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Potential of Sea Buckthorn (*Hippophae rhamnoides* L.) Thickets in Preserving Endangered Ecosystems in Kyrgyz Republic

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Abstract

Intensive urbanization from year to year reduces natural ecosystems that play a huge balancing ecological role on the planet. Preservation of natural ecosystems bordering on cultivated ones requires the development of new approaches to mutually beneficial sustainable development. Great potential lies in the preservation of unique ecosystems with wild fruit-bearing plantations. In this article, using the example of the natural ecosystems of the shores of Lake Issyk-Kul, included in the list of Ramsar Convention on the Conservation of Wetlands, the possibility of using natural thickets of sea buckthorn to improve the socio-economic situation of the local population and preserve unique but endangered natural ecosystems is analyzed. Studies have shown that sea buckthorn (*Hippophae rhamnoides* L.) fruits do not accumulate heavy metals and contain an increased content of ascorbic acid. A survey of the local population showed that local residents do not consider the use of sea buckthorn plantations as a potential source of income, but recognize it as the most environmentally friendly. In order to develop the mutually beneficial development of the local population and natural ecosystems, it is necessary: to use wild-growing fruit-bearing shrubs with the maximum benefit from the annual harvest, among which the sea buckthorn (*Hippophae rhamnoides* L.) has a potential; to develop recommendations and modern technologies for the production of a wide range of products, using all possible parts of sea buckthorn; educate local people on the importance of preserving natural ecosystems and involve local businessmen in preserving vulnerable ecosystems.

Keywords

Vulnerable ecosystems; Seabuckthorn; Issyk-Kul lake; Wetlands; Sustainable development

Introduction

Coastal ecosystems of alpine mountain lakes are among the centers of the planet's biodiversity and are of great interest to many

researchers (Pech *et al*., 2008). However, these biodiversity hotspots are the most vulnerable objects due to the threat of domestication of these unique ecosystems (Binggeli *et al*., 1992). High-mountain lake Issyk-Kul is one of such unique and at the same time endangered ecosystems. Lake Issyk-Kul is the largest lake in Kyrgyzstan; it is one of the 25 largest lakes in the world and the seventh deepest. Issyk-Kul is the second most transparent lake in the world after Lake Baikal. Lake Issyk-Kul is rich in natural resources and biodiversity, with several areas under the protection of the Issyk-Kul State Reserve and wetlands protected under the Ramsar Convention (The Government of the Kyrgys Republic, 2014).

Photo 1: Cleared coastal plantations of sea buckthorn thickets (Photo by first author)

The development of beach tourism in the region has jeopardized the existence of coastal ecosystems; shrubs are cut down and the vacated areas are used for the beach (Photo 1), causing irreparable damage to local flora and fauna (Photo 1).

As a result of vigorous human activity, in the last 20 years alone, more than 700 hectares of sea buckthorn thickets have been destroyed, which perform many ecological functions: strengthening sandy shores; serving as a mechanical filter; providing habitat for many animals and birds of the region (Photo 2).

Excessive population growth has led to the intensification of land cultivation ranging from steep slopes to coastal lands in many developing countries of the world (Liu *et al*., 2000; Rumpel *et al*., 2006), which causes serious environmental damage with dramatic consequences in terms of degrading natural ecosystems and water availability (Liu *et al*., 2013). According to the National Report on Priorities for Conservation of Biological Diversity of the Kyrgyz Republic for the period up to 2024, due to the anthropogenic impact on the shores of Lake Issyk-Kul, which caused the degradation of wetlands, 2 species of mammals, 20 species of birds, 2 species of amphibians, and 6 species of fish have disappeared or are under threat of extinction. The fish productivity of water bodies has decreased, and many wetlands have lost their recreational value (Government of the Kyrgyz Republic, 2014).

Photo 2: Sea buckthorn plantations of Lake Issyk-Kul (Photo by first author)

The total number of tourists annually visiting this resort area of Issyk-Kul is more than 1,000,000 and their number is growing from year to year. Due to the decrease in land suitable for the construction of boarding houses, new lands are being developed due to the cutting of coastal shrubs, mainly sea buckthorn. Sea buckthorn performs a great ecological function while maintaining the ecological stability of the lake ecosystem (Campbell *et al*., 1994; Mugagga, Kakembo and Buyinza, 2012). How to find a balanced solution to preserve the natural coastal vegetation while improving the socio-economic well-being of residents?

Healthy ecosystems are not only their ecological health but also their ability to sustain the social and ecological growth of the population of the region (Nakata, 2018;, 2008; Ziv *et al*., 2012). Using this principle, the main idea and purpose of this research was to develop a method for preserving the unique natural ecosystems of coastal zones, which are subject to cultivation by increasing the interest of the local population to receive a good income from the natural gifts of natural ecosystems, for example, sea buckthorn (*Hippophae rhamnoides* L.).

Materials and Methods

This study was carried out in the Issyk-Kul region of the Kyrgyz Republic. Issyk-Kul region is located in the north-eastern part of the Kyrgyz Republic. The total area of the territory is 43,100 km², which is 21.58% of the total area of the republic, located at an altitude of 1,600 to 7,439 m above sea level. The population is 413,100 people (8.6% of the total). In the north-east, the region borders with the Republic of Kazakhstan, in the southeast with the People's Republic of China, in the north-west with the Chui region of the Kyrgyz Republic, in the south-west with the Naryn region of the Kyrgyz Republic.
The relief of the territory is subdivided into 2 main parts: the Issyk-Kul depression and the Issyk-Kul syrts. The Issyk-Kul depression is bounded from the north and south by the Kungey and Teskey Ala-Too ridges, it has a length from east to west of 240 km and a width of about 100 km. The only natural outlet from the basin to the Chu Valley is the Chu River, flowing through the Boom Gorge. The central part is occupied by Lake Issyk-

Kul. It is located in the northeastern part of the country between the mountain ranges of the Northern Tien Shan at an altitude of 1,609 m above sea level. Lake Issyk-Kul extends from west to east for 182 km, and from north to south for 58 km, with a surface area of 6,236 km². Being an inland lake, there are up to 80 tributaries running into it. The lake water is slightly salty, with a salinity of 0.59 percent. The maximum lake depth is 702 m, with the average depth being 278 m.

The climate of Northeastern Kyrgyzstan is formed under the influence of the large non-freezing lake Issyk-Kul and has the features of the sea: mild winters, relatively warm summers, smoothed annual air temperature variation. Northeastern Kyrgyzstan can be divided into two sub-regions: western - very arid, and eastern - well-humidified. Our research was carried out in the western sub-area. There, the climate is warm and dry, it has a deserted western coast of the lake Issyk-Kul. This is the driest territory of Kyrgyzstan with a semi-desert climate. The annual amount of precipitation is 100-120 mm, 92-98% of them fall in the warm season, the maximum precipitation is in July-August, at least in January. Winters with little snow, stable snow cover is practically absent. The average annual air temperature is 7-8ºC.

The area covered with forest vegetation of the studied region was determined according to the materials of the Forest Cadastre of the Republic. Four points of the coastal zones of Lake Issyk-Kul were selected and studied according to the following features: zones with an intact ecosystem; zones with the most pronounced anthropogenic impact; areas with minimal anthropogenic impact; zones with average anthropogenic impact. Schematically the location of research points are shown in figure 1.

Figure 1a: Sampling points

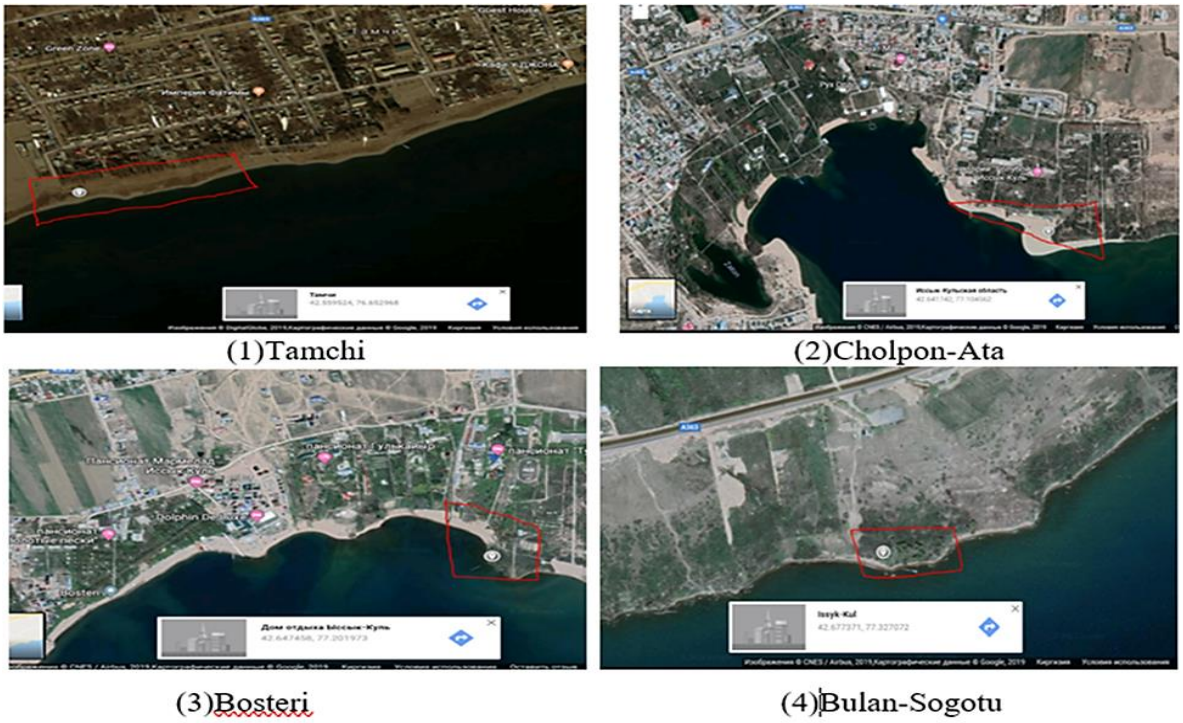

Figure 1b: Sampling points

Questionnaire Survey on Sea Buckthorn Management

A survey on current management practices of sea buckthorn was conducted between 2018 and 2020 to assess its awareness of the local population about the importance and possible benefits of using sea buckthorn (*Hippophae rhamnoides* L.). A mixed methods survey, combining quantitative and qualitative questions, among residents of Ton, Jetioguz and Balikschi was carried out. Respondents had been selected by age and gender. They needed to be involved in marketing activities of sea buckthorn. The questionnaire covered the following topics: environmental awareness, sea buckthorn awareness, knowledge, use, economy, future. Thirty adult respondents answered. The descriptive data were analysed using qualitative content analysis and Excel. The survey questionnaire worksheet is provided in the appendix 1.

Sample Collection

The region was conventionally divided into four zones: western, eastern, northern and southern to identify the most enhanced anthropogenic effect on the soil. A total of 28 soil samples were collected. Each soil sample was taken at a depth of 0–20 cm from five different points and combined into one composite sample. The samples were placed in labeled polyethylene bags and transported to the laboratory for subsequent preparation for analysis. In the laboratory, all samples were air-dried at room temperature and sieved through a 2-mm sieve. 1 gram of soil samples were digested with 15 ml concentrated hydrochloric acid (HCL) and 5 ml of concentrated nitric acid (HNO_3). The mixture was heated. Distilled water was added to the digested sample and then filtered

with a whatman filter paper and topped up to 100 ml volumetric flask with distilled water. Then concentration of Pb, Cd, Zn, Cu, Fe in the soil samples was analyzed using Atomic Absorption Spectrophotometer. The pH was measured using a Horiba B-213 Twin pH meter after extraction of soil using one part solid to 2.5 parts distilled water.

Microbial Analysis

Number of microorganisms was determined by the plate method. Ten grams of each soil sample were added to 90 mL of distilled water. The solution was diluted (10−1 to 10−6) and aliquots of the resulting solutions plated on appropriate culture media. Czapek media was used for fungal growth, meat-peptone agar (MPA) for bacteria growth and starch-ammonia agar (SAA) for Actinomycetes growth. All experiments were performed in triplicate. After incubation at 25 or 30 °C, for up to 10 days, the colony forming units (CFU) were counted. In addition, the cultures were determined according to macromorphological types. The determination of microorganisms was carried out in accordance with the most common determinants (Krasilnikov, 1961).

Isolation and Detection of Bacteria from Samples

To isolate hydrocarbon degrading bacteria from hazardous landfill soil samples were taken on the Voroshilova-Dianova medium, contained, per litre: NH_4NO_3 1.0g, K_3HPO_4 1.0 g, K_2HPO_4 1.0 g, $MgSO_4$ 0.2 g, $CaCl_2$ 0.02 g, $FeCl_2$ – 2 drops of concentrated solution, with sterile oil as the sole carbon source. 5 ml of crude oil, and oil contaminated soil sample was added in a 250 ml Erlenmeyer flask with liquid medium. The suspension was shaken in an orbital shaker at 200 rpm and incubated at 300C for 15 days. Pure bacteria strains were isolated by traditional spread technique on meat-and-peptone agar (MPA). The key features in determining the bacterial generic membership were: mobility, bacterial colony characteristics, Grams staining, availability of oxidase and catalase. The shape and mobility of the cells were determined by microscopy of living bacterial preparations. Morphological features were detected on fixed preparations stained with fuchsine or methylene blue according to microbiological standard methods.

β-Carotene

The total carotenoids content was determined spectrophotometrically using a Specord 50 (Analytik Jena AG, Jena, Germany) spectrophotometer. The UV-Vis spectra were registered at 300–550 nm. The measurement was using the absorption value at 450 nm (Pop *et al*., 2017).

Ascorbic Acid

Ascorbic acid determination was carried out by iodine titration. When iodine is added to a starch solution, it reacts to produce a purple color. However, if there is any vitamin C in the solution, it “neutralizes” the iodine, preventing the formation of the purple color. Thus, the amount of vitamin C present in a solution may be measured by first adding a small amount of acidified starch (called “reaction mix”), and then adding iodine drop wise until the solution turns purple. The end point is the appearance of the blue starch-iodine color. The iodine reagent was standardized by titrating it against 5mL of 1.00%

ascorbic acid solution (to which three drops of 1% starch was added) until the appearance of the blue starch-iodine color. 5 mL of the samples were then treated the same way. The iodine solution was prepared by dissolving 5.00 g potassium iodide (KI) and 0.268 g potassium iodate (KIO_3) in 200 mL of distilled water, and then adding 30 mL of 3 M sulfuric acid, before making up the volume to 500 mL with distilled water. The concentration of ascorbic acid in the samples was determined as follows:

- Concentration in the juices (g/100 mL) = y/b
- Concentration in the pastes (g/100 g) = 25y/b

Where b = titer (mL) from the titration of the standard ascorbic acid solution. y = titer (mL) from the titration of the sample solution (Xinyan *et al*., 2023, 2011).

Statistical Data Analysis

Mean and standard error were computed from triplicates of soil physico-chemical parameters using Statistical Package for Social Sciences (SPSS 20.0).

Results

In a rapidly developing world, the preservation of natural ecosystems is important. The preservation of this requires the adoption of decisions that satisfy both the issues of the socio-economic development of the regions and the preservation of the virgin corners of the planet, for a balanced development of life on the planet. Wetlands are highly productive (Maikhuri, Rao and Saxena, 2004) and support a variety of ecosystem goods and services. On a local scale, wetlands provide food and raw materials, filter pollutants, keep clean the water and habitat for wild animals, and have aesthetic and other functions (Zedler and Kercher, 2005; Zhao *et al*., 2006). On a wider scale, wetland-rich landscapes help regulate regional climate (Wylynko, 1999) and provide critical habitats for continental and intercontinental migratory species (Myers, 1983). Wetlands are the most vulnerable to land-use and management change, but the accelerated pace of climate change has made it difficult to maintain functioning wetlands (Osti *et al*., 2011).

To preserve wetlands as regulators of micro- and macroclimate, in addition to prohibitive and punitive measures, it is necessary to develop management that will encourage local residents to obtain long-term benefits by preserving natural ecosystems, learning to use the gifts of nature rather than looking for a small profit from short beach tourism or the creation of artificial plantations of introduced species.

A potential opportunity is provided by the use of the wild-growing sea buckthorn (Photo 3), which is a multifunctional culture and, moreover, is a plant that does not accumulate heavy metals in its fruits, which does not limit its use both in food and in the pharmaceutical and cosmetic industries (Antosiewicz, 1992; Baker, 1981; Maikhuri, Rao and Saxena, 2004). *H. rhamnoides* is widely distributed throughout the temperate zone of Asia and Europe, between 27˚ and 69˚N latitude and 7˚W and 122˚E longitude (Proorocu, 2015; Swenson and Bartish, 2002).

The natural conditions of Europe and Asia are the natural habitat of sea buckthorn thickets, where it has always been very common in areas with loose soil, such as beaches and other sandy areas. It is more resistant than most plants. Due to its unpretentious care

and significant health benefits, there has been an increase in interest in growing this amazing plant for commercial purposes (Bittová *et al*., 2014). Gardeners and landscape designers appreciate the sea buckthorn bush because it preserves the soil very well. It controls erosion by keeping the soil in its dense root system and requires little maintenance to thrive. Vibrant orange berries add an exhilarating hue of color to any landscape design. It has silvery deciduous leaves and colorful orange berries that persist for most of the winter (Proorocu, 2015; Tiitinen, Hakala and Kallio, 2005). In addition, sea buckthorn thickets are an important habitat, nesting, migration, wintering, and feeding of many bird species. Due to a wide range of applications (ecological, food, decorative, therapeutic, etc.), sea buckthorn is a true multipurpose species of great importance throughout the world (Mihai Enescu, 2014; Vescan *et al*., 2010).

Photo 3: Sea buckthorn fruits growing on the shores of Lake Issyk-Kul (photo by first authors)

The total area of sea buckthorn thickets in the Issyk-Kul depression is approximately 5,720 hectares with a biological stock of fruits of 2,500 tons with an average yield of 430 kg/ha. However, the intensive development of the coast as a resort area has led to the transformation and significant reduction of the territories of natural ecosystems with the international status of wetlands, as a wintering place for migratory birds. So, over the past 20 years, only sea buckthorn thickets have decreased by more than 600 hectares and continue to decrease at an even greater rate, which is of great concern. The analysis showed that 60% of deforested forests fall on the arid zone of the Isyk-Kul region, which can affect the microclimate of the region by increasing arid areas (Zheng *et al*., 2005) (Photo 4).

This research has also shown that sea buckthorn fruits growing both in a relatively clean zone and in a zone subject to the greatest anthropogenic pressure do not accumulate harmful heavy metals in their fruits.

Photo 4: Cut-down plantations on the shores of Lake Issyk-Kul (Photo by first author)

Figure 2: pH value of the studied soils

The study of soil pH showed that they tend to alkalinize in the zone of a developed resort area, the soil pH varied from 7.0 (Bulan Sogotu) to 8.9, in one of the most polluted areas of the region (Cholpon-Ata) (Figure2). The study of soils for the content of heavy metals showed that the coastal soils of the Issyk-Kul region are not contaminated with heavy metals and their content does not exceed the permissible dose (Pb - 2.31 mg/kg - Cholpon-Ata; 1.30 mg/kg - Bulan Sogotu), but requires carrying out constant monitoring. Also, the content of heavy metals was not detected in the fruits (<0.02 mg/kg) (Table 1).

Table 1: Pb content in the soil

Heavy metal content	*Bosteri*	*Cholpon-Ata*	*Tamchi*	*Bulan Sogotu*
Pb [mg/kg]	1.69±0.09	2.31±0.08	2.1±0.12	1.30±0.06

X ± SD = mean ± standard deviation (n=3)

It was noted that, with the development of plants, differences in the quantity and quality of the substrate are observed, which leads to a change in the composition of soil microorganisms (Ribolzi *et al*., 2011; Yang, Yang and Yu, 2018). Microbiological analysis of soils in the area of the most polluted by the cuttings of sea buckthorn

plantations showed that the microbiological diversity of soil samples with sea buckthorn thickets was high compared to the samples where they were cut (Figure 3). Soil samples taken at the sites with the highest tourist visits and developed beach tourism (Cholpon-Ata) were dominated by micromycetes of the genera *Aspergillus*, *Mucor* and *Penicillium*. In soil samples with the lowest anthropogenic pressure (Bulan-Sogotu), a rich species diversity of both soil micromycetes and actinomycetes and bacteria was observed. Bacteria predominated in areas with cut-down plantations. Therefore, any changes in the microbial communities or activities can affect soil biochemical processes and, consequently, influence soil fertility and plant growth. The vegetation cover has an important effect on soil properties (Rinklebe and Langer, 2006) through its contribution of organic matter inputs from plant residues and root exudates to the soil (Myers *et al*., 2001).

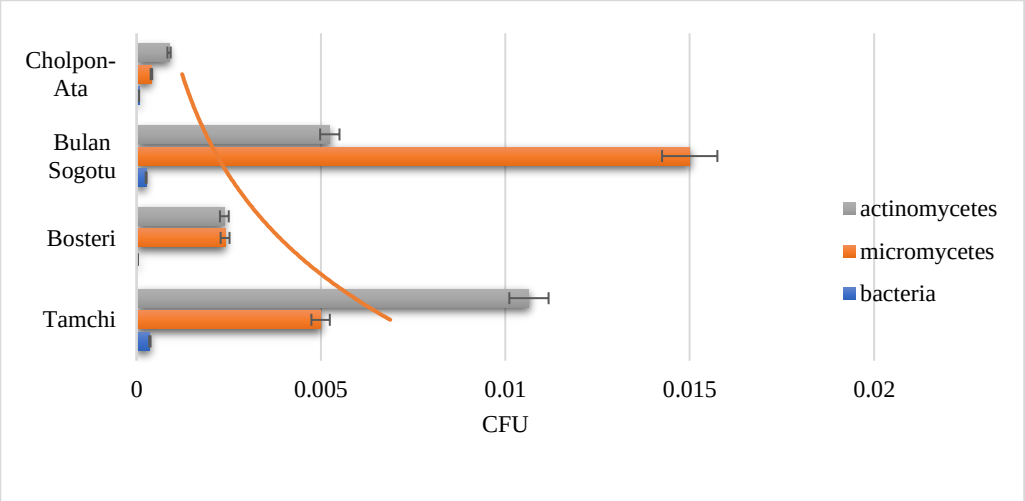

Figure 3: Microbial diversity of the study sites

Studies of the content of ascorbic acid in the sea buckthorn berries showed that the largest amount of ascorbic acid is contained in the fruits of sea buckthorn growing in the zone of the highest anthropogenic pressure. So, in the samples from Cholpon-Ata, the content of ascorbic acid reached 368.6 mg%, and in Bulan Sogotu - 311.2 mg% (Table 2).

Table 2: Ascorbic acid content of sea buckthorn berries

Chemical composition	*Cholpon-Ata*	*Bulan-Sogotu*
ascorbic acid [mg%]	368.6±0.3	311.2±0.2

X ± SD = mean ± standard deviation (n=3).

The content of β-carotene is varying from 21.0-35.1 (mg/100 g) samples taken in different months. The decrease in beta carotene concentration from August to November in the present study may be associated with the specific geographic nature of the area, also with temperature changes and where a short reproductive season prevails (Table 3).

Table 3: β-carotene content of sea buckthorn berries

Chemical composition	*August*	*September*	*October*	*November*
β-carotene [mg/100 g]	35.1±0.42	24.1±0.20	23.4±0.17	21.0±0.16

X ± SD = mean ± standard deviation (n=3).

Questionnaire surveys were conducted with the local people of the study region, 80% of respondents are aware of the medicinal properties of sea buckthorn, but only 10% see the opportunity to benefit from the development of the sea buckthorn business by producing several dozen varieties of products. Also, the questionnaire survey showed that the local population is interested in obtaining environmental knowledge and note a significant decline in coastal forest ecosystems. In addition, the older generation noted that earlier the biodiversity was high, a variety of wild birds lived in the coastal forest thickets: pheasants, etc. Of course, it was noted that the climate has become drier with more frequent cases of mudflows.

The local population mainly uses only sea buckthorn fruits and only for making jam, which, however, is recognized as the most useful. So, 1 kg of sea buckthorn fruit costs on average $ 7-10 USD, and 1 liter of jam costs an average of $ 15 USD. But sea buckthorn pickers do not perceive this business as their main business and, therefore, this industry has not received development and support (Photo 5). This photo represents a typical sea buckthorn jam trade along the road, taken by the author.

Photo 5: Sea buckthorn jam in the local market (Photo by first author)

Discussion

Preservation of the area of unique natural ecosystems requires the development of new approaches to the sustainable development of such regions. Developing mutually beneficial development of human interaction with the biosphere is essential to ensure future prosperity and sustainable development. It is important to properly assess the regenerative capacity and the ability of the environment to heal itself in order to pave the way for sustainable progress. Human depletion of natural resources is widely recognized as a serious threat to sustainable consumption. The growing intensity of resource use has led to the degradation of soil ecosystems, depletion of groundwater, and a decrease in fresh water supplies throughout the world (Dhyani, Maikhuri and Dhyani, 2011). It is necessary to involve the local population in the preservation of unique

ecosystems, through education and development of interest in obtaining benefits from the use of wild fruits by increasing the manufactured products and developing technologies for obtaining them. Wild fruits are richer in nutritional composition than cultivated fruits. Wild fruits and their edible products have high energy content and enormous medicinal potential. Among wild fruits, *Hippophae rhamnoides* has the highest potential for widespread use for sustainable development in regions. The experience of countries developing technologies for the use of wild fruits, such as Germany, China, Mongolia, and others, makes it possible to obtain more than 200 types of products from sea buckthorn (Christaki, 2012). In addition, according to Maikhuri, Rao and Saxena (2004), *Hippophae rhamnoides* has the highest protein content, which has the possibility of developing its use as an alternative to cereal crops (Maikhuri, Rao and Saxena, 2004), which may greatly expand the potential for using wild fruits of sea buckthorn.

In addition, numerous studies (Antosiewicz, 1992; Baker, 1981) show that wild sea buckthorn fruits meet the sanitary and hygienic standards of consumption. It is known that according to their ability to accumulate heavy metals, plants can be divided into three groups: 1) batteries that accumulate metals, both at low and high content in the soil; 2) indicators in which the concentration of the metal reflects its content in the environment; and 3) exceptions, in which the supply of metals to the shoots is limited, despite their high concentration in the environment. Studies have shown that *Hippophae rhamnoides* belongs to the third group of plants, exceptions, in which the supply of metals to the shoots is limited, despite their high concentration in the environment, which makes it possible to widely use the fruits of sea buckthorn growing near industrial areas (Antosiewicz, 1992).

This means that sea buckthorn plantations perform a soil-protecting function and play an important role in preventing climate change by accumulating and retaining moisture and preserving the structure of the soil (Li and Schroeder, 1996; Strat, n.d.; Zhang and Chen, 2007). Therefore, it is important to conserve local fruit-bearing shrubs by maximizing the environmentally friendly benefits from them. Thus, through the development of the integrated use of the gifts of nature, it is possible to preserve the unique natural landscapes of coastal zones performing many ecological functions, including during climate change (Dhyani, Maikhuri and Dhyani, 2011; Li and Schroeder, 1996). The development of technology for the industrial use of wild fruits, together with the simultaneous development of ecological tourism, will significantly help maintain the ecological balance of such regions.

Conclusions

The preservation of unique coastal ecosystems experiencing anthropogenic pressure requires the development of a method for the sustainable use of vulnerable ecosystems. It is necessary to actively involve the local population in the conservation of coastal ecosystems, by obtaining benefits from natural gifts, i.e. the use of wild fruits and berries of coastal plantations. It is necessary to expand the environmentally oriented knowledge about the possible benefits of ecosystem services, develop practical recommendations on production technologies for a variety of products and develop technologies for the production of a variety of products. Sea buckthorn has a great potential, which is an integral component of natural coastal areas, performs a large water protection and water

regulation function, and has many useful pharmaceutical, culinary, and other properties, which can also be used to preserve their natural ecosystems of growth with the development of sustainable nature management.

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Annexure

Appendix 1: Questionnaire to research question: How is the decline of sea buckthorn interpreted/seen by local people?

Serial Number: _____ Place:_____ Date: / /20_

Personal information of interviewee		
Name:	Age:	Marital status:
Gender: □ Male □ Female	Work today:	
Education: □ Primary education □ Secondary education □ Higher education Highest degree:	Work experience before:	
Accommodation, how do you live? Household members: number of adults: _____ number of children (beyond 16 years):_____ Living space:		

A Environmental awareness
A 1 How do you see the ecological situation in your city (village)? □ Absolutely perfect □ Rather well off □ Dysfunctional □ Very bad
A 2 Are you able to improve the ecological situation in your city (village)? □ Yes (go to 2.1) □ No (go to 2.2) □ I don't know (try to answer 2.1. and 2.2)
A 2.1 Could you improve the ecological situation in terms of □ Reduce the number of animals (to avoid erosion) □ Avoid plastic bottles □ Planting trees or shrubs □ Buy local products □ Use public transport □ others, _____ _____
A 2.2 Why?_ □ The ecological situation is fine □ I don't need an intact environment □ There is no organized waste management □ I need all animals □ I don't have time because I have to work □ others,_____ _____

Sea buckthorn
B Sea buckthorn (awareness/knowledge)
Is sea buckthorn a local plant? □ Yes □ No □ I don't know
How often do you see this plant in your neighborhood? □ very often (large areas are covered more than 30 %) □ often (more than 5% covered) □ not so often (less than 5%) □ seldom (2-3 shrubs) □ never
Have you observed I the last 10 years propagation/planting of sea buckthorn in your neighborhood? □ Yes □ No
Have you observed in the last 10 years active clearance of sea buckthorn in your neighborhood? □ Yes □ No Who cleared the land? □ Animals □ Private people □ Authorities □ others,_____
What about the distribution of sea buckthorn in your city (village)? 2x 3x 4x 5x 6x 7x 8x 50 years ago it was larger □ □ □ □ □ □ □ 40 years ago it was larger □ □ □ □ □ □ □ 30 years ago it was larger □ □ □ □ □ □ □ 20 years ago it was larger □ □ □ □ □ □ □ 10 years ago it was larger □ □ □ □ □ □ □ 2x 3x 4x 5x 6x 7x 8x 50 years ago it was less □ □ □ □ □ □ □ 40 years ago it was less □ □ □ □ □ □ □ 30 years ago it was less □ □ □ □ □ □ □ 20 years ago it was less □ □ □ □ □ □ □ 10 years ago it was less □ □ □ □ □ □ □
Which of the following causes lead from your perspective to a decline of sea-buckthorn? □ Development of tourism □ other(s) □ Animal husbandry Which one(s):_____ □ Urbanization □ Climate change □ Diseases or parasites
How could the decline of sea-buckthorn be stopped? □ Planting □ Protection (fences) □ Laws □ Others, _____ _____

Which of the following benefits of sea buckthorn do you know?

□ Fruits contain more vitamin C than citrus fruits
□ Fruits can be used to produce juice
□ Fruits can be used to produce jam
□ Fruits can be used to produce fruit powder
□ Buckthorn oil can be used (e.g. sun protection)
□ Buckthorn can be pruned to improve harvest
□ Sea buckthorn assist water filtration and soil protection
□ Sea buckthorn is well adapted to dry and slightly salty soils
□ Sea buckthorn can be propagated by cuttings
□ Sea buckthorn can be propagated by seeds
□ Sea buckthorn is home for birds and insects
□ Sea buckthorn can be used for reforestation

Which additional benefits of sea buckthorn do you see?

D Sea buckthorn (use, economy)

Which parts of sea buckthorn are used?
□ Fruits □ Leaves □ Bark □ Root □ others,_____
_____

How do you personally use sea buckthorn?
For private use
□ Medicine □ Food (jam, juice, tea …) □ Perfumery □ others, _____
_____

For commercial use
□ Medicine □ Food (jam, juice, tea …) □ Perfumery □ others, _____
_____

How much money do you spent in general for food per day/ week/ month?
_____

How much do you earn with sea-buckthorn products in comparison with other incomes?
5% 10% 15% 20% 25% others, _____

What about your harvest: Could you increase the harvest the last years?
□ Yes □ No

How much do you earn with Sea buckthorn per kg/day/month/year?
With Jam _____
With Juice_____
Others _____

Which month are the time of harvest?

Jan	Feb	March	April	Mai	June	July	Aug	Sep	Okt	Nov	Dec

At what times you sell products made from sea buckthorn?

Jan	Feb	March	April	Mai	June	July	Aug	Sep	Okt	Nov	Dec

How do you harvest sea buckthorn?

□ Cutting the whole brunch □ Collecting only the fruits

Have you contributed in sea buckthorn replanting? Did you plant this shrub?

E Economic status
Have you less than 69 KGS (1,25 US Dollar) per day? □ Yes □ No Which sources of income do you have? How high is your income per month?

Open qualitative questions …

- What is the importance of preserving sea-buckthorn for the sustainable functioning of the Issyk-Kul ecosystem?
- What is the ecological function of the root system of sea-buckthorn?
- Does the decrease in the number of this plant species affect the coastal zone of Lake Issyk-Kul?
- Does the root system serve to strengthen sandy soils?
- Your proposals for the protection of sea-buckthorn?

Authors' Declarations and Essential Ethical Compliances

Authors' Contributions (in accordance with ICMJE criteria for authorship)

Contribution	*Author 1*	*Author 2*	*Author 3*
Conceived and designed the research or analysis	Yes	No	Yes
Collected the data	No	Yes	No
Contributed to data analysis & interpretation	Yes	No	No
Wrote the article/paper	No	Yes	Yes
Critical revision of the article/paper	Yes	Yes	No
Editing of the article/paper	No	Yes	Yes
Supervision	Yes	No	Yes
Project Administration	No	Yes	Yes
Funding Acquisition	Yes	No	No
Overall Contribution Proportion (%)	60	20	20

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Research involving human bodies or organs or tissues (Helsinki Declaration)
The author(s) solemnly declare(s) that this research has not involved any human subject (body or organs) for experimentation. It was not a clinical research. The contexts of human population/participation were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of Helsinki Declaration does not apply in cases of this study or written work.

Research involving animals (ARRIVE Checklist)
The author(s) solemnly declare(s) that this research has not involved any animal subject (body or organs) for experimentation. The research was not based on laboratory experiment involving any kind animal. The contexts of animals were only indirectly covered through literature review. Therefore, an Ethical Clearance (from a Committee or Authority) or ethical obligation of ARRIVE does not apply in cases of this study or written work.

Research on Indigenous Peoples and/or Traditional Knowledge
The author(s) solemnly declare(s) that this research has not involved Indigenous Peoples as participants or respondents. The contexts of Indigenous Peoples or Indigenous Knowledge were only indirectly covered through literature review. Therefore, prior informed consent (PIC) of the respondents or a Self-Declaration in this regard is not applicable for this article.

Research involving Plants
The author(s) solemnly declare(s) that this research has not involved the plants for experiment and field studies. Some contexts of plants are also indirectly covered through literature review. Yet, during this research the author(s) obeyed the principles of the Convention on Biological Diversity and the Convention on the Trade in Endangered Species of Wild Fauna and Flora.

Research Involving Local Community Participants (Non-Indigenous) or Children
The author(s) solemnly declare(s) that this research has directly involved local community participants or respondents belonging to non-Indigenous peoples. Neither this study involved any child in any form directly. The contexts of different humans, people, populations, men/women/children and ethnic people were only indirectly covered through literature review. Hence, a prior informed consent (PIC) of the respondents in this regard is appended.

(Optional) PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)
The author(s) has/have NOT complied with PRISMA standards. It is not relevant in case of this study or written work.

Competing Interests/Conflict of Interest
Author(s) has/have no competing financial, professional, or personal interests from other parties or in publishing this manuscript. There is no conflict of interest with the publisher or the editorial team or the reviewers.

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To see original copy of these declarations signed by Corresponding/First Author (on behalf of other co-authors too), please download associated zip folder [Declarations] from the published Abstract page accessible through and linked with the DOI: https://doi.org/10.33002/nr2581.6853.070205.

INFORMATION AND CONSENT FORM FROM RESPONDENTS
(Non-Indigenous or Indigenous Respondents)
This form was translated into local language for the respondents

Title of the Research: Potential of Sea Buckthorn (*Hippophae rhamnoides* L.) Thickets in Preserving Endangered Ecosystems in Kyrgyz Republic

Principal Researcher:	Rahat Abdykadyrova Kyrgyz-Turkish Manas University, Department of Environmental Engineering, Chyngyz Aytmatov Avenue 56, 720044 Bishkek, Kyrgyz Republic
Research Supervisor:	Nurzat Totubaeva Kyrgyz-Turkish Manas University, Department of Environmental Engineering, Chyngyz Aytmatov Avenue 56, 720044 Bishkek, Kyrgyz Republic

A) INFORMATION TO PARTICIPANTS

1. Objectives of the research
The objectives of this study were assess the awareness of the local population about the importance and possible benefits of using sea buckthorn (*Hippophae rhamnoides* L.).

2. Participation in research
The researcher will ask you several pertinent questions. This interview will be recorded in written form and should last about 50-60 minutes. The location and timing of the interview will be determined by you, depending on your availability and convenience.

3. Risks and disadvantages
There is no particular risk involved in this project. You may, however, refuse to answer any question at any time or even terminate the interview.

4. Advantanges and benefits
You will receive intangible benefits even if you refuse to answer some questions or decide to terminate the interview. You will also contribute to a better understanding of the causes for natural ecosystems transformation into the recreational, agricultural zones.

5. Confidentiality
Personal information you give us will be kept confidential. No information identifying you in any way will be published. In addition, each participant in the research will be assigned a code and only the researcher will know your identity.

6. Right of withdrawal

Your participation in this project is entirely voluntary and you can at any time withdraw from the research on simple verbal notice and without having to justify your decision, without consequence to you. If you decide to opt out of the research, please contact the researcher at the telephone number or email listed below. At your request, all information concerning you can also be destroyed. However, after the outbreak of the publishing process, it is impossible to destroy the analyses and results on the data collected.

B) CONSENT

Declaration of the participant

- ⇨ I understand that I can take some time to think before agreeing or not to participate in the research.
- ⇨ I can ask the research team questions and ask for satisfactory answers.
- ⇨ I understand that by participating in this research project, I do not relinquish any of my rights, including my right to terminate the interview at any time.
- ⇨ I have read this information and consent form and agree to participate in the research project.
- ⇨ I agree that the interviews be recorded in written form by the researcher: Yes ( ) No ( )

Signature of the participant : _____ Date : _____

Surname : _____ First name : _____

Researcher engagement

I explained to the participant the conditions for participation in the research project. I answered to the best of my knowledge the questions asked and I made sure of the participant's understanding. I, along with the research team, agree to abide by what was agreed to in this information and consent form.

Signature of the researcher : Date : 15-05-2020

Surname: Abdykadyrova First name: Rahat

- ⇨ Should you have any questions regarding this study, or to withdraw from the research, please contact Ms.Rahat Abdykadyrova by e-mail rahat.estebesovna@gmail.com

- ⇨ If you have any concerns about your rights or about the responsibilities of researchers concerning your participation in this project, you can contact the Assoc. Prof. Nurzat Totubaeva, Kyrgyz-Turkish Manas University, Department of Environmental Engineering, Chyngyz Aytmatov Avenue 56, 720044 Bishkek, Kyrgyz Republic by e-mail nurzat.totubaeva@manas.edu.kg