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Seabuckthorn a new approach in ecological restoration of Himalayan Ecosystem: A review

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Abstract
Seabuckthorn belongs to the family Elaeagnaceae is a multipurpose plant for soil erosion control, wildlife protection, land reclamation, soil improvement and ecological restoration which is mostly found in cold mountainous regions. The wide adaptation, fast growth, strong coppicing and suckering habits, coupled with efficient nitrogen fixation, makes seabuckthorn plantation suitable for soil and water conservation and reforestation for fragile mountain areas. As soil is a dynamic habitat for an enormous variety of life forms provides mechanical support to the plant but also provides nutrients for its growth and development which can only be achieved if the soil is healthy and fertile. It provides us various products (health food, cosmetics and medicines) and is also a popular fodder, fuel wood and soil binder in cold deserts of Himalayas. Especially, seabuckthorn plantation has an obvious role in improvement of soil organic carbon and available N which are two most important factors in improved soil fertility. It thus qualifies as a unique option for the simultaneous management of several problems emanating from the fragility, marginality, inaccessibility and diversity characterising in mountain areas. Hence for biodiversity conservation, seabuckthorn plantation in cold deserts can play a significant role in combating soil erosion, enhance soil quality and fertility, solve the threat of climate change and also will make the people of Himalayan ecosystem economically strong.

Keywords: Conservation, ecological restoration, Himalayas and soil improvement

1. Introduction
The Himalayas are the youngest and loftiest among the mountain systems of the world and are major component of global environment. The glaciers of Himalayan ecosystem are largest resource of snow and ice, feeding perennial rivers that are source of drinking water, irrigation and hydropower for a large human population within and outside the mountain region. Also, according to Agenda 21, adopted by the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992, explicitly recognises that mountain ecosystem and uplands are a major source of different ecosystem services (Provisioning, Supporting, Regulating and Cultural Services) interlinked with global environment (UNEP, 1992; Li *et al.,* 2014) [54, 26].

Himalayan ecosystem is an ecologically sensitive region characterized by harsh conditions like extreme temperature, high UV radiations, high wind velocity, high rates of soil erosion, decreasing soil fertility, scarcity of fuel wood, sparse vegetation and a high degree of instability (Sharma, 2002; Sharma *et al.,* 2009; Tewari and Kapoor, 2013) [44, 42, 51].

Himalayan ecosystem is most affected by climate change (Singh *et al*. 2010) [46]. The predicted rise in temperature is more than 3^{o} C by the end of the 21st century. Sea level rose during the 20th century by 0.17 meters. By 2100, sea level is expected to rise between 0.18 and 0.59 meters. Intergovernmental Panel on Climate Change (IPCC) was able to conclude in a cautiously worded statement that "the balance of evidence suggests that there is a discernible human influence on the climate" (Attri, 2006) [4]. Also, the fifth assessment report of the IPCC has concluded that there is an unequivocal evidence of current trends of global warming of earth's atmosphere caused by greenhouse gas emissions and predicts serious effects of climate change including reduced crop yields leading to increased risk of hunger and greater risk of water stress. The fractions of the global population that will experience water scarcity and be affected by major river floods are projected to increase with the level of warming in the 21st century (IPCC, 2014) [21].

Fig 1: Spiti Valley, Spiti

Also, the Himalayan ecosystem is vulnerable to adverse impacts of global climate changes on account of both natural causes and anthropogenic emissions arising out of unplanned developmental activities in the region. Which will result in a) natural disasters like storms, landslide and avalanches, b) deforestation and degradation, c) melting of glaciers causing floods leading to habitat fragmentation and species loss, d) deterioration of infrastructure, e) loss in biodiversity are expected to become more common which will effect on environment and people's health, agriculture, forests, water resources and species and will pose major danger to the economy of the country especially farmers who are totally dependent on the services provided by the Himalayan ecosystem (Barnett *et al*., 2005; Xu *et al*., 2009; Bali *et al.*, 2011) [7, 57, 6].

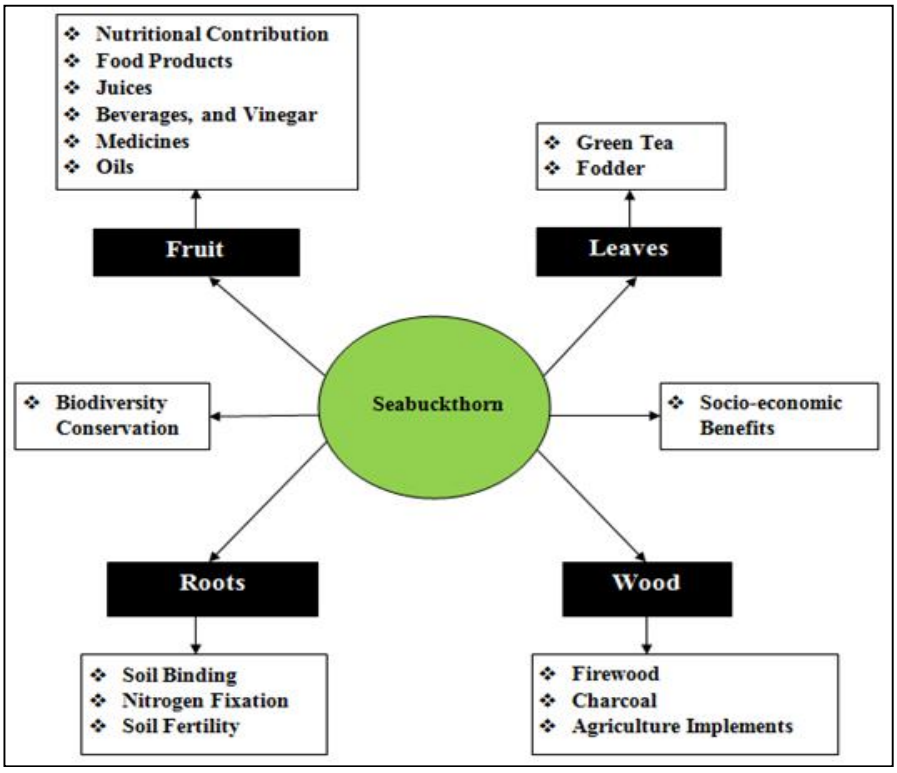

Fig 2: Different attributes of seabuckthorn

To solve all these problems this study was designed to determine role of seabuckthorn in rehabilitation and upgrading of fragile Himalayan ecosystem through soil binding and creating environmental balance. Seabuckthorn afforestation will not only conserve fragile Himalayan ecosystem by greening the cold desert, controlling soil loss and increasing soil nutrients but its plantation will also be economically beneficial for the farmers by providing job opportunities and a sustainable livelihood.

Hippophae rhamnoides L., commonly known as seabuckthorn is a cold resistant, nitrogen fixing, deciduous and thorny shrub of 1-5 m belongs to the family Elaeagnaceae. Seabuckthorn grows at high altitude of 2000-5500 m asl in cold deserts of Asia and Europe and is adapted to extreme climatic conditions of low temperature upto –43 ºC and can tolerate high temperature of + 40 ºC (Rousi, 1975; Rongsen, 1992) [36, 35]. In India it is found in high altitudes of Himachal Pradesh, Ladakh (Jammu and Kashmir), Uttranchal, Sikkim and Arunachala Pradesh. There are 6 species, *i.e. Hippophae rhamnoides*, *Hippophae salicifolia*, *Hippophae tibetana*, *Hippophae goniocarpa*, *Hippophae gyantsensis* and *Hippophae neurocarpa* and 12 subspecies of seabuckthorn out of which three species are found in Indian Himalayas: *Hippophae salicifolia*, *Hippophae rhamnoides* subsp. *turkestanica* and *Hippophae tibetana* (Singh *et al.*, 1995; Singh, 2003) [47, 48].

Latest research showed that seabuckthorn can be used as cold tolerant transgenic in other crops which may not only bring additional areas under cultivation but also help in optimizing productivity in high altitude and remote areas (Gupta and Ahmed, 2010) [19].

Spiti is a cold desert mountain valley located high in the Himalayan Mountains in the north-eastern part of the Indian state of Himachal Pradesh situated between the mountain ranges of Great and Middle Himalayas. Spiti valley is situated at an average elevation of 4000 m ASL, with geographical area of 5,582 sq km lying between 32º 05'55.1"-78º 21'99.8" Latitude and 32º 26'72.0"-77º 53'81.1" E Longitude.

There are excellent stands of *Hippophae rhamnoides* growing in higher altitudes areas at (Tabo 3390 m asl), Shichling (3520 m asl), Lingti (3560 m asl), Shego (3615 m asl), Rangrik (3790 m asl) and Hansa (4040 m asl) (Sharma, 2011; Sharma and Singh, 2017a) [42, 40].

Fig 3: Seabuckthorn stand growing at Lingti

2. Ecological Characteristics of Seabuckthorn

Ecological characteristics can be summed up as wide ecological adaptation, fast growth, strong coppicing and suckering habits coupled with efficient nitrogen fixation. These all characteristics make it well suited for soil conservation, soil improvement, marginal land reclamation and ecological restoration. A considerable body of literature exists documenting that seabuckthorn is a multipurpose wonder plant sustaining the ecosystem as well as fulfilling needs of human being.

3. Strong Root System

Seabuckthorn has a very strong root system and outstanding ability of holding soil on fragile slopes of hill tops and mountain system.

The root system of seabuckthorn not only grows up and respires in soil but also suck up the moisture and nutrition material for the plant growth. The tap root (vertical root) system of 5 year old plant goes upto 3 m deep and horizontal root system spreads upto 6-10 m binds large area of soil and decrease loss of topsoil less than 30 per cent and more water will be held in the soil (Rongsen, 1992) [35].

Yang *et al.,* (2014) [58] recently studied the effect of Seabuckthorn Flexible Dam (SFD) on soil erosion of the Pisha Sandstone area of Loess Plateau, China and results showed that on comparison between gully with the SFD and without SFD; there was strong sediment retention capacity occurred in the SFD gully and seabuckthorn had good horizontal expansion capacity by its roots making it successor of ecological restoration and soil improvement. Similar results of control in soil loss by use of seabuckthorn were authenticated by (Bi and Li, 2003; Li *et al.,* 2009) [10, 28].

In seven year old seabuckthorn forests, 99.6 per cent of runoff and 96.6 per cent of sediment reduction against waste mountain land was reported. Therefore, the canopy and litter can regulate surface runoff and increase the soil infiltration capacity effectively (Quanzhong *et al.,* 1989) [34].

Tamchos and Kaul (2015) [50] demonstrated that seabuckthorn has a extensive root system reportedly prevents wastage of 90 per cent runoff water and contributes a check on soil erosion upto 95 per cent.

4. Nitrogen Fixation

Seabuckthorn has an outstanding ability to take roots even in poor soil, because of its ability to fix atmospheric nitrogen through the presence of symbiotic bacteria *Frankia (Actinomycetes)* in the root nodules. Root nodules of seabuckthorn fixes 180 kg of nitrogen/ha/year, which generally improves soil fertility and therefore allows fast growth of grasses and other crops and trees. The resulting improved root growth enhances the entire soil ecosystem in the form of rich organic matter, more oxygen and more soil organism, which means more soil biodiversity (Rousi, 1971; Jike and Xiaoming 1992; Xiaoning *et al.* 2002) [36, 22, 55].

The role of *Hippophae rhamnoides* in the mixed stands with *Populus* sp. and *Salix matsudana* was studied in Liaoning, China. The results showed that *H. rhamnoides* played a significant role in N supply. The accumulated nodules in 4 to 7 year-old *H. rhamnoides* stands were 2650.7 kg/hm^2 and the accumulated amount of N fixed was 378 kg. The annual average N-fixation was 54 kg/hm^2 in a 7 year-old stand. Compared with pure stands of *Populus* sp. and *Salix matsudana*, the N content of the soil of mixed stands was increased by 20-22 per cent, and the height increment of the main tree species increased by 18-19.4 per cent. All of the plants characteristics especially its strong nitrogen-fixing ability and rapid growth, makes seabuckthorn a good species for improving soil fertility (Xingyuan *et al*., 1996) [56].

Chengjian and Daiqiong (2002) [14] found that root nodule of *Hippophae rhamnoides* can fix nitrogen and also decomposition of litter, press and cementation of root system and decomposition of dead root improves soil structure and make nutrient elements return to soil to keep the soil nutrient balance. Another study by Tian *et al.,* (2002) [52] observed that root nodules of *Hippophae tibetana* with VA mycorrhizae and *Frankia* can stimulate the growth and the nitrogen fixation ability of the host plant.

The effects of mixed *Hippophae rhamnoides* on community and soil in planted forests in the Eastern Loess Plateau, China were examined and results showed that *Hippophae rhamnoides* had significant positive effects on community structure, species diversity, soil physical and nutrient conditions in mixed forests over pure forests (Zhang and Chen, 2007) [59].

5. Effects on Soil Fertility

Seabuckthorn plays a very important role in improving soil fertility. It is pioneer plant within a fragile and marginal context which produces biomass both above and underground through the metabolism of leaf litter and dead roots. This biomass is transformed into organic minerals by the activities of microbes in the soil which improve nutrients and hence raise soil fertility.

Seabuckthorn plantation has played a crucial role in improving the soil health with the enrichment in soil organic matter that is one of the important nutrients to soil which has led to increase in soil fertility (Gou, 2003; Gong *et al.,* 2007; Sharma and Singh, 2017b) [18, 17, 41].

Zhang *et al.* (1998) [61] studied several types of forest stands, the effect of vegetation and land use on the surface soil in the Wutai Mountains of Shanxi Province, China and found that the seabuckthorn land contained high nutrient contents.

Mishra *et al.* (2009) [31] in his study investigated the soil physio-chemical property under two different lands uses i.e. seabuckthorn growing stand and non-seabuckthorn stand and found that seabuckthorn plant improved soil organic carbon.

Qinxiao and Hongyan (2003) [33] also demonstrated that seabuckthorn plays an important role in improving soil fertility through nitrogen fixation, reclamation of degraded and wastelands, besides soil erosion control and helps in poverty alleviation through economic benefits to local people in China. Seabuckthorn plantation makes a 2-3 cm thick litter ground cover to the woodland, along with 4-10 m horizontally spread and 20-40 cm vertically deep, well developed root

system network, which effectively helps in soil and water conservation. The properly developed canopy of 5-7 years old stand intercepts about 10-20 tons/square meters rainwater, thereby conserving soil moisture and reducing rain splash. Also seabuckthorn improves the soil fertility.

Lu *et al.* (2008) [29] studied the basis of assessing the benefits of seabuckthorn as main shrub species by artificial vegetation and four seabuckthorn stands of 4, 8, 12, 15 years, respectively, were chosen for soil nutrient measurements in semi-arid loess hilly region. Results indicated that much more soil nutrients enriched in the layer of 0-10 cm. Soil in the measured stands, nutrients content decreases gradually with the increase of soil depth. Seabuckthorn shrub age has definite effect on the change of soil nutrients content in the stands, which shows a trend of soil nutrients content increasing slowly with increasing age seabuckthorn. Therefore, nitrogen-fixing seabuckthorn plant is a very good option to improve soil fertility and increase productivity in a long run.

Mao *et al.* (2010) [30] investigated effects of nitrogen fixing shrub species mixed into poplar plantation on soil fertility and selected soil chemical and microbial properties in pure poplar and mixed poplar-seabuckthorn (*Hippophae rhamnoides* L.) stands at ages of 5 and 15 years in a semi-arid region of Northeast China and results revealed that both stands at age of 5 years have similar values of above ground biomass, total soil organic carbon concentration, total N concentration, microbial biomass concentration and metabolic quotient. However, at age of 15, these values except for soil metabolic quotient are significantly greater in mixed poplar-seabuckthorn stand than in pure poplar stand. Therefore, nitrogen-fixing seabuckthorn plant is a very good option to improve soil fertility and increase productivity in a long run.

Zhao *et al.* (2013) [62] in the west-northern Loess Plateau of China, found to have high growth rate in the first 4-6 year and 8-10 year, indicating that seabuckthorn may be good species choice for activating soil development in the early stage of reclamation and also, the results showed that the values of available N levels in the top soil layer were higher than the below layers.

In recent study by (Ali *et al.* 2013; Khan *et al.*, 2015) [2, 25] demonstrated that seabuckthorn plantation plays a crucial role in improving the soil health with the enrichment in soil organic matter that is one of the important nutrients to soil which leads to increase in soil fertility. Simultaneously, seabuckthorn plantation act as soil binder, reduces soil erosion, improves soil fertility, adds organic matter in soil with the decomposition of leaves and dead roots and can adapt itself in any condition. It has high growth rate, indicating as a good choice for activating soil development in the early stage of reclamation and different studies showed that the values of organic carbon levels in the top soil layer were higher than the below.

Sharma and Singh (2017a) [40] investigated the effect of seabuckthorn on soil micro-nutrients in comparison to willow and a wasteland soil in Spiti, Himachal Pradesh, India and it was observed that the nutrient percentage and accumulating contents in seabuckthorn plantations were higher as compared to the willow plantation and wasteland. The species wise trend of these properties was in the order of seabuckthorn > willow > wasteland.

6. Enrich the Biodiversity

Seabuckthorn, because of its strong root system and nitrogen fixing ability, is well adapted to both dry and moist soil conditions. Therefore, it is being used in reclaiming and conserving soil, especially on fragile slopes and riversides. In northwest China, an area of more than 11000 km^2 is covered by Pisha Sandstone. Pisha Sandstone is hard when it is dry but becomes loose when it is wet and this place has poor vegetation. In order to reforest gullies, seabuckthorn (*Hippophae rhamnoides* L.) was successfully used to encourage vegetation growth in this area. Through this investigation, it was discovered that seabuckthorn encouraged the growth of approximately 15 species of plants in the sub-layer of forest in the gully and 90 per cent of the sub-layer cover is *Clinelymus dahurcus* Turcz. Moreover, planting seabuckthorn in the gully also promoted growth of other plant species, especially the *Clinelymus dahurcus* Turcz, which effectively improves biodiversity and abundance (Zhang *et al.* 2009) [60].

Bi and Zhang (2014) [11] recently studied role of the different planting age of seabuckthorn forest to soil amelioration in coal mining subsidence land and results showed that soil microorganism quantity, soil enzyme activities were higher in 0-20 cm layer than in 20-40 cm layer. Also, the quantity of soil microorganism and enzyme activities were found to increase to a higher level 5 to 8 years later which indicated that seabuckthorn is of great significance for the increase in soil biodiversity and ecosystem restoration.

Sezen *et al.*, (2015) [39] in the Coruh valley in Turkey which is considered as ecological zone by World Wide Fund for Nature and one of the biodiversity hotspot by the IUCN studied the use of *Hippophae rhamnoides* L. on biodiversity and landscape and found a high diversity in terms of plant, leaf and berry characteristics. Also, seabuckthorn shrubs can be important element for natural landscape in various dry areas as well as by riversides.

Li (2004) [27] also studied the effect of seabuckthorn on biodiversity in semiarid region of China and reported that after plantation of *Hippophae rhamnoides* for 13 years, natural shrubs and grass species increased in number and introduced new plant species which proved *Hippophae rhamnoides* could form a new ecosystem and restore the old ecosystem and restore the old ecosystem, enhance biodiversity, bio stability and harmony to biosphere. Similar results were shown by (Enescu, 2014) [15].

Hippophae rhamnoides a fine water ecological adaptability and its extensive root-system can absorb deep soil water to enhance water supplement. Also when shrub gets mature, soil physical and chemical properties are improved, as is soil water 1-1.5 m deep in woodland works very well in the dry season and the soil moisture content (7.6%) of shrub land becomes more than that of natural grasslands covering a barren mountain (6.8%) (Ruan *et al.*, 2000) [38]. Similar results are authenticated by (Hou *et al.*, 1995; Li, 2004) [20, 27], who mentioned that planting *Hippophae rhamnoides* not only control soil erosion, improve soil fertility but also conserve biodiversity.

7. Protect wildlife

Seabuckthorn plays a significant role in conserving wildlife by providing an excellent habitat for number of wildlife species. Many observations and surveys shows that for promoting wildlife, seabuckthorn provide valuable habitat, source food, especially the thorns present in the plant for protection of various bird species and small rodents. It has been observed that number of wildlife species depend on seabuckthorn stems, leaves, flowers, roots, fruits and seeds.

In China, 51 bird species are entirely dependent and 81 bird

species are relatively dependent on seabuckthorn for their food. In winters, the importance of seabuckthorn increases as it is almost the only food available for birds (Zhiben *et al*., 1989) [63].

8. Nutrient accumulation and dynamics of soil nutrient

Root nodule of *Hippophae rhamnoides* L. can fix nitrogen, decomposition of litter, press and cementation of root-system and decomposition of dead root, which improve soil structure and make nutrient elements return to soil to keep the soil nutrient balance. The measure of 2-13 years old artificial *Hippophae rhamnoides* L. plantation at Wuqi showed mean annual net primary productivity of ground is 3,820 kg/hm^2; mean annual nitrogen accumulation is 17,475 kg/hm^2 and phosphorus 8.25 kg/hm^2 (Chengjian and Daiqiong, 2002) [14].

Ruan and Li (2002) [37] at Wuqi County of Shaanxi Province, China found that in 2-13 year old seabuckthorn plantation the mean annual net primary productivity above ground was 3820.00 kg/ha (in barren grassland it was 665.79 kg/ha) which proves seabuckthorn as significant nitrogen fixer in addition improves the soil structure and assist in increasing soil nutrients in soil through the decomposition of dead roots and plant parts.

9. Compact canopy of seabuckthorn, which protects soil from erosion

Seabuckthorn has a strong canopy can stabilize slopes, reduce surface runoff and stream flow, dense canopy intercepts rainfall and lessens the speed of raindrops thus protects the soil from soil erosion and also encourages the vegetation growth (Zhang *et al.,* 2009) [60].

Seabuckthorn (*Hippophae rhamnoides* L.) because of its strong canopy has the ecological function of protecting against wind and preventing sand from drifting, improving the biological diversity and also recovering and rebuilding the ecological system. Branching in seabuckthorn is intense and upward oriented. So its dense canopy intercepts rainfall and lessens the speed of rain drops. This releases the rainwater slowly on the ground canopy and thick layer thus, protect the soil from erosion (Chengjian and Daiqiong, 2002) [14].

In seabuckthorn plantation, the flourishing capacity layer and rich undergrowth could effectively intercept precipitation. The average intercepting rate of canopy on rainfall in a7-10 year old seabuckthorn plantation was 8.5 per cent. Intercepting maximum of litter layer of a 5-10 year old seabuckthorn plantation was 0.89 mm in a single rainfall (Chen and Chen, 2003) [13].

Ruan *et al.,* (2000) [38] in his research work on use of *Hippophae rhamnoides* in control of soil erosion found that plantation of *Hippophae rhamnoides* in the fragile wind sand zone of Mongolia and the Shaanxi Province of China effectively controlled the sand storms and improved soil physical and chemical characteristics.

After plantation of *Hippophae rhamnoides* for 4-5 years, *Hippophae rhamnoides* became the crown canopy, with 10-20 species of lush weeds growing under forest stands and extensive root system is distributed in a 20-80 cm soil layer and forms a root network. *Hippophae rhamnoides* was able to intercept precipitation thus keeping the soil surface from direct exposure to rain, reduced rain form intensity, reduced soil erosion by 39 %, 37 % and 47 % and intercepting silt (Ruan and Li, 2002) [37].

10. Nutritional Attributes of *Hippophae rhamnoides*

Seabuckthorn plant as whole is of multipurpose value leaves and is rich source of medicinal properties. Seabuckthorn leaves posses high protein (15 percent) and can be used as source of nutritious food and fruit berries are rich source of various antioxidants. Berries are used to prepare jams, juices, jellies, sauces, beer, wines, candies and tea (from leaves).

Seabuckthorn berries are very rich in variety of vitamins and other bioactive compounds (flavonoides, carotenoides and fatty acids) with nutritional and medicinal properties (Kallio *et al.,* 2002; Anderson *et al.,* 2008; Geetha *et al.* 2009) [14, 3, 16].

A study conducted by Stobdan *et al.,* (2010)[49] revealed sthat growing seabuckthorn in Trans Himalayas showed the presence of high content of multivitamins including vitamin C (275 mg/100 g), vitamin E (3.54 mg/100 g), Riboflavin (1.45 mg/100 g), Niacin (68.4 mg/100 g), vitamin B6 (1.12 mg 100 g) and vitamin B2 (5.4 mcg/ 100 g).

Pant *et al.,* (2014) [32] demonstrated that *Hippophae salicifolia* have high amount of vitamins A, B1, B12, E, K and polyphenols which shows that seabuckthorn is a plant with multifarious benefits for human health. Another study conducted by Rongsen (1992) [35] investigated that seabuckthorn berry is quite rich in vitamin C (300-2400 mg/100 g), vitamin A, E, K, protein, organic acids, cartenoides, flavonoides and steroids which haven used in many countries for the production of several medicines, cosmetics and food products. The concentration of vitamin C in seabuckthorn fruit ranged from 100-300 mg/100 g, which is higher than strawberry, kiwi, tomato and carrot (Bernath and Foldesi, 1992) [8].

Bhartee *et al.,* (2014) [9] reported that seabuckthorn contains different kind of nutrients and bioactive substances such as vitamins, cartenoides, flavonoides, polyunsaturated fatty acids, free amino acids and elemental compounds which have been proved to be very effective for the treatment of various diseases and skin related problems.

11. Socio-economic benefits of *Hippophae rhamnoides*.

In cold desert regions there is scarcity of resources. On one hand, the region is cold, so require fuel wood to keep the houses warm during winter months and on other hand there is limited fodder for the livestock. There are ample opportunities to bring change in the livelihoods of high mountain people utilizing the kind of hidden treasure of the Himalayas. So seabuckthorn is the only choice left for fulfilling these purposes.

The local people can use seabuckthorn wood for fuel wood purpose, fruits for manufacturing juice and foliage for fodder, green manure and bedding of livestock. Moreover, it can uplift the livelihood through income generation for various products like juice, jam, tea, medicine and cosmetics like in China. Traditionally the dense and thorny shrub is planted around agricultural field and plantation sites to protect against stray animals and pedestrian movement.

According to Rongsen (1992) [35] is best energy plant because of its high quality biomass. Experiment carried out in China, revealed that one ton of seabuckthorn wood is equal to a ton of standard coal, which is more than that of most species of trees. This means seabuckthorn is well capable for providing fuel wood to local people.

The calorific value of dry seabuckthorn is 4,785.5 calories per kg. Also, six year old seabuckthorn plantation on one hectare can produce 18 tons of firewood which is equal to nearly 12.6 tons of standard coal (Chaurasia *et al.,* 2003-04) [12].

12. Conclusion

Himalayan ecosystem which provides ecosystem services is

an ecologically sensitive region; needs rehabilitation, upgrading and conservation. Seabuckthorn plantation is a promising tool for the ecological restoration of the fragile Himalayan region.

Our study revealed that seabuckthorn has a strong root system and fix atmospheric nitrogen with help of root nodules; controls soil erosion, indulge nutrients and improve soil fertility. The seabuckthorn forest helps in improving other forests and increases soil microorganisms which enhance soil biodiversity leading to conservation and restoration of fragile ecosystem. Also seabuckthorn plant provides food and habitat for wildlife. Besides, its large contribution towards environmental conservation and ecological restoration, it has also a major contribution towards health industries, medicinal values, as a fuel wood, fodder and feed. Also, seabuckthorn cultivation and harvest will provide work to the farmers of Himalayan ecosystem and will improve socio-economic status of the local people. Hence in future seabuckthorn plantation should be encouraged and will be new approach for ecological restoration in cold deserts of the Himalayan ecosystem.

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