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Seabuckthorn- A Traditional Versatile Plant Species in Cold Desert Region of India

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ABSTRACT

Sea buckthorn as an ancient economically and ecologically important plant with modern traits recently gained global attention due to its nutritional and therapeutic properties. It is one of the most important, underutilized plants at high altitudes, in the cold desert region of the Spiti Valley which has immense industrial, medicinal, cosmetic, and pharmaceutical importance. Numerous bioactive chemicals, such as vitamins A, C, and E, unsaturated fatty acids, and phenolic compounds which bestow favorable effects on the cardiovascular system, may be found in the plant's leaves, fruits, and oils. Additionally, Sea buckthorn has a lot of potential as a bio-resource for land reclamation because of its ability to bind soil, provide rapid surface cover, fix nitrogen, and endure cold and drought. However, research on sea buckthorn is still limited due to a number of issues, including a lack of meticulous field studies, data gaps, and the difficulty of accessing remote cold desert areas, despite its enormous potential. Due to its multipurpose nature, the plant is widely utilized to obtain different valuable products such as oil, wine, medicinal supplements, and other products. This brief review summarises the current literature, highlights ecological and economic potential, and significant knowledge identified on Sea buckthorn which will give momentum to recognise it as an exceptional plant in the Spiti Valley.

Keywords: *Sea buckthorn, Fruit berries, Socioeconomic, Cold desert, Spiti Valley, Trans-Himalayas, Nutritional properties, Bio-resource, Soil conservation*

Introduction

Cold deserts are significantly distinct biome in Indian Trans-Himalayas which range from Himachal Pradesh in areas of Lahaul & Spiti and upper areas of Kinnaur, Jammu & Kashmir in Leh, Ladakh and Kargil, Uttarakhand in Uttarkashi, Chamoli and Pithoragarh and North Sikkim in Lachung and Lachen valley with a total geographical area of about 1,26,400 square kilometer[1]. The area is characterized by severe cold winters, moderately hot summers, and arid or semi-arid conditions with an average rainfall of 25 mm to a maximum of 400 mm (low rainfall), snowfall 3-12 ft. (high snowfall), and temperature ranges from -40 to 33 $^{\circ}$C. About 11,000 km^2 of Himachal Pradesh is covered by cold deserts, of which Spiti Valley makes about Sea buckthorn 7100.81 square kilometer[2]. It is one of the worst scourged areas on earth and lies on the leeward side of the Greater Himalayan ranges having an extreme climate of short-lived summer and a long freezing winter[3]. Like other cold desert areas, Spiti Valley has also limited natural resources with lesser vegetation and only a few plants like Sea buckthorn are able to adapt and thrive in frozen harsh climatic conditions.

Sea buckthorn commonly refers to all taxa of genus 'Hippophae'[4-8] which comes from two Latin words, 'Hippo' which means Horse, and 'Phaos' means to shine and combined means to shinning horse[9]belongs to the family 'Elaeagnaceae' and native to Europe and Asia[10] and it naturally grows in locations near to the sea, specific traits which build up its name. The *Hippophae* species is widely distributed across Asia and Eastern Europe including India, China, Pakistan, Mongolia, and Russia. There are usually 7 species and 8 sub-species of Hippophae globally [11].The four species namely *Hippophae rhamnoides* L. subsp. *Turkestanica* Rousi, *Hippophae tibetana* Sch., *Hippophae salicifolia* D. Don and *Hippophae rhamnoides* subsp. *Gyantsensis* Rousi is reported to occur in India [12] and out of which three species of Sea buckthorn (*Hippophae rhamnoides* L. subspp. *Turkestanica* Rousi, *Hippophae salicifolia* D. Don and *Hippophae tibetana* Sch.) are found in Spiti, Himachal Pradesh [13] and their distribution and growth behavior pattern is described [14-16] in Table 1. Sea buckthorn is also locally called as Chharma, Sutz, Tirkug, Chasterlulu, Sarla or Pilickcha, in Himachal Pradesh; Tsemarang and Chasterlulu in Ladakh; Tare and Taroobo in the north-east region and Ames and Chuk in Uttarakhand [17-18].

Sea buckthorn is a deciduous, thorny plant species, dioecious or occasionally monoecious, spinaceous and arborescent shrub varying in height from 50 cm to 8 m mainly found in low humid, alluvial soils, wet-lands and riverside with brown rusty-scaly shoots with altitude ranging from a few meters to 5200 meters having the surprising ability to grow and survive under unfavorable conditions (-40 to 40º C), has small silvery leaves, colorful red, orange or yellow berries, extensive subterranean rooting system with nitrogen-fixing nodules which helps in atmospheric nitrogen fixation[19,20]and strong soil binding capacity [21]. The plant is pioneer, multipurpose, fast growing usually drought and cold tolerant, aiding farmstead protection, land reclamation, biodiversity protection, soil conservation, water retention and particularly useful as a source of medicines, food, fodder and fuel wood [22-24].

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Every part of the plant viz. fruit berries, leaf, twig, root and thorn has been traditionally used but above all fruit berries gain importance in the whole world [25] due to high nutritional values, the extremely rich source of vitamins (B1, B2, B5 etc.)[26-30] and also have unique medicinal properties due to more than 190 bioactivity substances so called as the treasure of bio-activity substance or wonder plant or golden bush or gold mine [31-34].

In view of the unique and valuable characteristics of Sea buckthorn and its ability to survive in harsh cold arid areas like Spiti, the present article serves as a storehouse for researchers which will be helpful in its conservation and moreover benefit the whole society through scientific research [35]. It further helps to maintain a sustainable livelihood and socioeconomic development of the local inhabitants living in these harsh areas.

Table 1. Distribution and growth behaviour pattern of Sea buckthorns in Cold desert area, Himachal Pradesh, India

Species	Area	Growing Altitude (m amsl)	Average plant height (m)	Flowering duration	Fruiting duration
Hipophae rhamnoides	Hurling, Kaza, Tabo, Poh, Sumdoo, Shego, Lara, Lingthi, Shichling, Sumling, Kiato, Kukumsari, Lahaul, Tinu, Gemur, Jispa, Darcha, Kiamal, Rangrik, Upper Kinnaur	1600 – 4200	2 – 6	May- June	September- October
Hipophae salicifolia	Maane, Rangrik, Kaza, Lahaul valley, Sangla, Pooh	2700 – 3700	3 – 10	June- July	September-October
Hipophae tibetana	Sangnam, Mud, Kibber, Lossar, Takcha	3000 – 5200	0.8 – 1.2	May- June	August-September

Description:

Sea buckthorns are an early-succession-plant species having perfect physiological mechanisms to grow under environmental stresses, as well as tolerance to cold, drought, saline-alkali, and strong winds so the cold desert fragile ecosystem is an ideal environment for the Sea buckthorns to grow and flourish.

Among the three species, *Hippophae rhamnoides* is a shrub to small tree form (2-6 m), *Hippophae salicifolia* is a small to large tree (3-10 m), whereas *Hippophae tibetana* is a shrub (0.8-1.2 m). The significant constituents found in various parts of the Sea buckthorns plant are described in Table 2[36-42].

a) Leaves: The leaves of sea buckthorns are small (3-8 cm long and 0.4-1 cm wide), alternate, linear, lanceolate, and covered on the backside with pale silvery stellate scales and a thick greyish-green crown that reflects solar radiation and reduce moisture loss[9,43]. The fodder values of sea buckthorns are very high [44] as compared to locally available fodder species and the crude protein content in the leaves was 21.6 %, fat content varied from 3.5-4.8 % in *Hippophae rhamnoides*, while the ash content was 5.1 %, total phenolics content was 12.7 %, out of which 92 % were in the form of hydrolysable tannins[45]. Also, the leaves of sea buckthorns are used for the preparation of various products like antioxidant-rich beverages as they contain many nutrients and bioactive substances.

b) Flower: It is dioecious with separate male and female plants. The male produces brownish color flowers which produce wind-distributed pollen [46] and pollination predominantly takes place by wind as both the male and the female flowers have no nectar so it rarely attracts bees or other insects. Generally, the flowering may occur in the third year, whereas in certain conditions it may happen in the fifth or sixth year[40]. Floral buds appear in summer or autumn and usually open in the spring. The male flower buds consist of four to six flowers and the female consists of mainly one flower and rarely two or three.

c) Fruit: Fruit is small ovoid berry-like, varied from yellowish to orange-reddish in colour.

Fruit berry size varies from 8 to 35g/100 fruits that remain on the branch till the following in spring which provide the sufficient time to harvest them. Fruit berries are sour in taste and contains 60 to 80% juice rich in amino acids, organic acids, sugar, tannins and vitamins and also contains 3 to 5% of pulp oil and 8 to 18% of seed oil [47] and used in making juice, jams, jellies, marmalades, pickles, snacks etc [48]. The fruits progressively shrink with the passage of time but don't fall and become the food for animals, especially birds even after snow in winters also. Also, the fruit is a rich source of Vitamin C, which ranges between 300 to 1600 mg per 100 gm of fruit juice[49,50].

d) Seed: Sea buckthorns have single seed fruit, which varied from ovate-elongate to elliptical in shape and dull white to brown in color [51] and it consists of only 10% of the fruit by weight. The seed require 24-26 º C of temperature for germination [52]. The seed consists of 10 to 20 % of oil [45] which contain 12 -20 % saturated fatty acids and 88-89 % unsaturated fatty acids, particularly Linolenic acid (32.3 %), Linoleic acid (40.8 %) and Oleic acid (15%)[37]. The seed oil is used in various fields of food, drug and cosmetics[53].

e) Stem/ Wood: Sea buckthorns is a woody-shrub plant which is hard, erect, perennial, spiny, cylindrical and waxy and used for fencing fields, orchards and dwellings also used as fuel wood as its calorific value is 4785 calories/kg [44]. Sea buckthorns, as the name indicates, is a highly thorny plant. Thorns are very stiff and multifaceted arising as appendages from stem with thorn intensity has been found ranging between 1-5 thorns/square centimeter[39].

f) Roots: The roots have a strong and well-developed tap root system, having primary, secondary and tertiary roots covered with root hairs, found more prominently in the apical portion [54]. Horizontal roots also have root underground buds (turions) which sprout and give rise to another plant (succours) and modulated roots bear *Frankia* species which fix atmospheric nitrogen [55]. The root system is very extensive form a complex network which has high soil binding capacity that help in preventing erosion and protecting soil [55,56].

Traditional Uses and Benefits

The plant is sometimes considered as 'Kalptaru'[58,59] due to its immense use. The use of sea buckthorns has a very long history, as it is believed to be the favored food of Pegasus, the winged flying horse of Greek mythology. In the 8th century, the medicinal value of Sea buckthorns was recorded. There are more than a hundred popular Sea buckthorns-based formulations in various pharmacopoeia as of *Sowa Rigpa* (Tibetan medicine). The three major species of Sea buckthorns have been established in Tibetan medicine as Sa-sTar for *Hippophae tibetana*, Bar-sTar for *Hippophae rhamnoides* and

Nam-sTar for *Hippophae salicifolia*. Even it was the first fruit juice in space as Russian cosmonauts were supplied with Sea buckthorns beverage to enhance their health and resistance to stress and oil for protection against harmful radiation and also has anti-inflammatory, antioxidant, antibacterial, antiviral activities and immunomodulatory effects [60-66].
Native people who live in the Spiti Valley have widely used sea buckthorns. Due to the scarcity of resources in freezing deserts, Sea buckthorns have been used traditionally for a number of applications [67], and various types of products developed through indigenous techniques are described in Table 3.

a) Sea buckthorns Products: Every part of the plant viz. fruit, leaf, twig, root, and thorns has been traditionally used as medicine, nutritional supplement, fuel, and fence. Also, it is used in industries because of its medicinal, cosmetic, and nutraceutical value [68,69]. In general, fruit berries are used for the preparation of juices (condensed juice, syrup juice, mixed juice, health protection juice, carbonated juice); hard drinks (sweet, medium, dry, carbonated wines, champagne, and beer); jams, squash, juice powder, sea buckthorns pickle, sweets, chocolates, tea, sauce and oil (pulp, seed and residue oil), blended products like drinks, mixed fruit jam, jelly[70-72].

b) Socioeconomic benefits: Sea buckthorn has great potential to change the livelihood and economical position of the local community. Sea buckthorns products can be certified as organic, as most of them are derived from natural forest and community land where chemical fertilizers and pesticides are not used [18].

Many factories are producing sea buckthorns food, beverages and other products such as jam, jelly, juices, syrup, condensed juice, mixed juice, sea buckthorns carrot jam, candied fruit, sea buckthorns cheese, sea buckthorns butter, tea and health protection drinks. The pigments of sea buckthorns consists of flavours, carotene and vitamin E and its useful physio-chemical properties, make it a very important food additive. Sea buckthorn is a fast-growing shrub plant and acts as a good source of fuel wood in cold desert regions for heating houses and domestic cooking. In monasteries, where hundreds of monks reside, the plant species are used as firewood to cook food [73]. Since the shrub grows fast, it reduces the harvesting pressure on native woody plants thereby maintaining the fragile ecosystem[74-76]. Sea buckthorn's stem is hard and often used as a handle for agricultural implements [77]. Various types of drugs have been developed from sea buckthorns and are available in the form of liquid, powder, plaster, paste, pills, liniments, aerosols, etc. which are used for treating burns, gastric ulcers, radiation damage, and skin ulcers also the oil is useful in diminishing inflammation, disinfecting bacteria, relieving pain and promoting regeneration of tissue. Many kinds of sea buckthorns cosmetics like beauty creams have been developed which have positive therapeutic effects on skin wrinkles, keratoderma, keratosis, xeroderma, facial acne, recurrent dermatitis, wound healing activity, and freckles[78,79].

c) Ecological benefits: The Sea buckthorn plant in the cold desert region provides many environmental benefits, including soil and water retention, land reclamation, desertification management, reforestation and habitat to wildlife[80].Sea buckthorns provides a protective shelter for flora and fauna [81] especially in cold desert ecosystems due to its extensive root system and habit of growing well in sandy, rocky, saline and ravine soils[82].Sea buckthorns play an important role as windbreak effective to prevent wind erosion [83,84]. Many of the wildlife species living in cold deserts directly or indirectly depend upon sea buckthorns for their food and shelter even in winter months also, when no other fodder is available in the region.

The change in microclimate due to Sea buckthorns plantations depends on geography, climate, scale of plantation, and many other factors[85-87]. It provides long-term benefits in maintaining the ecological equilibrium and improving the environment [76,88,89].

Cultivation Practices:
a) Propagation: There are many methods for the propagation of Sea buckthorns. Seeds don't germinate immediately after harvesting as there is the problem of short physiological dormancy in freshly harvested seeds but seeds remain viable for more than two years. Various type of seed treatment like seed stratification in alternate layers of moist sand, and cold water soaking improves the germination percentage. The method of propagation through Hard-wood cutting is generally for large-scale production. Cutting of one or two years dipped in 2/3 to 1/2 of lower portion in water for 2-3 days followed by 500 ppm IBA treatment in greenhouses, trenches, and poly-houses result in an even higher success rate in cold desert conditions[90].

b) Grafting: Grafting technique is very successful in Sea buckthorns. Cuttings can be prepared during winters and Scion can prepared during early spring after treatment with Hetero auxin in a one-year-old branch to give better results [91].

c) Soil: Sea buckthorns are found to grow best in soil with a pH near neutral (pH 6.5-7.5), sandy, gravelly, saline with light physical structure, rich in minerals [29].

d) Irrigation: Sea buckthorns is generally grown best near rivers, water streams, etc. but are able to tolerate drought conditions. Proper irrigation is required generally for the growth and development.

e) Farming System: Sea buckthorns can be raised in a Single or double hedge row system or integrated farming system. In general, the spacing between plant to plant is to be 1-2 m whereas, row to row is to be 2-4 m for pure cultivation and at 4-5 m for intercropping[92]. The plants are planted into rows at a distance of 1- 2 m. However, moderate pruning helps in increasing the fruit yield. Pruning has to be done every year in the month of March-April, for proper light penetration, to remove overlapping of branches which should be headed to encourage the development of lateral shoots [93].

f) Fruit Harvesting: After the ripening of fruit, harvesting should be done but constraints like small fruit size, short pedicel, force required to pull off each fruit density of fruit on the branch and the thorniness of the plant increase the time of harvesting process[29].Harvesting can be done by various direct and indirect harvesting techniques in the morning hours[94,95].

g) Yield: Fruit yield depends on species, cultivar, age of plantation, and cultural practices. Vegetative propagated plants start bearing fruits at the age of 4 years while that of seedling-raised plants takes 5-6 years[96].

Generally, fruit yield under the orchard system is 10-15 t/ha and 0.2 to 8 kg per plant without any management practices[32].

h) Postharvest handling and storage: Sea buckthorns berries when overripe carry a strong musky odor with a rancid taste, which can be detectable even in the fields [67].

Fruit berries must be harvested at the correct time, quickly transported to the processing plant, and it should be cooled immediately to 4-6 °C to retard spoilage. The pulp can be stored using preservatives such as KMS or benzoic acid [97]. Fruits are small, soft, delicate, juicy, and highly perishable which cannot be transported over long distances[98].The diagram of a processing method of Sea buckthorn to separate useful components of the berries, yielding the key products of juice, dried fruit nutrients, and oil from the seeds and pulp[99]; residues can be utilized as a valuable animal feed are shown in Figure 1.

Table 2. Product development through indigenous techniques

Fruit			
Component	**Content**	**Component**	**Content**
Fruit colour	Yellow, Orange to Orange red	Protein in fruit	34.6 %
Shape	Round, Oval, Ovoid	Total sugar	6.29 %
Fruit weight	10-16 gm/100 berries	Organic acid	4.35 %
Fruit juice extraction rate	64- 75 %	Sodium	41.28 mg/kg fruit
Vitamin C content	1161.1-1302.5 mg/100 gm	Potassium	1499.96 mg/kg fruit
Vitamin A in fruit juice	0.75 mg/100 gm	Calcium	383 mg/kg fruit
Carotenoid in fruit juice	7.2 – 7.4 mg/100 gm	Iron	11.68 mg/kg fruit
Soluble solids in fruit juice	15.92 – 17.66	Zinc	0.94 mg/kg fruit
Total flavone in fruit juice	365 – 885 mg/100 gm	Magnesium	47.7 mg/kg fruit
Total flavone in fresh fruit	354 mg/100 gm	Phosphorus	0.02 %
Pulp			
Component	**Content**	**Component**	**Content**
Oil in fruit pulp	8.44 %	Vitamin C in pulp	780 mg/100 gm
Carotenoid in fruit pulp oil	764 mg/100 gm	Total sugar	7.17 %
Vitamin E in fruit pulp oil	255 – 435 mg/100 gm	Organic acid	4.4 %
Leaves			
Component	**Content**	**Component**	**Content**
Total flavone in leaves	876 mg / 100 gm	Protein in leaves	17.43 – 24.13 %
Seeds			
Component	**Content**	**Component**	**Content**
Seed	6.54 %	Carotenoid in seed	3.3 mg/100 gm
Oil in seed	10.37 – 19.51 %	Organic acid	0.94 %
Vitamin E in seed oil	101.5 – 277.6 mg/100 gm	Saturated fatty acid	12 – 20 %
Vitamin C in seed	149 mg/100 gm	Unsaturated fatty acid	88.3 – 89.1 %
Protein in seeds	2 1.66 %	Linolenic acid	32.3 %
Total sugar	5.84 %	Linoleic acid	40.8 %

In a pan, fresh fruits are gathered, washed with fresh water, and crushed. A sieve is used to extract the juice. On average 1.5 liter of juice is obtained from 2.5 kg of fresh fruits. The residue (seeds and pulp) is sun-dried and used for making tea. 0.5 kg of sugar is added to the juice and boiled till the formation of jam. The jam is kept in a cool place. After cooling, KMS (Potassium Meta Sulphate) or Sodium Benzoate powder is added as a preservative to preserve the jam for up to 2 years. The jam is stored in the sterilized bottles.

Fresh fruits gathered in a pan are thoroughly washed with running water.

After that, the fruits are crushed in a jar and sieved. The seeds and pulps are separated. The extract is dried and used for making tea. As per the quantity of juice, sugar is added and mixed with the juice. KMS powder (0.25–0.30 gm/lt.) is added as a preservative in juice to preserve the juice for at least two years. The juice is stored in sterilized bottles.

10 kg of fresh fruits gathered in a pan are washed. After washing, the fruits are crushed and 200–400 g of fermenting agent (an enzyme of yeast available in the market), locally known as 'Fab', is added to the juice mixture. The mixture is kept for fermentation for 4–6 months. The pot is covered with warm clothes during the fermentation period.

The fermented juice is distilled with the help of a locally made distillation unit. Sweet wine is obtained which is locally known as 'Chang/lugri'. The distilled liquor, locally known as 'Sara' is stored in the sterilized bottles.

The residue separated from the pulp is sun-dried for a week. After complete drying, it is packed in boxes. The dried residue is locally known as 'Bangma'. The dried residue is packed in paper bags for sale as 'Seabuckthorn tea'. For preparation 2 cups of tea, 2 cup water, 1 tea-spoon of dried residue, a pinch of ordinary tea leaves, ginger, and cardamom, and 2 tea-spoons of sugar/honey/jaggery are boiled in a pan, filtered with a sieve and consumed Similarly, 2 cups of water and 2 tea-spoon of sugar are boiled for 5–10 min. After boiling, 2 tea-spoon of juice is added and sipped/taken.

For making tea from the male leaves, the disease-free male leaves are collected and washed in running water. Female leaves are also being used for the purpose, but the biochemical constituents are comparatively lesser than male leaves. The leaves are dried under shade for a week. After complete drying, 3–4 dried leaves are added to one cup of water and boiled for 3–4 min. This is locally known as 'Kaaru'. One tea-spoon of sugar is added and drunk.

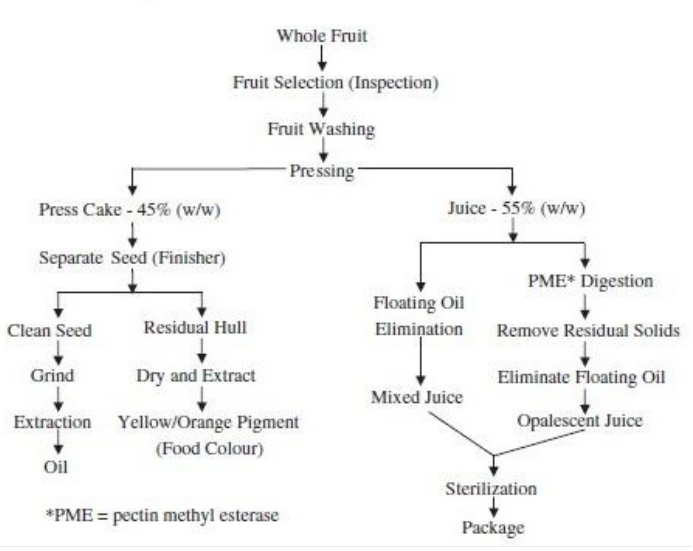

Figure 1. Processing Process of Sea buckthorns berries[25]

Constraints, Challenges, and Future Prospects

Sea buckthorns berry harvesting is a challenging task due to the thorny nature of the plant and the lack of convenient tools, leading to the use of traditional methods like beating the bushes. The effectiveness of potential harvesting tools in real field conditions needs further research and development. Harvesting Sea buckthorns from remote areas is difficult due to the perishable nature of the berries and the long transportation distances required for processing. Encouraging processors or cooperative societies to operate refrigerated vans and cold storage could address this issue. Sea buckthorns berries are fragile and must be processed on the same day as harvesting. Establishing cold chain facilities in key Sea buckthorns growing regions could extend processing time and facilitate the creation of value-added products. Sea buckthorns harvested in Spiti Valley are wild but they lacks organic certification and there is no standard package of practices for growing Sea buckthorns on a large scale, and there are no released varieties of Sea buckthorns in India. Developing facilities at berry processing sites to maintain the organic integrity of wild harvests is crucial for obtaining organic certification for Sea buckthorns in Spiti Valley.

Conclusions

This analysis of published literature provides comprehensive information on the importance and potential of Sea buckthorns as Superfoods. Even though it is narrowly produced and consumed in specific geographical areas, but it has an enormous exploitability within the food industry. The production potential of this species and the sustainable harvest of edible and other useful parts can boost the local economy and have serious ramifications on the socioeconomic and environmental balance. The present research on this unique plant with modern virtues is very fascinating leading to the emergence of new avenues of its utilization. The information will be helpful for natives, farmers, researchers, extension workers, and policy-makers to develop effective action plans for sustainable use and conservation management of sea buckthorns in cold desert fragile ecosystem.

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