected as forest species. Very few studies have been done.
11. H. neurocarpa	Sichuan, Qinghai, Gansu of China	Most of wild resources are protected as forest species. Very few studies have been done.
12. H. neurocarpa Subsp. stellatopilosa	Sichuan, Qinghai, Tibet of China	Most of wild resources are protected as forest species. Very few studies have been done.
13. H. tibetana	Sichuan, Qinghai, Gansu, Tibet of China, Nepal, India	Most of wild resources are protected as grassland species. Very few studies have been done.
14. H. gyantsensis	Tibet of China	Most of wild resources are protected as forest species. Some berries are collected for producing Tibetan medicine.
15. H. salicifolia	The southern slope of Himalayan Mt. Tibet of China, Bhutan, Nepal, India	Most of wild resources are protected as forest species. Some berries are collected for producing products.

Source: pers. comm., Dr. Sanjai Kumar Dwivedi (Deputy Director, Defense Research and Development Organization, Delhi, India)

3. Plant Morphology

Genus *Hippophae* is a deciduous, usually spinescent, shrub-tree species. Depending upon the species and microclimate variation, morphological structure of seabuckthorn shows much variation. According to Lu (1992) and Ghaffar (1997), though seabuckthorn is a hydrophyte, yet it has developed some xerophytic features. *H. tibetana* is a dense much-branched shrublet with less than 90 cm tall (ANSAB, 2003b). *H. salicifolia* is willow-like small tree with height 6 to 10 m. However, tree of height 17 m tall was observed in Mustang. Its natural lifespan appears to be at least 60 to 70 years (Lu, 1992) and in Mustang, *H. salicifolia* with 64 years was observed to be fruiting with its heartwood of lower trunk slightly decayed. It is estimated that the age of seabuckthorn is more than 320 years and it is still bearing fruit (Lu, 1992).

Separate Male and Female Plants

Seabuckthorn is either male or female but the sex of the plant is not clear till the flowering stage. The males produce pollen, have flowers without petals and each flower contains four stamens. The females produce fruit and seed and have flowers, also without petals. Each flower contains one ovary and one ovule.

Flower

Seabuckthorn floral buds are mostly mixed with vegetative buds and are rarely pure. Floral buds appear mainly in the summer or the autumn and usually open in the following spring. The male floral bud consists of four to six flowers; the female floral bud consists of one flower and rarely two or three. The sex of the seabuckthorn cannot be judged until the first flower bud appears. In the precocious plants this may be in the third year, whereas in slow plants it may happen in the fifth or the sixth year (Lu, 1992). In Mustang, *H. salicifolia* was found to be fruiting at the age of five. The female flower depends almost entirely on the wind for pollination because both the male and the female flowers have no nectar and they rarely attract bees or other insects.

Fruit

Seabuckthorn bears a special fruit, which is different from other common fruits or berries. Morphologically it develops from an ovary and a calyx tube which is closely connected to the ovary. Actually the fruit is a combination of an unsplit, fleshy, expanded calyx tube and an ovary. In other words, the expanded, juicy calyx tube is the important part with economic value.

The time taken from flowering to fruit maturation is 12 to 15 weeks. Young fruits are hard and greenish, but turn soft and orange or orange-red as they mature. Unlike the majority of fruits that

fall away from the maternal plant at maturity, the seabuckthorn berries remain on the branch for several months. This gives ample time to harvest them. In natural seabuckthorn forest, fruits can remain on the branches until the following spring. During this period, usually cold winter, the fruits gradually shrink but do not fall. Therefore they become the favourite food of animals, especially birds.

It has intense sour taste, sharp lemon flavor and contains 60 to 80% juice rich in sugar, organic acids, amino acids, tannins and vitamins and the fruit contains 3 to 5% of pulp oil and 8 to 18% of seed oil (Jasra, 1998). It cannot be eaten raw in any quantity, but makes an excellent juice, syrup or jam due to its strong acidity. It has also a unique aroma reminiscent of pineapple. Indeed, in Belarus the fruit juice is known as Russian pineapple.

The berries appear to be an unsurpassed natural source of vitamin A and several other carotenes, vitamin E and several other tocopherols and flavonoids. The vitamin C content of the juice ranges from 300 to 1600 mg per 100 gm of juice (Average 600 mg/100 gm juice) collected from Dolpa (Vaidya, 1999). Based on the studies, vitamin A is 3 times that of carrot and 20 times that of orange, vitamin C is 16 times that of Indian gooseberry and 30 times that of orange and similarly vitamin E is 6 times that of oil of the maize (Vaidya, 1999; ACAP, 2002). Biological studies suggest that the restorative action of the seabuckthorn oil may be in part due to its high content of essential fatty acids, carotenes, tocopherols and phytosterols, which are all important for the maintenance of a healthy skin. The essential fatty acids content in the seabuckthorn oil extract is 80 to 95 %. Among the carotenes found are alfa- and beta-carotenes, lycopene, cryptoxanthin, zeazanthin, taraxanthin and phytofluin. Tocopherols are mostly represented by vitamin E and gamma-tocopherol. Phytosterols of seabuckthorn include beta-sitosterol, beta-amirol and erithrodiol (Lu, 1992).

Comparison of the Vitamin Contents of Seabuckthorn and Others (mg/100g)

Species	Vitamin A	Vitamin B1	Vitamin B2	Vitamin C	Vitamin K
Seabuckthorn	11.00	0.04	0.56	300-1600	100-200
Cilicrosa roxburghii	4.83	0.05	0.03	1000-3000	-
Kiwi Fruit	-	-	-	100-470	-
Hawthorn	0.82	0.02	0.05	100-150	-
Orange	0.55	0.08	0.03	50.0	-
Tomato	0.31	0.03	0.02	11.8	-
Carrot	4.00	0.02	0.05	8.0	-

Source: Lu, 1992

Seed

Seabuckthorn is a single seeded fruit. The seed is ovate-oblong with a length of 4 to 7 mm, a breadth of 2.5 to 3.5 mm and a thickness of 1.6 to 2.2 mm. The skin of the seed is greyish-brown or dark brown, leathery and lustrous. The seed is surrounded by a parchment-like ovarian wall. *H. salicifolia* seed is globose and seem fissured on one side with length 3 to 4.5 mm long, a breadth of 2.5 to 3 mm wide and 1.5 to 2 mm thick. It tastes sour. Seabuckthorn belongs to the group of thermophilic plants. Ideal temperature for germination of seed is 24º to 26º C (Ansari, 2003).

Seed of *H. salicifolia*

The seed represents only 10 % of the whole fruit. Major chemical composition of seabuckthorn seed are carbohydrate, lipid (fat) and protein. The seed contains 10 to 20 % of oil depending upon the species of the plant (Singh, 2001). *H. tibetana* contains 19.51 % oil which is highest among all the species of *Hippophae* (Lu, 1990). The seed oil contains 12 % to 20 % saturated fatty acids and 88.3 % to 89.1 % unsaturated fatty acids, particularly Linolenic acid (32.3 %), Linoleic acid (40.8 %) and Oleic acid (15%) (Schroelder and Yao, 1995). Other constituents of the seed oil included gamma and alpha Tocopherol (Li, 1999). Vitamins A, E and K present in seed oil are used in various fields of food, drug and cosmetics (Bernath and Foldesi, 1992; Vaidya, 1999). The chemical composition of the two species of seabuckthorn seed oil is given below.

Chemical Composition of Seed on the Two Species of Seabuckthorn

Species	Oil Content %	Saturated fatty acid %	Unsaturated fatty acid %	Linoleic and Linolenic acid %
H. salicifolia	10.85	17.3	82.7	63
H. tibetana	19.51	11.7	88.2	64.9

Leaves

Leaves of *H. salicifolia*

The leaves are small (usually 3 to 8 cm long and 0.4 to 1 cm wide), alternate, linear, lanceolate and covered on the backside with silvery stellate scales that reflect sunshine and reduce moisture loss (Lu, 1992). Leaves of seabuckthorn are used to manufacture various products due to the fact that the leaves contain many nutrients and bioactive substances. Singh (1998) studied the fodder values of the foliage of seabuckthorn and found that the crude protein content in the leaves of *H. salicifolia* (21.6 %) was significantly ($p < 0.05$) higher than those of the *H. rhamnoides* biotypes. Fat content varies from 3.5 - 4.8 % in *H. rhamnoides* to 4.6 % in *H. salicifolia*. Natural detergent fiber value in the leaves of *H. salicifolia* was 32.7 %, which was significantly ($P< 0.05$) higher than the biotypes of *H. rhamnoides*. Ash content in *H. salicifolia* was 5.1 %. In general, the ash content increased in the leaves of both species (*H. rhamnoides and salicifolia*) in September. Total phenolics were 12.7 %, out of which 92 % were in the form of hydrolysable tannins. The content of hydrolysable tannins was quite high, when compared to other locally available fodder species.

In the main seabuckthorn growing areas in northwest China, the average farmer can earn US$15 per year by selling seabuckthorn berries and leaves. In Burduliang village, Erduos city, Inner Mongolia, China, over a period of 20 days in 2002, each household increased its income by an average of US $ 144.6 by collecting leaves; some households earned up to US $ 253.

Wood/Stem

Depending upon the species, *Hippophae* is either shrub or tree. It is hard, woody, erect generally multiparous, cylindrical, perennial, spiny and waxy at young stage. The young stem is generally silvery white and smooth in nature covered with white scales and multicellular hairs, which disappear as stem matures. Secondary growth starts in the first year only, so it is very difficult to find out a stem without secondary growth (Dwivedi et al, 2006). Every branch of the stem terminates into a thorn.

Thorn

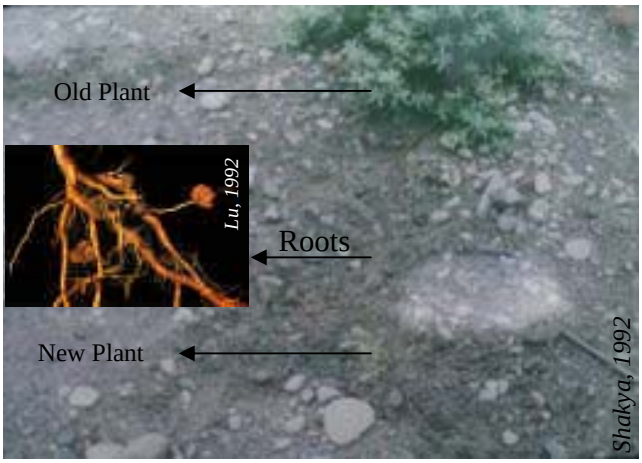
Seabuckthorn, as the name indicates, is a highly thorny plant. Thorns are very hard and compound arising as appendages from stem. Each branch of the stem terminates into a thorn. On

the stem, thorns are highly cutinaceous with a waxy outer surface covered with white and brown scales. The thorn intensity has been found varying from 1-5 thorns/cm^2 (Dwivedi et al, 2006).

Roots

Seabuckthorn has a mighty and well-developed tap root system, having primary, secondary and tertiary roots covered with root hairs, found more prominently in the apical portion (Dwivedi et al, 2006). Some 80% of its feeding roots are in the topsoil (0.2 to 0.8 m) helping to prevent erosion (Lu, 1992). Often young plants have twice the height of the plant and root widths three times wider than the crown of the plant above the ground. The seabuckthorn root system is so extensive that its roots can branch many times in a growing season and form a complex network of roots. Horizontal roots also have root turions (underground buds) which sprout and give rise to another plant. In this way, seabuckthorn bushes play an important role in protecting riverbanks, preventing floods and clogging mud, which would otherwise be washed away in floodwaters.

A symbiotic mycorrhizal fungus, which is identified as *Flankia* (Actinomycetes), has been found on seabuckthorn roots. This symbiosis between the fungus and seabuckthorn results in root nodule formation that can fix the maximum amount of atmospheric nitrogen. It is estimated that the capacity of seabuckthorn roots to fix nitrogen is twice that of soybean (Lu, 1992). Besides fixing nitrogen, the perennial root nodule has the function of transforming difficult to dissolve organic and mineral matter into an absorbable state.



Root System of 1-year-old *H. salicifolia*

4. Physical and Chemical Parameters

There are over 190 identified bioactive substances found in seabuckthorn and 60 unidentified (Maertz, 2006). The following table outlines the major constituents of seabuckthorn.

Major Constituents of Seabuckthorn

Main Components	Contents
Fruits	
Colour	Yellow, orange to orange red
Shape	Round, oval, ovoid
Fruit weight	10-16 gm /100 berries;
Fruit juice extraction rate	64 – 75 %
Vitamin C in fruit juice	1161.1 – 1302.5 mg/100 gm
Vitamin A in fruit juice	0.75 mg/100 gm
Carotenoid in fruit juice	7.2 – 7.4 mg/100 gm
Soluble solids in fruit juice	15.92 – 17.66
Carotenoid in fruit residue oil	1570 mg/100 gm
Total flavone in fruit juice	365 – 885 mg/100 gm
Total flavone in fresh fruit	354 mg/100 gm
Protein in fruit	34.6 %
Total sugar	6.29 %
Organic acid	4.35 %
Sodium	41.28 mg/kg fruit
Potassium	1499.96 mg/kg fruit
Calcium	383 mg/kg fruit
Iron	11.68 mg/kg fruit
Magnesium	47.7 mg/kg fruit
Zinc	0.94 mg/kg fruit
Phosphorus	0.02 %
Seeds	
Seed	6.54 %
Oil in seed	10.37 – 19.51 %
Vitamin E in seed oil	101.5 – 277.6 mg/100 gm
Vitamin C in seed	149 mg/100 gm
Protein in seeds	21.66 %

Total sugar	5.84 %
Carotenoid in seed	3.3 mg/100 gm
Organic acid	0.94 %
Saturated fatty acid %	12 – 20 %
Unsaturated fatty acid %	88.3 – 89.1 %
Linolenic acid	32.3 %
Linoleic acid	40.8 %
Oleic acid	15%
Pulp	
Oil in fruit pulp	8.44 %
Carotenoid in fruit pulp oil	764 mg/100 gm
Vitamin E in fruit pulp oil	255 – 435 mg/100 gm
Vitamin C in pulp	780 mg/100 gm
Total sugar	7.17 %
Organic acid	4.4 %
Leaves	
Total flavone in leaves	876 mg / 100 gm
Protein in leaves	17.43 – 24.13 %

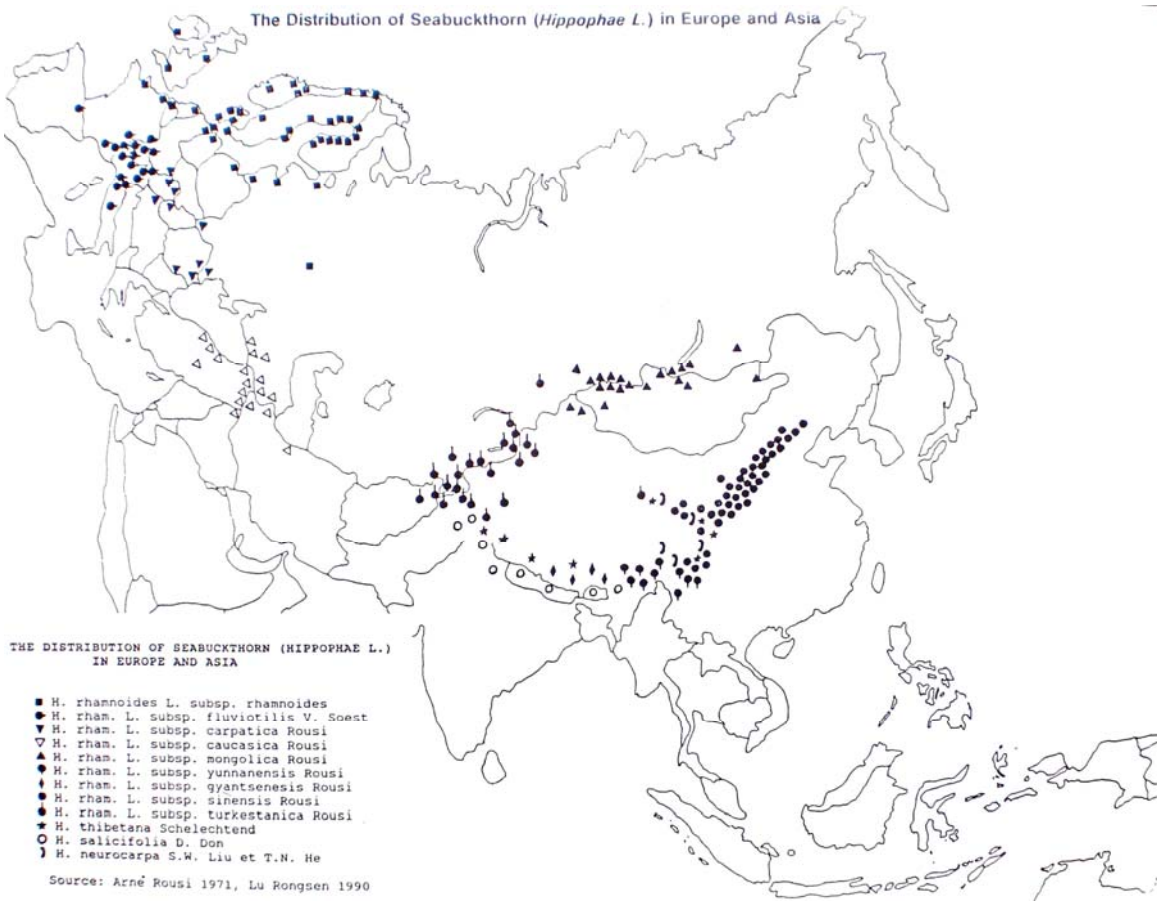
Sources: Schroelder and Yao, 1995, Li and McLoughlin, 1997, Vaidya, 1999, Lu, 2003, Dwivedi et al, 2006

5. Geographical Distribution

Many scholars and experts have certified that the genus *Hippophae* originated in the Himalayan mountain regions and then spread to southwest, northwest and northern China and eastern Inner Mongolia, as well as to the northwest regions of Eurasia where one route progressed west to reach the Alps via the Caspian and Black seas before finally arriving at the northwest shore of the Scandinavian peninsula and another route progressed northwest to reach northwestern Mongolia and southern Siberia in the Russian Federation via India, Nepal, Pakistan, Afghanistan, the Xinjiang Uygur Autonomous Region in China and several Central Asian countries of the former Soviet Union (Lu, 1990). In other words, seabuckthorn is a typical temperate plant of the Eurasian continent, widely distributed between 27º to 69º N latitude and 7º W to 122º E longitude (Rousi, 1971; Pan et al, 1989; Yu et al, 1989). It occurs at least in 38 countries including Afghanistan, Azerbaijan, Belarus, Bhutan, Britain, Bulgaria, Canada, China, Czech Republic, Denmark, Estonia, Finland, France, Germany, India, Iran, Italy, Kyrgyzstan, Kazakhstan, Latvia, Lithuania, Moldova, Mongolia, Nepal, Netherlands, Hungary, Norway,

Pakistan, Poland, Portugal, Romania, Russia, Slovakia, Sweden, Switzerland, Turkey, Ukraine and Uzbekistan.

The distribution throughout Europe and Asia shown in the map below shows that the species concentrates mostly in the Hindu-Kush Himalaya adjoining areas of China and parts of Europe and the former USSR as well as Scandinavian region. Considering the vertical range of elevations, seabuckthorn has a very strong ecological adaptability. It can grow from the seashore of the Baltic Sea in Europe to 5200 m above sea level in the Mount Everest in Asia. Generally, seabuckthorn grows in temperate regions of the world and it naturally occurs in the arid, semi-arid and high mountainous ecosystems. It grows well in the following climatic conditions: the monthly average temperature of the hottest month is 15 to 25°C and the maximum radiation on clear days in the vigorous growing season is 23500 to 26000 cal/cm²; annual rainfall ranges from 250 to 500 mm (Lu, 2002).



Source: Lu, 1992

The Distribution of Seabuckthorn (*Hippophae L.*) in Europe and Asia

Hippophae is the native plant of the mountain region of Nepal. The species is found within the altitudes ranging approximately from 2000m to 4500m (TISC, 2001) and has been reported from the mountain-areas of Baglung, Darchula, Dolakha, Dolpa, Humla, Jajarkot, Jumla, Kaski, Manang, Mugu, Mustang, Ramechhap, Rasuwa, Solukhumbu and Taplejung districts with altitudes ranging from 1950m at Dhunche of Rasuwa district to 4500m of Dolpa district. (Vaidya, 1999; Gupta et al, 2000; Baral, 2002).

As recorded by Gupta et al (2000), *H. salicifolia* has been distributed from 2000-3600 m from msl whereas *H. tibetana* is distributed from 3300 – 4500 m altitude in Nepal (Ansari, 2003).

Identified Distribution of Seabuckthorn in Nepal

District	Distribution of *Hippophae*
Baglung	Dhorpatan
Darchula	Khandeshwori, Rapla, Sunsera, Ghusa, Pala Kutirau
Dolakha	Nagaon
Dolpa	Sahartara, Khanigaun, Chhala, Pahada, Dho, Laini, Chharka, Puwa, Dhargaunko Kot
Humla	Bargaun, Kalika, Mauberikhola, Melchham, Yari, Hilsa, Limi, Lare Khola
Jajarkot	Chuthari, Tumko
Jumla	Uthu, Tila valley, Depalgaun, Gariyangkot, Giri khola, Dillichaur, Chimara Lekh
Kaski	Bhainsi Kharka
Manang	Dharapani, Bagarchhap, Hke, Bhimat, Yak Kharka, Braga, Manang, Humden, Khbusar
Mugu	Karanbheg, Mugu Karnali Basin, Daura, Maha, Tirpa, Tharpa, Gambheg Talcha, Tobla, Pina
Mustang	Ghasa, Lete, Kalopani, Larjung, Jharkot, Manang, Charang, Ghemi Lomanthang, Chhoser, Chhanup Phuwa
Ramechhap	Species recorded from the district but sites not mentioned
Rasuwa	Dhunche, Langtang Valley
Sindhupalchowk	Species recorded from the district but sites not mentioned
Solukhumbu	Feriche
Taplejung	Ghunsa, Ramdang, Chha Khola, Nup, Yangma, Syabok, Nangama Khola, Lahpook, Khambachen, Nupchu Khola, Lonak, Teyang Khola, Jorkin

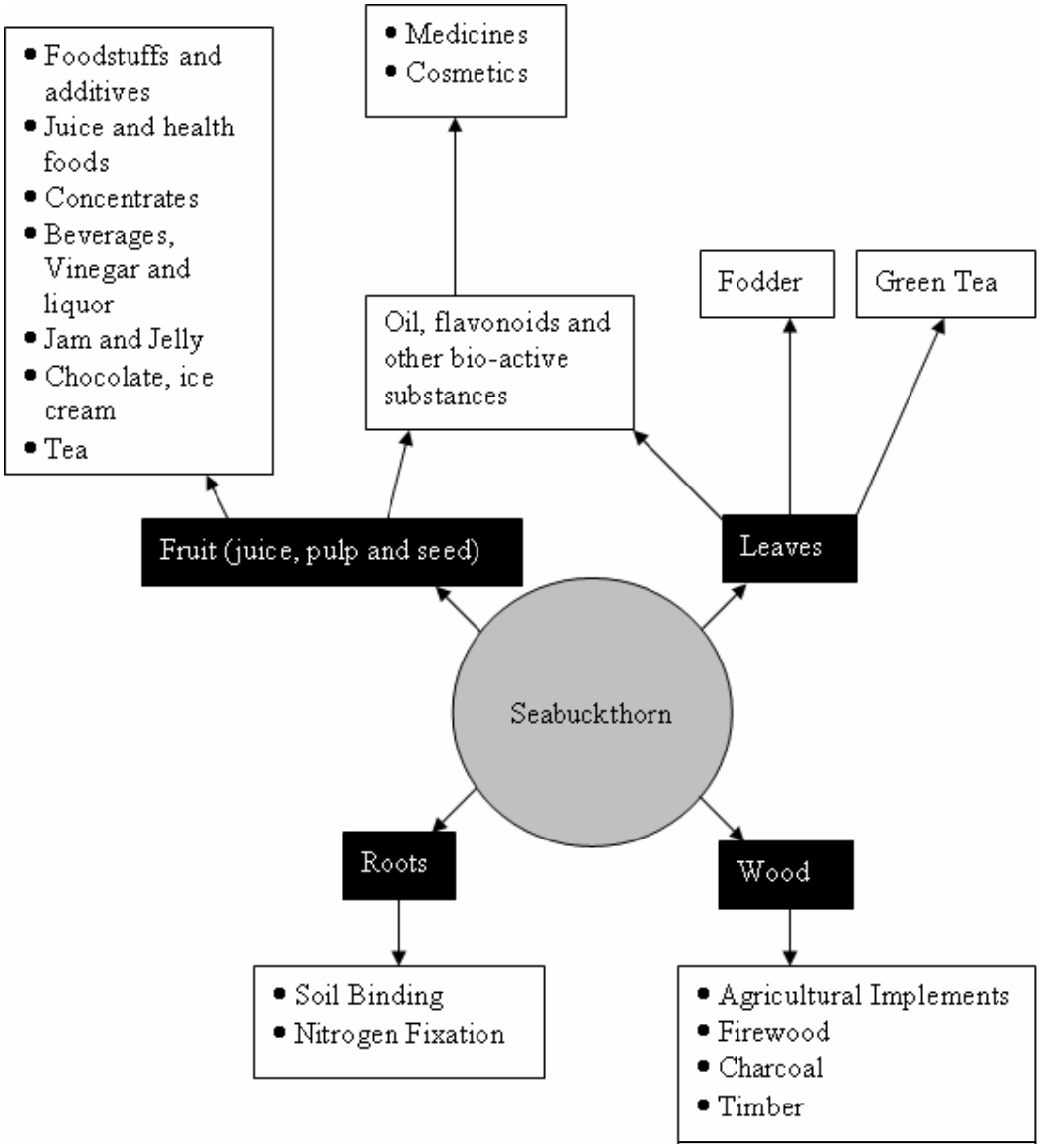
Source: Bhandari, 2003; Baral, 2002; TISC, 2001

6. Uses

Due to its immense use, it has aptly been called a wonderful plant, magic plant, super food, functional food and bank of vitamins. The use of seabuckthorn has a very long history, especially on the Tibetan Plateau. In the 8th century, the medical use of seabuckthorn was mentioned in the Tibetan medical classic the rGyud bzi – the four parts of pharmacopoeia, written by Yu Tuo Yuan Dan Kong Bu and completed during the Chinese Tang Dynasty (618 to 907 AD). The rGyud bzi gives 84 different set prescriptions for the preparation of seabuckthorn medicines. During the 13th century, the rGyud bzi was disseminated through Mongolia and seabuckthorn began to be used in traditional Mongolian medicines. In the Qing Dynasty (1821 to 1850), the Mongolian scholar, Losan Quepei, wrote a 120-chapter book – A Selection of Traditional Mongolian Medicine, 13 chapters of which document the properties of seabuckthorn and its effects in clinical cases. There are 37 different set preparations based on seabuckthorn.

However, it is only in recent decades that people have had a better understanding of seabuckthorn. The scholars who are engaged in scientific research on seabuckthorn in various countries have revealed its importance to human beings by carrying out a large number of scientific experiments. Russian and Chinese scientists, in particular, have made a considerable contribution to the research and development of seabuckthorn. Inspired by ancient Chinese literature, scientists in the former Soviet Union carried out research on seabuckthorn from the 1930s onwards and developed many new varieties. They developed various medicinal preparations, including health products for astronauts and pilots. Since 1985, the Chinese Government has developed seabuckthorn production nationwide in a systematic manner and the total area of seabuckthorn in China is now 1 to 2 million ha, corresponding to about 40% of the total area (Hilbert, 1997). China develops over 200 types of industrial products with the annual turnover of approximately 37.5 million US $ (Bhatt et al, 1993). Encouraged by success stories from China, many South Asian countries, such as Nepal, Bhutan, India and Pakistan started their own seabuckthorn development programmes in the 1990s.

With the gradually worsening quality of the environment and the overriding poverty in many countries today, seabuckthorn has attracted a great deal of attention from scientists and engineers all over the world because of its concentrated ecological and socio-economical benefits.



Use of Seabuckthorn Parts in Various Purposes

6.1. Ecological Uses

Due to its unique biological features, seabuckthorn has been used in various ways to maintain the ecology of the Himalaya.

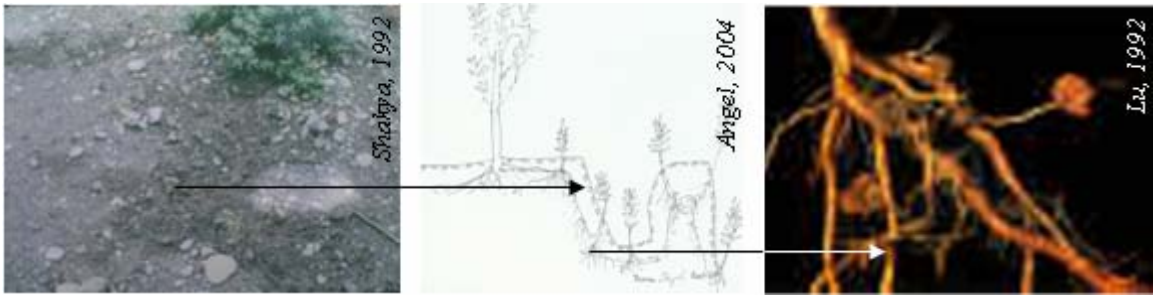
Unique Biological Features of Seabuckthorn

- Strong root systems and the ability to propagating itself: A five-year plant has a taproot of 3 m and horizontal roots of 6 to 10 m (Lu, 1992). A three-year old plant can produce 10 to 20 new generation plants by root turions (Jasra, 1998).
- Nitrogen-fixing capacity: An 8 to 10-year old seabuckthorn forest can fix 180 kg of nitrogen/ha/year (Lu, 1992).

- Biomass production ability: A 6-year old seabuckthorn plantation can produce 18 tons of fuel wood. The heat value of seabuckthorn wood is 4785.5 cal/kg (Lu, 1992). One ton of seabuckthorn wood is equal to 0.68 ton of standard coal.
- Water and soil loss controlling ability: Compared to wasteland, 7-year old seabuckthorn forest can reduce 99% of runoff and 96% of soil loss.
- Soil fertility improving ability: Seabuckthorn is pioneer plant within a fragile and marginal context and forest can greatly increase the contents of nitrogen, phosphorus and organic matter in the soil.
- Ability to promote the growth of tree species: When pine and poplar were planted with seabuckthorn in mixed forests, it was found that seabuckthorn greatly promoted better growth of pine and poplar (Jasra, 1998).

Here discussion has been made on various topics mainly based on the discussion made by Small et al, 2000.

As Soil Enhancer: Seabuckthorn is useful in reclaiming and conserving soil, especially on fragile slopes, due to its extensive root system. Because it is resistant to drought and tolerates soil salinity and low temperatures, it is suitable for many situations that are simply too demanding for most plants. Riverbanks, lakeshores, steep slopes and other susceptible terrain can benefit from the establishment of seabuckthorn. Windbreaks made up of seabuckthorn are effective at preventing wind erosion in open areas. The spiny shrub has even proven to be beneficial in acting as a barrier to pedestrian traffic, preventing sensitive vegetation from being trampled. Not only does seabuckthorn prevent the loss of soil, but it also improves degraded soils due to its nitrogen-fixing capabilities. Thus, there is reduced need to add fertilizers, which results in less input costs as well as fewer ecological problems.



Sub-terrain Rooting System of Seabuckthorn

As Pollution Reducer: Seabuckthorn is useful in lessening pollution resulting from erosion of contaminated mine waste, since it can be used to re-vegetate a variety of mine spoils. Because seabuckthorn is naturally resistant to pests, it has limited need of pesticides that are potentially

damaging to the environment. In parts of North America, it has been planted as cover along highways where de-icing salt prevents growth of many other woody plants. Thus, seabuckthorn helps to prevent erosion and release of pollutants from roadsides.

As a Landscape Management Tool: One of the most promising tools to control land degradation is re-vegetation and seabuckthorn is one of the species successfully used on a large scale. It can help to control desertification, conserve land and water resources and integrate economic exploitation with ecological rehabilitation. A living windbreak is a linear arrangement of plants, primarily trees and shrubs, established to reduce harmful effects of strong winds, such as soil erosion. It also helps protect crops, manage snow accumulation and create wildlife habitat. Plants that serve as windbreaks must be resistant to the drying effects and physical injuries caused by wind and seabuckthorn is well suited to this task.

Seabuckthorn Regeneration over Landslides Area

As Maintaining Ecological Balance: It has been observed that a number of wildlife species depend on seabuckthorn stems, leaves, flowers, roots, fruit and seed. In the Loess Plateau of China, 51 bird species are entirely dependent and 80 bird species are relatively dependent on seabuckthorn for their food (ICIMOD, 2006). In winter, the importance of seabuckthorn increases as it is almost the only food available for birds. Seabuckthorn provides long-term benefits in terms of maintaining the ecological equilibrium and improving the environment.

Bird Nest in Seabuckthorn tree

6.2. Socio-economic Uses

As food industry: At present, many factories are producing seabuckthorn food, beverages and other products such as jam, jelly, juices and syrup. Along with traditional foods, some new ones, such as condensed juice, mixed juice, seabuckthorn carrot jam, candied fruit, seabuckthorn cheese, seabuckthorn butter, tea and health protection drinks are also being produced.

As fodder and food for animals and birds: The leaves and tender branches of seabuckthorn contain many nutrients and bioactive substances and these are very good fodder for sheep, goats and cattle. Leaves and fruit residue used as supplementary food can promote growth of animals and poultry. There are no toxic or carcinogenic side effects.

As a food additive: The pigments of seabuckthorn are widely used as a food additive. Seabuckthorn yellow consists of flavours, carotene and vitamin E. Its physio-chemical properties, such as appearance, solubility, color value, heat and light stability and effect of pH and metabolic ions make it a very useful food additive.

As fuel wood: In the Hindu-Kush Himalaya region, plant biomass is the most important source of energy. Seabuckthorn has proved to be a popular green energy plant because of its quality biomass. It is a good source of firewood.

As medicine: About ten varieties of seabuckthorn drugs have been developed and are available in the form of liquid, powder, plaster, paste, pills, liniments, aerosols, etc. These drugs are used for treating burns, gastric ulcers, chilblains, scales, oral mucosities, rectal mucosities, cervical erosion, radiation damage and skin ulcers caused by malnutrition and other damage relating to the skin. The most important pharmacological function of seabuckthorn oil is in diminishing inflammation, disinfecting bacteria, relieving pain and promoting regeneration of tissue.

Seabuckthorn has been shown to have a potent antioxidant activity, mainly attributed to its flavonoids and vitamin C content (Rosch, 2004). Both the flavonoids and the oils from seabuckthorn have several potential applications (Li and Schroeder, 1996). Many health claims are associated with seabuckthorn. The berries seem to have preventive effects against, cardiovascular diseases, mucosa injuries, skin problems, cancer and immune system support. External uses of seabuckthorn include treating a wide variety of skin damage, including burns, bedsores, eczema and radiation injury. This section discusses the antioxitant, cancer, cardovascular, immunie system, skin and other treatments of seabuckthorn including cosmetic uses, which have mainly been taken from Anon, 2005.

> **Antioxidant:** Seabuckthorn berries have high contents of natural, potent antioxidants including: Ascorbic Acid (Vitamin C), Tocopherols (Vitamin E), Carotenoids, Flavonoids - isorhamnetin, quercein and kaempferol, Catechins, Proanthocyanidins and Chlorogenic Acids

Cancer: It has been estimated that 30-40 % of all cancers can be prevented by lifestyle and dietary measures alone (WCRF/AICR, 1997). Protective elements in a cancer prevention diet include selenium, folic acid, vitamin B-12, vitamin D, chlorophyll and antioxidants, such as the carotenoids (carotene, carotene, lycopene, lutein, cryptoxanthin) (Steinmetz, 1996). Drug metabolizing, detoxifying and antioxidant enzymes are important cellular defenses against carcinogenesis. Based on research findings, it is thought that due to the antioxidant proprieties of seabuckthorn, it may have chemopreventive and antitumorigenic efficacy. Research has also shown that the constituents present in the whole extract manifest radioprotection by several mechanisms, like free-radical scavenging, metal chelation, chromatin compaction and hypoxia induction (Goel et al, 2003; Kumar et al, 2002). It has also been reported to provide protection to whole body, various tissues, cells and cell organelles against lethal irradiation.

Cardovascular: There is increasing evidence to support the hypothesis that free radical-mediated oxidative processes contribute to atherogenesis (Eccleston et al, 2002; Ivanov and Nikitina, 1973). Research (in vitro) has shown that antioxidant nutrients have the ability to affect cell response and gene expression. Seabuckthorn is a rich source of antioxidants both aqueous and lipophilic, as well as polyunsaturated fatty acids, which may provide cardiovascular benefits.

Immune System: Seabuckthorn contains several nutrients that may help to strengthen the immune system, by building immunity at the cellular level.

Skin Health: Seabuckthorn seed oil contains a high content of two essential fatty acids, linoleic acid and -linolenic acid, which are precursors of other polyunsaturated fatty acids such as arachidonic and eicosapentaenoic acids. The oil from the pulp/peel of seabuckthorn berries is rich in palmitoleic acid and oleic acid helpful for treating burns and healing wounds. This fatty acid can also nourish the skin when taken orally in adequate quantities of seabuckthorn or its oil are consumed; this is a useful method for treating systemic skin diseases, such as atopic dermatitis. Seabuckthorn oil is already widely used alone or in various preparations topically applied for burns, scalds, ulcerations and infections.

Cosmetics: Many kinds of seabuckthorn cosmetics have been developed and tested in hospitals. It is proved that seabuckthorn beauty cream has positive therapeutic effects on melanosis, skin wrinkles, keratoderma, keratosis, senile plaque, xeroderma, facial acne,

recurrent dermatitis, chemical corrosion and inchthyosis, as well as freckles. Other seabuckthorn extracts can improve metabolism and retard skin maturation.

Others: Seabuckthorn has been shown to have additional health benefits for the liver, including treating liver fibrosis and providing a protective effect for liver injury. Research has shown benefits for gastric ulcer, treatment of chronic hepatitis, healthy mucus membranes and neurotoxicity protection.

II. PROPAGATION TECHNIQUE

1. Environmental Requirements

In natural conditions, seabuckthorn is found growing profusely on a wide range of soil types, but does better in soils with a light physical structure, rich in nutrient compounds, with a pH near neutral. Best growth occurs in deep, well drained, sandy loam with ample organic matter. Under cultivation, seabuckthorn has been grown on various types of soils: on chernozems, brown soils, grey forest soils, turf carbonates, turf-podzols, peaty loams and peaty-swampy soils with various physical structures such as sandy, semi-sandy, semi-clayey and even clayey in all horizons. Keeping in mind, conditions that best fulfill the needs of seabuckthorn root system regarding water and air relationships and soil pH near normal. Very light, sandy soils have low water carrying capacity and are also low in nutrient mineral elements; so without the previous addition of organic matter, are not appropriate. Similarly inappropriate are clayey soils, with high density and water retention characteristics. However, environment conditions discussed below are supposed to make the seabuckthorn propagation idea.

Temperature

Seabuckthorn belongs to the group of thermophilic plant because it needs higher temperature to germinate seeds than those of apple and cherry which can germinate at 1 to 3°C. Seabuckthorn seeds germinate only 13.2% at 12°C over a period of 47 days but if the temperature goes up to 24 to 26°C, 95% of the seeds will germinate within six days (Lu, 1992). During a study of germination and seedling growth of *H. salicifolia* and *H. tibetana*, Pyakurel (2001) found 20°C to be the best temperature to germinate seeds (growth enhanced by application of 10 ppm of gibberellic acid). He found that lower temperature decreases the germination and at 35°C, the germination was almost zero. Seedlings of *Hippophae* grow proportionately to the seed germination (Pyakurel, 2001) and it is unanimous that seedling grows best at that temperature where the seed germinates well (Koller et al, 1962).

Notwithstanding, an adult seabuckthorn plant can withstand extremely low temperatures; during the winter season air temperatures of -10 to -13°C are common in its natural habitat. It has been reported that seabuckthorn can endure an extreme minimum temperature of -40.4° C (in Northern China) and -43°C (in the Gorky State of the former USSR) without sustaining long-term damage (Lu, 1992). It has been mentioned that *Hippophae* contains several species and sub-species that are widely distributed throughout various physical environment of Eurasia and Asia, therefore it is understood that they survive in different climatic conditions.

Moisture

According to Lu (1992) and Ghaffar (1997), though seabuckthorn is a hydrophilous plant, it has developed some xerophytic features. In its natural habitat, it thrives well on river banks, valleys and shady slopes of mountains where air temperatures and soil conditions do not suit many agricultural crops. Most natural population grows in areas receiving 400 to 600 mm of annual precipitation. Seabuckthorn plantation is not considered good in the sites where the annual rain fall is less than 400 mm, the underground water below 2 m and where there are no irrigation facilities. Natural seabuckthorn populations are widely distributed throughout the temperate zones of Asia and Europe and in the subtropical zone of Asia and higher altitudes. In the mountain areas, the most suitable altitudes are between 1500 to 2500 m where precipitation is about 600 mm and the mean annual temperature is 4 to 8°C, as a result of which plants grow well and produce large, good quality fruit (Lu, 1992).

Soil

In the natural environment, thriving seabuckthorn plants are found on sloping, well-drained soil with silt and on the banks of rivers, lakes and seashores. This is the reason why many researchers considered these soils to be most suitable to the biological characteristics of seabuckthorn. Indeed, these soils provide seabuckthorn with enough water, air and fertilizer, thus making it grow well and producing fine fruit. Some plants have proved successful even on sandy and stony soil. Heavy clay may be suitable in some areas but only if internal drainage is good. The plant cannot withstand soil with poor porosity. Excess water and lacking of air would kill the plant. Extensive measurements taken for wild seabuckthorn populations in north and north-western China have shown that the plants thrive in soils ranging from pH 6 to 7, but in other places, they have been found in soils ranging from pH 5.5 to 8.3 (Lu, 1992). This indicates that soil acidity and alkalinity are probably not limiting factors but the experiences on plantations have shown that the productivity of seabuckthorn can be increased greatly by providing enough water and fertilizer (Lu, 1992). Researches have shown that the best soil composition in the polypot and plain bed should be prepared by mixing sand, humic soil and soil from seabuckthorn forest in the ratio 5:3:1 (Huo et al, 1989).

Salinity

Seabuckthorn is also a salt-tolerant plant because it grows well on the soils of wastelands, deserts and dunes of the seashore that have highly concentrated salt contents. It can also be used to reduce the soil salinity. When tested in the laboratory, some varieties of seabuckthorn showed increasing growth of seedlings when about 0.15% of sodium chloride solution was added. Furthermore, before sowing, soaking seabuckthorn seeds in 0.15% of sodium chloride solution

for 24 hours not only produced healthy seedlings but also increased the output of standard seedlings in nurseries (Lu, 1992).

2. Cultural Management

Drainage and Irrigation

Seabuckthorn can tolerate a little drought but it is a moisture sensitive plant especially in the spring when plants are flowering and young fruits are beginning to develop. Planting in arid or semi-arid areas, water must be supplied for establishment. For economic reasons, seabuckthorn plantings should be restricted to areas receiving a minimum of 400mm of annual precipitation, unless irrigated. It cannot tolerate over the crown, high water table or long-term inundation (two weeks), therefore situating plants on sandy loam soil on slight slopes with good drainage is best. The optimal soil moisture for mature, seabuckthorn, depending on soil type, is around 70%, inadequate soil moisture causes a reduction of leaf area and fruit set. Seabuckthorn has high requirements for nutrient mineral element content of the soil. The micro-element consumed in the highest quantity is phosphorus. It is indispensable for the normal life process of the nodules on the roots. The plant requires little nitrogen, and potassium is negligible.

Soil Testing

Results from a soil analysis are the most accurate guide to fertilizer and lime requirements. It is important to determine soil fertility and pH levels before planting, so that necessary lime and fertilizer can be applied to the soil.

Fertilizer Recommendations

Seabuckthorn, just like any other crop, requires adequate soil nutrients for a high yield of good quality fruits. Seabuckthorn responds well to phosphorus fertilizer, especially in soils low in phosphorus. Fertilizer recommendations should be based on the results of soil analysis.

Method of Fertilizer Application

There are various methods of fertilizer application. It can be broadcast on the soil surface and incorporated into the soil with tillage. Top dressing method can be used when seabuckthorn is growing.

Lime

Seabuckthorn can tolerate a wide range of soil pH, but a pH level between 5.5-7.0 is ideal. Soil acidity can be corrected by the application of lime. Use of some dolomitic limestone is recommended since it contains a significant quantity of magnesium which is an essential and often deficient plant nutrient. Quick lime, caustic lime, and burned lime are not recommended on agricultural land.

Manure or Compost

Manure or compost supplies plant food over a period of time, cow and poultry manures are commonly used. Maximum application rates of dairy manure should be about 45 tonnes/ha and poultry manure should be applied at no more than 20 tonnes/ha on cropped land.

Cover Crops

A cover crop before the land is to be planted with seabuckthorn is valuable in increasing organic matter in the soil and preventing nutrient losses and erosion by wind and water. Barley, oats or winter cereals such as winter wheat and fall rye at the rate of 80-150 kg/ha can be seeded in the fall and plowed under in the early spring to allow decomposition before seabuckthorn planting.

Nutrient Deficiencies and Corrective Treatments

There is very limited information in the literature regarding the nutrient deficiencies on seabuckthorn. Some of the information is based on other crops, fertilizer recommendations are quoted from other countries research institutes publications as follows:

Symptom	Deficiency	Treatment
Foliage is pale green or yellowish and later leaf senescence and dehiscence are accelerated, plants are smaller thannormal, leaf area is reduced	Nitrogen and/or phosphorus deficiency	Nitrogen and phosphorus fertilizer should be applied early in the spring in the forms of ammonium nitrate around 20g/m2 and phosphate fertilizer (superphosphate) should be added in the fall at a rate of 20-30g/m2, the rates should be based on the results of soil analysis.
Pale leaf colour, marginal	Potassium deficiency	Potassium fertilizer should be added

chlorosis, scorch, hortening of stem internodes, death of the terminal bud		with the phosphorus at 20-25g/m2 of potassium chloride.
Terminal leaves normal, basal leaves marginal chlorosis with V pattern, this symptom occurs when potassium is high or soil is acid, especially in young, vigorous trees and defoliation begins from the base of shoots and progressively affects the leaves above	Magnesium deficiency	As required Custom blend
Delayed opening of flower and leaf buds in the spring, small chlorotic leaves, shortened internodes and little leaves along the shoot, reduced growth and small fruits	Zinc deficiency	As required Custom blend
Loss of chlorophyll and leaves become chlorotic, interveinal areas become yellow but the veins remain green, symptoms develop first on young leaves	Iron deficiency Iron deficiency can result when there is insufficient iron in the soil, sufficient but unavailable iron or sufficient and available iron that is not properly utilized in the plant	As required Custom blend

Other Symptoms caused by Physiological Factors

Symptom	Factor
Smaller crowns and lower yields	Result of shading effect. Seabuckthorn can only be grown on well-lit unshaded areas
Poor growth and beginning of rot at the root zone	Too much water or ground water level is too high. Plant seabuckthorn on slight slopes or sandy loam soil with good drainage
Small leaf area and low fruit set	Lack of adequate soil moisture. Seabuckthorn is a moisture loving crop which needs irrigation regularly especially in the summer
Die back of branches with late emerging small leaves	Winter or frost damage
Breakage of branches	Heavy damp snow clings to branches
Leaves wilt, turn yellow and drop	Lack of moisture

3. Planting

Sterilization and Fumigation of Soil

Normally soil fumigation is not needed before seabuckthorn planting unless the field is known to be infested with disease in previous crops, which may affect seabuckthorn, an example would be root type crops.

Land Preparation

Ideally, soil preparation should begin at least a year before planting. Planting site should be well cultivated, removing all the roots of perennial weeds. Depending on soil analyses, a good cover crop, such as rye or green vegetable, before planting is recommended to increase organic matter in the soil. Light sandy soil has low moisture retention capacity and may be improved by the addition of organic matter, manure or various composts. If the soil pH is too low, liming the entire surface is necessary, also clay and heavy loam without mineral improvements are unsuitable for seabuckthorn.

Propagated by Seeds

Propagation from seed is relatively simple and produces a large number of seedlings at fairly low cost compared with other propagation methods. Seeds can be stored up to 3 years before lost viability.

Seed Treatment

For seabuckthorn, seed can be treated with hot water, some chemicals or bleaching solution before seeding for higher performance of seed germination.

Hot water

Prior to sowing, the seeds should be soaked in water for 48 hours and at this time seeds that are floating should be discarded. Soaking in cold water can also be done for three days prior to sowing. Other reports indicated that soaking seeds at a temperature of 70º C and stirred intermittently until the temperature drops to 10-15º C then leave standing 48 hours may improve germination rate. The results from experiment indicated that the water temperature did not show any significant differences for germination rates, but seed soaking before seeding shortened the days required to start and complete germination compared to non-soaking seeds.

Chemical

Experimentally, seeds were treated with GA_3 and KNO_3 (rooting hormone) for 48 hours before seeding which did not improve germination rate significantly among species tested.

Bleach Solution

To prevent fungal infection of cotyledon on emergenge, it is recommended that soaking should be performed for a 20-minute in 10% bleach solution before planting. The ratio of 10 parts water to 1 part bleach is based on 5.25% sodium hypochlorite content, which is the normal concentration in household bleach.

Direct-Seeding Outdoors - Seed Depth and Germination

The results from experiments indicated that seeding at soil surface has significantly higher emergence rates than the depth of 1 and 2 cm. Soil should be irrigated (mist) periodically to prevent seeds drying out. If seeding in late spring, seeds should be covered with a very light layer of soil. Seeds should start to germinate within 5-10 days based on the condition of the seeds and the species of seabuckthorn. A number of seeds per planting site is recommended at spacing of 1 m within the row and 4 m between the rows.

Seeding Indoors and Transplanting

Seabuckthorn seeds can be seeded indoors in pots, in sterilized soil, in January or early February, one seedling per pot is allowed to grow for 3 months before transplanting in early May. Manufactured tree seedling trays can be used for early greenhouse mass production. Size recommended is 2"-4" diameter - 12" deep. Spring is the best time for planting seabuckthorn. On light sandy soil, the root is buried 6-8cm deep to encourage the development of another tier of roots. They should be watered once every week after transplanting. In orchard planting, a spacing of 1 m within the row and 4m between rows is recommended, although high density planting of 1X1 m is being considered in Europe. Rows should be oriented in a north–south direction to provide maximum light.

4. Propagation by Cuttings

Cuttings produce rooted plants with the same genotype as the parent plant. The cuttings will bear fruit 1-2 years earlier than seed propagated trees. Seabuckthorn can be propagated using hardwood, softwood cuttings, layering or suckers.

Hardwood Cuttings

Hardwood cuttings should be chosen from healthy, well-developed plants in fruiting stage. Cuttings (15-20 cm long) should be taken from the previous year’s growth during dormancy in the late fall or in the early spring. One week before planting, bundles of cuttings are soaked in water (room temperature and change once a day) and covering 2/3 of their length until the beginning of root formation. Cuttings can be transplanted when the roots are 1-2 cm long. Rooted cuttings can be directly planted outdoors in the field, but planting in pots, under a controlled environment for 1 to 2 months before transplanting will give better results.

Softwood Cuttings

The advantage of softwood cutting propagation is its high success rate. Softwood cuttings (15-20 cm long) are taken when shoots begin to become woody. Remove the lower leaves, leaving 2-4 leaves at the tip and dip into rooting hormone before rooting in media such as sand. Pay special attention to the moisture of the media (mist). Root cuttings should be planted in pots for 1-2 months before transplanting to the field.

Root Cuttings and Suckers

Root cuttings also can be an effective propagation method for seabuckthorn. Root cuttings are planted in pots in a greenhouse for 6-8 weeks before transplanting to the field in spring. Seabuckthorn easily produces suckers within a few years of planting, which is a good source for propagation, but sometimes do not carry the good genetics of the mother plant.

5. Male/Female Ratio

For economic reasons, the ratio of male to female plants is important, as the number of female trees in each planting directly affects the total yield. If seedlings of unknown sex are planted, it may result in an uneven distribution of male and female plants within each planting. There are two approaches to avoid this problem, remove male plants and replace with female plants, or vegetative propagation from mature plants of known sex. Recommendations for male and female ratio vary from 6 to 12%. A report from Siberian Institute of Horticulture in Russia indicated that one male:female mixed row for every two rows of female plants and in the mixed row every fifth plant is male. This design gave significantly higher total yield than other designs. It is estimated that orchard planting with 4,000 trees per hectare and 1:6 male and female ratio, should yield approximately 10 tonnes.

Pruning

The purpose of pruning seabuckthorn is to train branches, promote growth and facilitate harvesting. Moderate pruning will increase the yield and fruiting life of the plants. The crown should be pruned to remove overlapping branches, and long branches should be cut to encourage development of lateral shoots. Mature fruiting plants should be pruned to allow more light penetration. Pruning is also recommended to eliminate thorns on the mature wood to facilitate harvesting.

Mulches and Row Covers

In an orchard planting, it is ideal to have row covers such as grass between rows to reduce loss of soil moisture. Mulches between trees within the row will reduce the cost of weed control and keep soil moisture and temperature to promote better growth. The use of black plastic during first 3-4 years from seed is ideal for moisture conservation and weed control.

6. Pest Management

Insects, Diseases and Others

At present time, seabuckthorn has relatively few pests and diseases. In tea production (leaves) the most damaging of insects is the green aphid (Capithophorus hippophae), which can be controlled with an insecticide soap. The most serious diseases in seabuckthorn is verticillium wilt, scab, damping-off and fusarium wilt. Mice and rats are other pests, which can destroy and girdle the trunk or chew up roots. Game birds, such as pheasants or grouse eat berries during the winter months, but ordinary birds do not touch. There are no insecticides and fungicides registered in Canada for seabuckthorn.

Weed Control

Weed control or vegetation management is very important in seabuckthorn plantings. Proper weed control promotes growth of newly planted seedlings. Only low concentration of herbicides should be used. Several chemicals are registered in Canada for weed control. As stated, black plastic may be used to control weeds during orchard establishment, also to retain standards for organic production.

III. HARVESTING TECHNIQUE

As discussed earlier, the harvesting technique of the local people was the major concern in the sustainable management of seabuckthorn forest. The current harvesting practice seemed to be destructive and good harvesting techniques are necessary. The harvesting of ripe fruits of seabuckthorn is the most difficult and time consuming operation (Li and McLoughlin, 1997; Dwivedi et al, 2006) because it is highly thorny and fruit being soft, small, delicate and highly perishable and attached strongly to the plant poses difficulty in the operation. There are several techniques of harvesting fruits being practiced in the developed countries like Canada and China. The harvesting techniques have been discussed here and tried to find out the better options for the locality.

1. Hand Picking

Hand picking of fruits from the standing tree was not a general practice for seabuckthorn in Mustang because it is a time consuming process and as trees are tall, it is difficult. More than that while picking the berries by squeezing with the help of hand, some of the berries get ruptured resulting in the loss of juice. Some of the schoolteachers, officials and other interested people who want to ensure the hygiene of the juice may not like this method. It is a pretty time consuming method and requires better passion. Obviously, it is a labor-intensive method, so requires more investment.

2. Cutting of the Branches

Cutting or slashing of the branches / branchlets is not a legal approach in Mustang but due to difficulty in other methods, the local people were allowed to cut branches on the specified period of time to harvest fruits. This method is quicker and easier than hand picking. One person can harvest about 2 kg of ripe fruits per hour by this method (field study, 2006; Dwivedi et al, 2006).

3. Beating the Branches using Sticks

It has been observed that harvesting of fruits is comparatively easier and effective in early morning hours before sunrise when the air temperature is almost 0º C, since subsequently fruits develop turgidity and after sunrise it becomes difficult to harvest (Li and McLoughlin, 1997). Some of the people use sticks to shake the berries from the plant and drop down the fruits. The positive aspect of using shaking method to harvest the berries is that one does not have to suffer

from the thorns and the picking becomes easy and quick. But the negative aspect of adopting this method is that all the dried leaves and other unwanted parts of the plants including the insects also get mixed along with the berries and the juice. The berries must be completely ripe to ensure the complete harvesting by this method. A greater difficulty with of this method is that as the temperature increases the fruits do not fall and all the branches are not accessible in the tree. Use of ladder has also been practiced to reach the height of the tree.

4. Mechanical Harvesting/Shaking

Except when frozen on the branches, fresh fruits mechanical harvesting method is still in the development stage. Principally, this is due to the difficulty in separating the stem (pedicel) from the berry (pericarp). Prairie Agricultural Machinery Institute, Partage La-Praire (Canada) has designed an individual branch shaker for harvesting fruits. The branch shaker shakes the branches with a frequency of 1200-1500 cycle per minute and amplitude of 1-1.25 inch and takes about 30 second to harvest approximately 70 % of ripe seabuckthorn fruits (Dwivedi et al, 2006). However, mechanical harvesting/shaking needs huge money and power and sufficient space, which is not currently possible in Mustang.

5. Using Forks

Forks, used in kitchen can be better in the sense that people have been using such equipments as they found it easier to work with (Nepal and Adhikari, 2003). More than that, the essence of using forks is that it can be used to get the berries from the plant without any loss of juice and without damaging the plant itself. Plus, in terms of hygiene, it is better than other options as it is used to collect the berries much selectively. It can be a bit more time consuming in comparison to some of the other options.

6. Using Mineral Water Bottle

In Manang, some local people are adopting using mineral water bottle direct from the plant (Nepal and Adhikari, 2006). The bottom part of mineral water bottle is cut in such a way that it looks like U-shaped fan. With the help of rope and a long stick, the berries can be collected without damaging the plants. For the conservation of resources, this method seems very nice but it is not economically feasible. Per unit time harvest of the berries is very low in comparison to the other methods tested (Nepal and Adhikari, 2006).

Easiness of the tools and technique is one aspect that draws more attention of the harvesters. No matter how efficient is the method, harvesters may not accept and use the recommended option if it is not user-friendly. There is no doubt that the local people are those who have gathered lots of experiences from the history and modified themselves to meet the newer challenges by developing their own skills and knowledge's. In this context, it is imperative that the scientific verifications must analyze the local knowledge base and if possible, should add more innovations as to make the skills and tools locally used by the local people. Providing due respect to the local knowledge base and based on the scientific information shaking/beating could be better option. The local method of using mineral water bottle may also hold good. For the remaining berries, kitchen forks or modified bi-furcated hooks can be used. If some community based resource management options are used, these options may be practicable and sustainable and may reduce the branch cutting.

7. Post Harvest Handling and Storage

After harvest, the berries should be placed in shaded area in flats no more than 6 inches (15.24cm) deep. Pre-cooling for storage is advisable if high temperatures (20° C) at harvest, especially if breakage occurs at harvest and before cleaning. Fresh market berries, after cleaning, should be delivered and sold within five days. After cleaning, residue (burst berry etc.) can be included in fruit shipment for processing (jams, soils, etc.), where quick frozen, remaining at -18° C until required in processing plant. Seabuckthorn does store very well. Respiration is minimal in comparison to other berries such as saskatoons or raspberries. During storage at 20° C, the respiration rate comparison is saskatoons 100, raspberries 200 and sea buckthorn 50. If berries are to be transported to a processing plant, growers should build a pre-cooler on their property, relative in size to yield. A walk-in type cooler/wind tunnel is relatively inexpensive to construct. Maximum containment in cooler of ten days is recommended before shipment in cooler transport, to the processing plant. Transport should be contained (once fruit is cooled) in plastic wrapping, and then placed in cold storage at the processing plant at a temperature below freezing (-1 to -2° C) if processed within 30 days. Fruit can be frozen to -18° C for long-term storage (1 year) without further loss of ingredients.

IV. MERCHANDISE FROM SEABUCKTHORN

The basic processed seabuckthorn products are juice, beer, wine, jam, preserves, compote and tea (from leaves). Essential oil from seeds and berry pulp are the most valuable product, which has medicinal values. High contents of Vitamin C and carotenes are another valuable natural product. Considerable research is currently being conducted into the health-foods, pharmaceutical, cosmeceutical and nutraceutical applications of seabuckthorn. Followings are some of the products, which can be manufactured locally and easily sold in the markets in a reasonable price.

1. Squash

The squash can be formulated with 25 % crude juice, 40 – 45 % sugar and remaining water. Sugar mixed with water is boiled and then juice is mixed. It is again boiled for a moment and squash is prepared. About 0.5 gm of potassium meta-bisulphide can be used for one litre of squash if it has to be stored for several months. It needs dilution with three parts of water before serving. The squash does not need any extra artificial flavors and colours as the juice contain its natural yellow and orange red colour and orange flavors.

2. Tea

Tea can be prepared from fruits and leaves. From leaves, the collected leaves can be quickly washed to sure the removal of dust particles. It should be fried for a while and twist it. Frying should be continued by stirring the leaves. It should be moistened after this frying. Second stir-frying should be continued and flutter it. It makes the leaves into dust particles and ready. Now it can be packaged and sterilize to store for long duration. This tea can be used as commercial tea by mixing in hot water and serves with sugar if necessary. From the fruit, the juice of fruit can be used just as making lemon tea because the juice is very sour and nutritious.

3. Jam

Best quality jam can be prepared out of the fruit extract. The jam is prepared with 0.75 % pectin, 10 % juice, 70 % sugar, 1.14 % acid and remaining water. These are boiled till paste is prepared and then cooled.

4. Wine

The juice contained less amount of sugar and excessive amount of acid to make the wine, so addition of water and sugar is essential. The wine made with 10 kg sugar, 2 gm ammonium sulphate, 1.35 kg fruit juice and 38 litres of water should be mixed and heated to 60º C for about five minutes and then cooled. About 10 % of activated wine yeast should be added in the heated mesh and allowed to ferment for 3 – 4 weeks. Within that period, the fermented mesh produce a fine taste and flavor of wine. However, maturation for 6 – 8 months enhance fine aroma and clarity in the wine.

5. Juice Powder

The juice power can be prepared by mixing 100 gm of juice in a kilogram of sugar and 36 gm of acid and dried, preferably in electric oven at about 40 – 50º C and ground to powder. This powder easily mixes with water and gives a taste of seabuckthorn squash.

6. Fenugreek Pickles

Fenugreek is good for controlling blood sugar, Fenugreek seed and radish seeds should be roasted till dark brown in colour and grind to a fine powder separately. Other ingredients like, mustard seed, black pepper, cumin, ginger, turmeric, asafetida, salt powder and seabuckthorn juice and water should be mixed together in a steel vessel and boiled for 10 – 15 minutes. At the end, sodium benzoate should be mixed well and the mixture should be filled in a wide mouth previously boiled bottles. The lids of the bottle should be kept tight while hot.

5. LOCAL BIOMASS TABLE

Diameter at 30 cm (in cm)	Oven Dry Weight of Wood in kg	Fresh Weight of Fruits in kg	Oven Dry Weight of Leaves in kg
1	0.04	0.00	0.02
2	0.22	0.00	0.05
3	0.60	0.00	0.08
4	1.23	0.21	0.12
5	2.13	0.29	0.16
6	3.36	0.37	0.21
7	4.93	0.46	0.26
8	6.87	0.56	0.31
9	9.20	0.66	0.37
10	11.96	0.76	0.43
11	15.15	0.87	0.49
12	18.81	0.99	0.55
13	22.95	1.11	0.61
14	27.60	1.23	0.68
15	32.76	1.35	0.75
16	38.46	1.48	0.82
17	44.72	1.61	0.89
18	51.55	1.75	0.96
19	58.96	1.88	1.04
20	66.98	2.03	1.11
21	75.62	2.17	1.19
22	84.89	2.32	1.27
23	94.81	2.47	1.35
24	105.39	2.62	1.43
25	116.64	2.77	1.51
26	128.59	2.93	1.60
27	141.24	3.09	1.68
28	154.60	3.25	1.77
29	168.70	3.42	1.86
30	183.53	3.58	1.95
31	199.12	3.75	2.04
32	215.47	3.92	2.13
33	232.60	4.10	2.22
34	250.52	4.27	2.32
35	269.24	4.45	2.41
36	288.77	4.63	2.51
37	309.12	4.81	2.61
38	330.31	5.00	2.70
39	352.35	5.18	2.80
40	375.24	5.37	2.90
41	398.99	5.56	3.00
42	423.62	5.75	3.10
43	449.14	5.95	3.21
44	475.56	6.14	3.31
45	502.89	6.34	3.42

6. ACRONYM

ACAP	Annapurna Conservation Area Project
ANSAB	Asia Network for Sustainable Agriculture and Bioresources
cal	Calorie
cm	Centimeter
ComForM	Community Based Natural Forest and Tree Management in the Himalaya
DANIDA	Danish International Development Agency
DSCO	District Soil Conservation Office
gm	Gram
ICIMOD	International Centre for Integrated Mountain Development
INGO	International Non Governmental Organization
IoF	Institute of Forestry
kg	Kilogram
km	Kilometer
m	meter
mm	Millimeter
NARMSAP	Natural Resource Management Sector Assistance Programme
NGO	Non Governmental Organization
ppm	Parts per million
Spp	Species
TISC	Tree Improvement and Silviculture Component

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