Ecosystem service assessment of the Ili Delta, Kazakhstan

Niels Thevs, Volker Beckmann, Sabir Nurtazin, Ruslan Salmuzauli, Azim Baibaysov, Altyn Akimalieva, Elisabeth A. A. Baranoeski, Thea L. Schäpe, Helena Röttgers, Nikita Tychkov

1. Territorial and geographical location

Ili Delta, Kazakhstan

Almatinskaya Oblast (province), Bakanas Rayon (county)

The Ili Delta is part of the Ramsar Site *Ile River Delta and South Lake Balkhash Ramsar Site*

2. Natural and geographic data

Basic geographical data:

location between 45° N and 46° N as well as 74° E and 75.5° E.

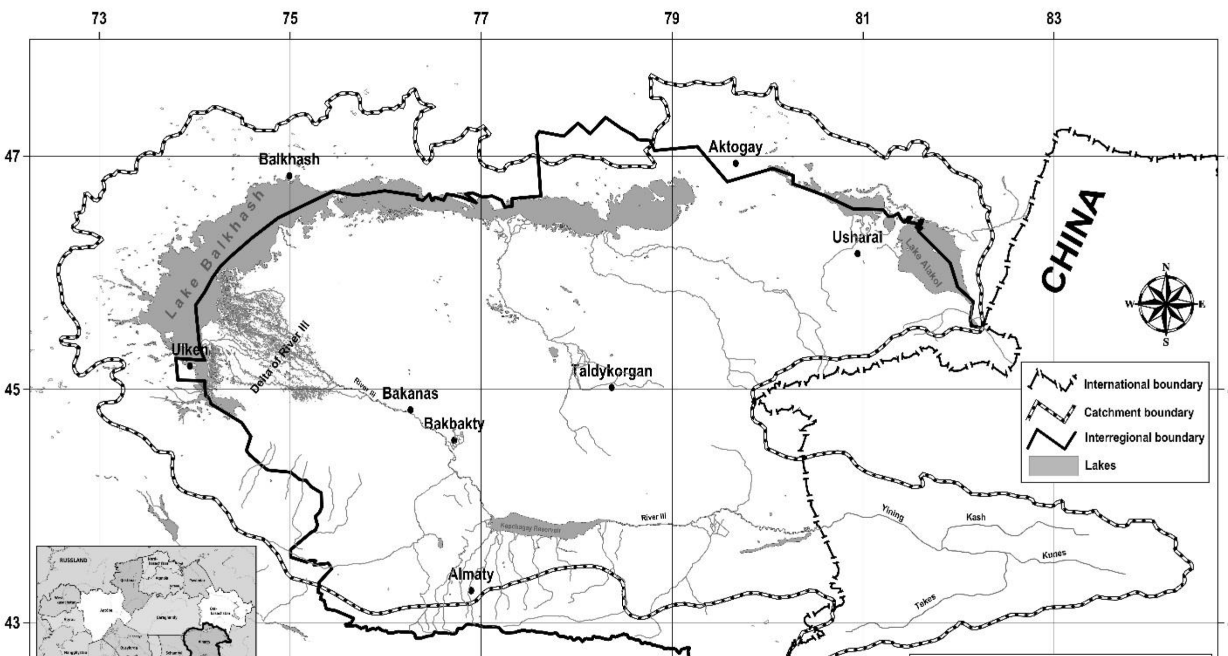

Fig. 1: Map of the Ili-Balkhash Basin (Imentai et al., 2015).

Natural areas:

The Ramsar Site *Ile River Delta and South Lake Balkhash Ramsar Site* comprises wetlands and meadow vegetation (the modern delta), ancient river terraces that now harbour Saxaul and Tamarx shrub vegetation, and the southern coast line of the western part of Lake Balkhash.

Most ecosystem services (ESS) can be attributed to the wetlands and meadow vegetation. Therefore, this study focusses on the modern delta with its wetlands and meadows. During this study, a land cover map was created through classification of Rapid Eye Satellite images from the year 2014. The land cover classes relevant for this study were: water bodies in the delta, dense reed (total vegetation more than 70%), and open reed and shrub vegetation (vegetation cover of reed 20-70% and vegetation cover of shrubs and trees more than 70%). The land cover class dense reed was further split into submerged dense reed and non-submerged dense reed by applying a threshold to the short wave infrared channel of a Landsat satellite image from 4 April 2015. The shortwave infrared channel SWIR I was converted into radiance. Pixels with radiance lower and equal to 8.75 were classified as dense submerged reed.

Thus, the whole remote sensing analysis resulted in the land cover classes relevant for this ecosystem service assessment as shown in Table 1 and Fig. 2.

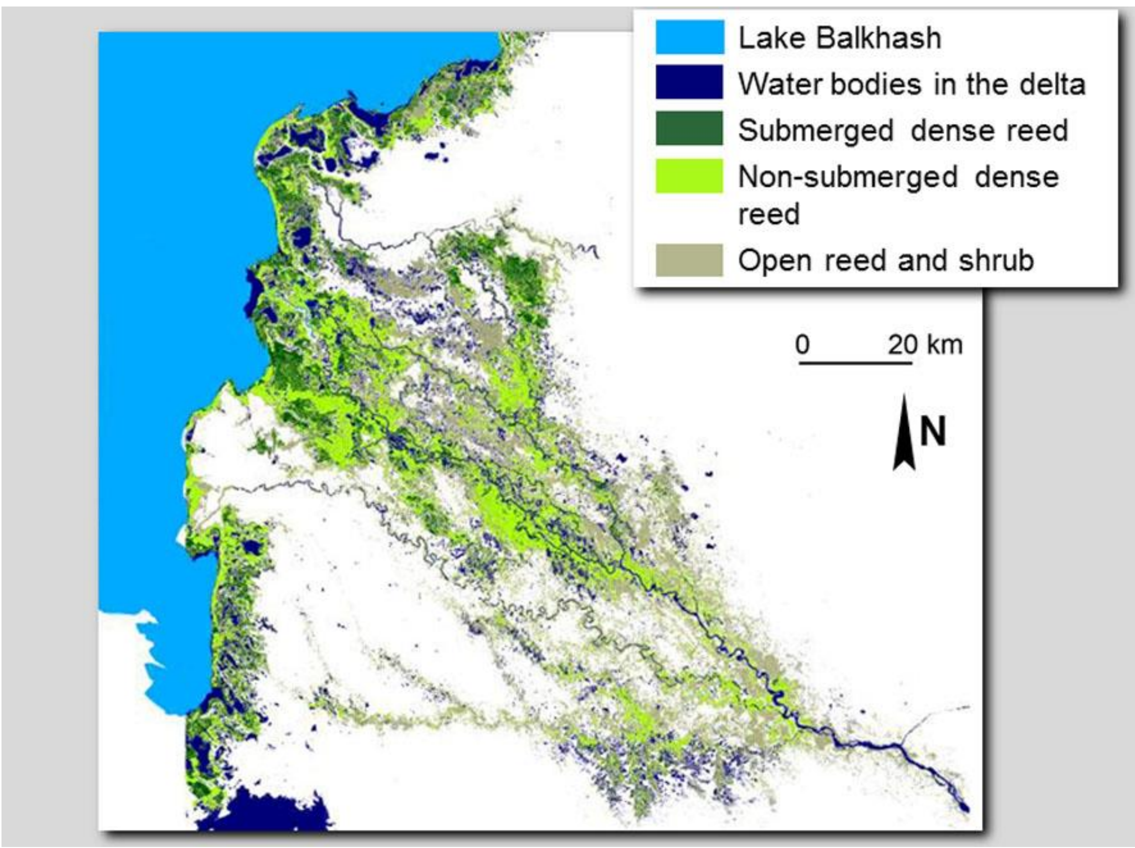

Fig. 2: Map with land cover classes relevant for ecosystem service assessment.

Tab. 1: Land cover classes relevant for assessment and monetizing of ecosystem services

Land cover class	Area [ha]
Water bodies in the delta	100208
Submerged dense reed	85400
Non-submerged dense reed	126378

Open reed and shrub vegetation	138400

In 2014 reed biomass was measured in the field after Thevs et al. (2007). These field measurements were related to the NDVI of July 2014 of the Rapid Eye Satellite images. The following relationships were fitted:

$$\text{Log(stem biomass)} = 3.4429 * \text{NDVI}_{\text{July}} - 1.009 \qquad R^2 = 0.69$$

The stem biomass of submerged and non-submerged dense reed amounted 869,097 t and 2,322,976 t, respectively. Thereby, the former is relevant for biomass used as raw material.

Important natural objects:

Most important natural objects are the wetlands (submerged dense reed and water bodies) with the numerous river branches of the modern delta, the coast of Lake Balkhash, and meadows (also dominated be *Phragmites australis*, but not submerged by water) largely corresponding to non-submerged reed and open reed.

Reserves:

This Ramsar Site covers an area of 976,630 ha and is situated within the borders of the three Zakazniks: Balkhash, Karroy, and Kukan, which together cover an area of 1,061,100 ha. The Ramsar Site contains three Important Bird Areas (IBA): Ile Delta (574,300 ha), Topar Lake System (32,530 ha), and Lower Reaches of the Karatal River (102,195 ha) (Ramsar Convention, 2012). All three Zakazniks within this Ramsar Site are under the management of the Altyn-Emel National Park. The category Zakaznik is equivalent to the IUCN category VI, i.e. Protected Area with Sustainable Use of Natural Resources.

Important habitats (local, national or international):

The Ile Delta is a mosaic from perennial and seasonal river branches and lakes with reed beds (dominated by *Phragmites australis*), riparian forests (Tugai), halophytic meadows, desert meadows, and shrub vegetation, according to the Russian vegetation classification, which is used in this study (Ogar 2003; Sivanpillai et al. 2006; Ramsar Convention 2012).

The riparian forests are built by *Elaeagnus angustifolia*, *Populus pruinosa* and *P. euphratica* as well as Salix species and thus are the only forests in the study region (Rachkovskaya et al. 2003). Halophytic Meadows are formed by Grass species, including *Phragmites australis*, on sites which are not or seldom submerged, with groundwater levels of 1.5-2.5 m (Ogar 2003). Desert Meadows are distributed on terraces along active river branches or on previous flood plains with groundwater levels deeper than 2.5 m. Desert Meadows are formed by grasses, perennial herbs like *Alhagi pseudoalhagi* or *Glycyrrhiza uralensis*, and shrubs like *Halimodendron halodendron* or *Tamarix* species. Both meadow vegetation types are the most important land for grazing and hay making.

The shrub vegetation splits into *Tamarix* dominated shrub vegetation, *Haloxylon aphyllum* vegetation, and shrub communities dominated by Halophytes (Ogar 2003). Such shrub vegetation is distributed on terraces or on previous flood plains and forms the boundary to the desert which surrounds the delta.

Important species of plants and animals, if available:

The delta and southern part of Lake Balkhash support a range of threatened species, including one fish, 25 bird, and three mammal species as listed in Imentai et al. (2015) and Sultanova et al. (2012). Eight bird species, which nest in or migrate through the Ili Delta and the southern part of Lake Balkhash (*Anas platyrhynchos, Netta rufina, Aythya ferina, Bucephala clangula, Fulica atra, Pelecanus crispus, Pelecanus onocrotalus, Phalacrocorax carbo*) have more than 1% of their global population in the Ili Delta and the lower reaches of the Karatal River at Lake Balkhash. Hereinafter, these eight species are called flagship species. From the 56 bird species, which are listed as endangered in the Red List of Kazakhstan, 33 live in the Ile Delta and Lake Balkhash (Imentai et al., 2015).

The former eight bird species require wetlands, lakes, or estuaries with adjacent vegetation as their habitat. All of those eight species, except for *Bucephala clangula*, migrate away from the Ili Delta for winter (http://www.birdlife.org/datazone/). Only *Bucephala clangula* winters in the Ili Delta.

3. General socio-economic data

Population (age, gender and ethnic composition, education, urbanization):

The Ili Delta is a rural area. There are 20 settlements, which belong to nine village governments in the Ili Delta. In total there is a population of 16,000 people (pers. comm. County Government Balkhash, 2015-07-24). The village Kuigan, as an example, had a population of altogether 1,440 people in 2013, out of which 25 % were less than 18 years old, 8 % were above 65 years, and 78 % were of age in between (Hirschelmann, 2014). The population in the delta is mainly Kazakh. Only the settlement Aral Töbe is inhabited by a significant Russian population. During summer, a small number of employees of tourist resorts (mainly Russians and Kazakh) and herders come into the delta as non-permanent population.

Employment and income:

The major sectors of employment and income sources for the population in the Ili Delta are livestock herding, fishery, and to a small extent agriculture and tourism. Thereby, most of the population in Kuigan lives from commercial fishery out on the Lake Balkhash. In Karoi, both livestock herding and fishery are the sources of income. In all other villages, livestock herding is the main income source. The livestock herders use pastures in the delta, several kilometers away from their villages. Agriculture is concentrated in the settlement Aral Töbe. In the other villages, there are only a few small kitchen gardens for self-consumption.

Tourism takes places in resorts that are located remotely in the wetland and in Karaoysek, The resorts are owned and managed by people from outside the delta region. The tourism in Karaoysek is family-based so that it contributes to income of the local population there.

4. Questions of land use and ecosystem services (ESS)

In this section the current situation of land use and ecosystem services is described and the approaches of valuing ecosystem services are explained.

In terms of area, livestock herding is by far the most prominent land use with a total of 101,767 cattle, horses, sheep, and goats (Tab. 2). During Soviet Union times, there were a number of 500,000 animals in the Delta (Jungius, 2010). During summer, reed beds that are not submerged by water and meadows with adjacent shrub vegetation, are grazed and mown for haymaking. Still, large areas of reed beds and meadows are not grazed. Instead reed beds and meadows are burned during winter and spring, in order to remove old stems on non-grazed reed beds. A very small proportion of reed is harvested during winter, in order to use it as construction material. Commercial fishery takes place on Lake Balkhash, but is forbidden throughout the Ili Delta. The water bodies of the delta and submerged dense reed are a major spawning place for the commercially caught fish. The major tourism activities are sport fishing, hunting, and to a very small extent bird watching. Tourism takes place only in parts of the delta’s wetlands. The largest group of land users is livestock herders.

Tab. 2: Livestock in the Ili Delta in 2ß14. One livestock unit is one cattle / horse or 10 sheep / goats. Source: Veterinary Department of Bakanas County, pers. comm. 2015-07-24

Livestock	Number	Livestock units
Cattle	39067	39067
Sheep	22977	2298
Goats	28726	2873
Horses	10997	10997
Total	101767	55235

The major ecosystem services relevant for the Ili Delta are:

Provisioning: i) fodder for livestock. ii) fish as the Ili Delta serves as spawning place and thus provides a large share of the commercial fish catch of Lake Balkhash. iii) biomass currently is used in small amounts. iv) habitat (fodder) is provided to wildlife, e.g. the bird biodiversity that justifies designation as Ramsar site.

Regulating: i) carbon sequestration may play a role considering ongoing deposition of organic material in submerged reed beds, though this effect might be counterbalanced by methane emissions from those reed beds. Considering conservation of the carbon that is bound in organic deposits under submerged reed, reed beds play a role to retain sequestered carbon. ii) regulating water quality plays a role as the Ili Rivers carries a nutrient load from agriculture upstream, especially the rice fields in Bakanas and Bakbakty. Furthermore, reed beds purify the waste water from the local population and tourism. iii) regulating the local climate (cooling effect). iv) flood control does not play a role with regard to the Ili Delta, because flood pulses from upstream are controlled by the Kapchagay Reservoir. Furthermore, there is only Lake Balkhash downstream of the delta, for which flood control is not essential.

Cultural: i) basis for recreation. ii) identity, The Ili Delta is a well-known place in Kazakhstan to which people attribute significance.

The following sections on monetizing ecosystem services of the Ili Delta include the following ecosystem services: provisioning of fodder, fish, and biomass, retaining carbon under submerged reed beds, water purification as well as basis for recreation. Additionally, the amount of fish and biomass eaten by the eight flagship bird species is estimated and treated as provisioning service, too. Biomass and retaining carbon are only assessed in the following section, where development scenarios are investigated with regard to ecosystem services and their monetary values. The methods and data sources for the assessment of values are given in Tab. 3.

Tab. 3: Methods and data source for assessment of values of ecosystem services of the Ili Delta

Ecosystem service	Valuation method	Data source
Provisioning of fodder	Market prices: farm-gate selling prices of animals and milk as animal product.	Statistical data, expert and farm interviews, costs of lifestock production from Baranowski (2016)
Provisioning of fish	Market prices: selling prices of 60% of the annual fish catch of Lake Balkhash. The assumption behind is that 60% of all fish in Lake Balkhash grew up in the Ili Delta.	Statistical data, literature data, expert and farm interviews (see Piechottka, 2015)
Provisioning of biomass	Market price for harvested reed biomass: farm-gate selling prices (will be applied for scenarios in the following section.)	Expert interviews on selling prices and use of biomass. Costs for harvest from Köbbing et al. (2015)
Retain carbon in organic matter under submerged reed beds	Carbon price from voluntary market for organic matter that is exposed if water level drops (will be applied for scenarios in the following section.)	Expert interviews
Water purification	Transfer value from other wetlands	De Groot et al. (2012)

Basis for recreation – tourism	Zonal travel cost approach (after http://www.ecosystemvaluation.org/)	Interviews with owners and managers of all tourist facilities in the Ili Delta, expert interviews

The basis year for this monetizing study was 2014. Thereby monetary figures given in Kazakh Tenge (KZT) were converted into USD after the average exchange rate of 1 USD : 177.086 KZT for 2014. Monetary figures from 2015 were converted into 2014 figures with an inflation rate of 5%. All interviews in 2015 took place before the devaluation of the KZT, i.e. before August 2015.

The ecosystem services from Tab. 3 are attributed to the land cover classes from Tab. 1 as follows: Submerged dense reed and water bodies in the delta comprise the wetlands. The ecosystem services provisioning of fish and basis for recreation are attributed to the total wetland area. Provisioning of biomass, retain carbon in organic matter under submerged reed beds, and water purification are only attributed to the submerged dense wetlands. The ecosystem service provisioning of fodder stems from the non-submerged dense reed and open reed and shrub vegetation. Submerged reeds are not grazed as they are too wet and hay making does not take place there, because summer harvest, as required for hay, is too difficult. Due to grazing and hay making, game that is interesting for hunting tourism, moves back into the wetlands.

Provisioning of fodder

The total livestock numbers of the nine villages in the Ili Delta were obtained from the veterinary service of Balkhash County (Tab. 2). As annual vaccinations are free of charge, it can be assumed that all livestock has undergone vaccination and thus has been registered by the veterinary service. The share of livestock sold or consumed, livestock farm-gate selling prices, milk production, and milk prices were obtained from farm interviews during summer 2015. The farm gate selling prices revealed through farm interviews were attributed to livestock, which was sold as well as for which was consumed. The number of livestock and the farm-gate selling prices of livestock are given in Tab. 4.

Tab. 4: Livestock numbers included into the calculation of the monetary value of ecosystem service provisioning fodder and farm-gate selling prices of each livestock

Livestock	Number sold and consumed 2014	Farm-gate selling price per animal [USD ad 2014]
Cattle	11,720	753
Horses	3,299	1,345
Sheep	6,893	161
Goats	8,618	67
Milk	1,513,913 litres	1.08

The accumulated revenue from those farm-gate selling prices for the Ili Delta was 15 million USD for 2014. The costs for livestock production in the Ili Delta were 37.2% and 75% of the farm-gate selling prices (Baranowski, 2016) for small farms and large intensive farms, respectively. In this study, the average of the two, 56% of the farm-gate selling prices was used. These costs included variable costs as well as fixed costs, including annuities for investments.

The net benefit from the ecosystem service provisioning fodder (including costs) amounted to 6.6 million USD per year in 2014.

Provisioning of biomass as raw material

Reed biomass as raw material is harvested in winter. In 2014, it was sold at a farm gate price of 7000 KZT/t. As for the costs, 59% of the farm-gate selling price was used after Köbbing et al. (2015), who had studied a similar reed economy in Inner Mongolia in China. Currently, only small amounts of biomass are harvested. Therefore, the monetary value of this ecosystem service is only assessed in future scenarios (cf. section 5), when reed biomass based enterprises will be operating at their planned scale.

Provisioning of fish

The total fish catch of Lake Balkhash has been fluctuating around 10,000 t per year from 1930 to 2007, whereby it peaked with slightly more than 18,000 t in 1942 and dropped to slightly less than 4000 t in 2001 (MacDonald, 2010). According to Kazakh National Fishery Research Institute, the upper limit for the total fish catch from Lake Balkhash was 7271 t for the year 2015, which was in the range of upper limits of the past few years (personal communication, 18-May-2016). This upper limit is about 10% of the total fish catch in Kazakhstan.

For this assessment of ecosystem service of provisioning of fish that annual fish catch of 7271 t was assumed at an average farm-gate selling price of 150 KZT/kg for 2013 (after interviews with fishermen in Piechottka, 2015). Furthermore, it was assumed that 60% of the fish catch results from spawning and growing up in the Ili Delta. Costs were assumed as 50% of the farm-gate selling price of the fish that resulted from spawning in the Ili Delta. This results in a net benefit from the ecosystem service provisioning fish of 1.9 million USD per year for 2014.

Fish and biomass eaten by birds

Wildlife in the Ili Delta consumes fodder that is provided by wetland ecosystems. Here, only the eight flagship bird species are considered, because those species have been investigated regarding their numbers in the context of designation of the Ramsar Site. So, the amounts of fodder and associated values will be an underestimate. Only fish and reed will be considered, because those two are items from the category of provisioning ecosystem services that are actually traded in the

Ili Delta. So, with respect to fish and reed one can argue that consumption by birds could be forgone revenues to local fishers and land users, as the current fish catch is considered to be at the margin of over-fishing.

For pelican (*Pelecanus crispus* and *Pelecanus onocrotalus*) and cormorant (*Phalacrocorax carbo*) fish diet values are listed in Tab. 5. For the non-fish eaters the following assumption was made: During summer (90 d) those birds feed on reed, whereby they eat a daily amount equivalent to their body mass (Glutz von Blotzheim and Bauer, 1999; Svenson, 1999). This results in 800 g fresh reed per day or 470 g dry reed biomass. The total amount of reed biomass consumed (cf. Tab. 5) is treated as harvested reed biomass, i.e. farm gate selling price of 7000 KZT/t and costs of 59% of that farm-gate selling price, as explained before in the paragraph on provisioning of biomass as raw material.

Tab. 5: Estimate of diet from the Ili Delta for the eight flagship bird species. These species are migratory. For the two pelican species, duration of stay of 180 d was assumed, for *Phalacrocorax carbo* 270 d was assumed. For *Anas platyrhynchos*, *Netta rufina*, *Aythya ferina*, and *Fulica atra* it was assumed that these species feed on reed for 90 d with 470 g biomass per day and individuum.

Species	Number (individuals)[1]	Fish diet [%][2]	Fish consumption [kg/d][3]	Fish consumption [t]	Reed consumption [t]
Pelecanus crispus	200	100	1.09	39.2	
P. onocrotalus	200	100	1.09	39.2	
Phalacrocorax carbo	1619	100	0.4	175	
Anas platyrhynchos	10000	0			720
Netta rufina	30000	0			2160
Aythya ferina	20000	0			1440
Bucephala clangula	5000	0			
Fulica atra	30000	0			2160
Total amount				253.4	6480
Value [million USD]				0.11	0.11

Sources:

[1] https://rsis.ramsar.org/RISapp/files/RISrep/KZ2020RIS.pdf

[2] http://www.birdlife.org/datazone

[3] https://fishandgame.idaho.gov/public/wildlife/planPelican.pdf

The fish and biomass consumed by the birds considered is equivalent to 0.22 million USD annually.

Waste water treatment

Here the average value of de Groot et al. (2012) of 3,015 Int$/ha (International Dollar) at 2007 prices was used. This results in a present value of 1,146 USD/ha for 2014 (http://data.worldbank.org/indicator/PA.NUS.PPP?page=1). Currently, waste water only stems from the population inside the delta (16,000 people), the population between the delta and Kapchagay Reservoir, as well as from agriculture in Bakanas and Bakbakty.

The water quality in the downstream part of the Ili Delta is good according to field experience of the authors. Therefore, it is assumed that the wetlands (dense submerged reed) in the upstream part of the Ili Delta provide the ecosystem service of waste water treatment, which results in the good water quality in the downstream part of the delta. The upstream third of the river length with its adjacent wetlands (i.e. 4,443 ha of dense submerged reed) was considered for the current ecosystem service of waste water treatment.

For the waste water treatment for the population of 16,000 people inside the delta, an area of 5 m^2 per person for plant (reed) based biological waste water treatment plants was calculated, which results in an additional 80000 m^2, i.e. 8 ha. This total of 4,451 ha of wetlands results in a value of 5.1 million USD per year.

Basis for recreation – tourism

During May to July 2015 all tourist bases within the Ili Delta were visited and interviewed regarding their number and origin of guests, activities, services and related costs, in order to collect the data needed for the zonal travel cost approach (http://www.ecosystemvaluation.org). In 2014, there were 9,370 tourists who visited the 13 tourist bases in the delta. 8,610 tourists came for sport fishing, while 760 came for hunting as their main activity. In addition, throughout the delta there were about 5,000 sport fishers that used their own tents. Most of all tourists come from Almaty, followed by Russia, other regions of Kazakhstan, and Europe (outside Russia). These four regions were also used as zones for the zonal travel cost approach. The interviews revealed a total number of 45,572 nights in all tourist bases with prices ranging from 90 to 170 USD per night including meals and boat services. The tourists did not visit other places in Kazakhstan, but solely undertook their travel, in order to visit the Ili Delta.

Tourists from outside Kazakhstan travel by airplane to Almaty followed by car transport into the delta region. Tourists from Kazakhstan drive by their own car into the delta region. Most bases are not accessible over land so that most of the tourists are picked up by boat from a designated parking lot maintained by each tourist basis. For transportation costs, for tourists coming from Kazakhstan the gasoline costs were assumed and the costs for boat transfer to the bases as indicated by the bases. For tourists from Russia and Europe outside Russia, average flight tickets from Moscow and Berlin to Almaty were assumed, respectively, plus costs for transport services from Almaty as offered by the bases (7,000 KZT for a group of three people).

Fishing licenses for Kazakh citizens and foreigners cost 1,500 KZT and 2,500 KZT per 2 days and 10 kg of fish, respectively. The license fees for hunting were assumed with 25,000 KZT, i.e. the fee for shooting one wild boar, which is the most popular game.

The monetary value of the time that the visitors spent for their visits in the Ili Delta was estimated based on average monthly wages of Kazakhstan, Russia, and Germany (for guests of Europe, as most guests from Europe outside Russia came from Germany) after www.knoema.de. Thereby, monthly salaries of 677.63 USD, 848.60 USD, and 4041.67 USD were used for tourists from Kazakhstan, Russia, and Europe outside Russia, respectively.

The benefit from the ecosystem service basis for recreation – tourism – amounts to 8.5 million USD in total or USD 593 per visitor. For costs 50% of this benefit were assumed, which results in a net benefit from tourism of 4.25 million USD

The net benefits of ecosystem services from the Ili Delta currently enjoyed are given in Tab. 6. Thereby, provisioning of fodder and fish directly reflects the income from livestock and fish for the delta region. The net benefit written for tourism in Tab. 6 differs from the actual income made from tourism, as it is the consumer surplus, which includes the monetary value of the time of the visitors. Water purification does not inhere any direct monetary income to people in the delta, but contributes indirectly to people's income, as good water quality is the basis for fishery and tourism.

Tab. 6: Net benefit of ecosystem services currently used in the Ili Delta

Ecosystem service	Net benefit [million USD per year]
Provisioning of fodder	6.6
Provisioning of fish	1.9
Provisioning of biomass	
Retain carbon in organic matter under submerged reed beds	
Water purification	5.1
Basis for recreation – tourism	4.25
Diet for bird biodiversity	0.22
Total	**18.07**

5. The issues of land degradation and ecosystem services

The Ili Delta with its wetlands and meadows and associated ecosystem services depends on the inflow of water by the Ili River. During the 1960s, i.e. before the construction of the Kapchagay Reservoir and before large scale developments of irrigation in Kazakhstan and China, in average 15 km³ water per year were drained into Lake Balkhash, with 12 km³ per year coming from the Ili River and three km³ per year from the four minor rivers Karatal, Aksu, Lepsi, and Ayaköz (Figure 1). During the 1970s, the Kapchagay Reservoir was filled and the area under irrigation in the Ili river basin was increased, too. Thus, the annual runoff of the Ili River into Lake Balkhash shrunk to between 12.2 km³ and 12.9 km³ (Petr 1992; Abdrasilov and Tulebaeva 1994). The water level of Lake Balkhash dropped by 2 m to 341 m above sea level (a.s.l.). The lake area shrunk from 18000 km² in the 1960s to 16,000 km². In the Ili Delta, after the Kapchagay Reservoir was constructed, from 1974 to 1985, the area of open water shrunk from 1209 km² to 354 km². At that time, first concerns were raised that Lake Balkhash may turn into a second Aral Sea (Dostaj et al. 2006).

From the mid-1980s, the Kapchagay Reservoir was not further filled and after independence of Kazakhstan the irrigated area shrunk (Table 5). Thus, the inflow of the Ili River through the delta into Lake Balkhash increased to 15 km^3 per year and peaked with 26.3 km^3 per year in 2002. Since that year, the inflow dropped again to 15 km^3 per year in 2009 (Esekin et al. 2011). While 2010 again was a year with an inflow into Lake Balkhash significantly higher than 15 km^3 per year, during the past five years the inflow into Lake Balkhash and into the delta sunk from year to year (personal communication with representative of Balkhash county and farm interviews).

The area of agricultural land in the upstream part of the Ili River in China has been increasing from the 1970s until today (Tab. 7), while the area in Kazakhstan sharply dropped after independence.

Tab. 7: Agricultural land [ha] in the Ili river basin from 1970s to 2013 (Thevs et al., 2014)

Year	1970s	1990s	2001	2013
Kazakhstan	1,242,170	1,093,362	613,317	492,958*
China	572,294	630,928	808,551	940,276
Total	1,814,464	1,724,290	1,421,868	1,433,234

*Part of the fields in Kazakhstan are planted only if there is enough water available. This figure only reflects the planted fields in 2013.

Today, it is an open question, how the runoff of the Ili River and thus vegetation and ecosystem services in the Ili Delta will develop in the near future. Though, it is very likely that the runoff into the Ili Delta will decrease, mainly due to increasing agricultural activities and water withdrawal upstream of the delta in Kazakhstan and China (Imentai et al., 2015). Furthermore, climate change, due to glacier melt, may result in lower runoffs mid of this century as suggested for many rivers of Central Asia (Unger-Shayesteh et al., 2013).

Along with a decreasing inflow into the Ili Delta, it is to expect that water levels of the water bodies in the delta will drop. Furthermore, periodically submerged areas of the delta will become non-submerged throughout the year. Along with those changes in water levels and duration of being submerged, groundwater levels will drop, too, as has been reported by Treshkin (2001) and Geldyeva et al. (2012) for the Amu Darya Delta in the course of vanishing of the Aral Sea. Along with those changes of the water resources, the following ecosystem changes can be expected (cf. Ogar, 2003; Thevs et al., 2008):

- Part of *submerged dense reed turns* into *non-submerged dense reed*. Thus, livestock herders gain land for grazing and haymaking. Spawning space and space for young fish to grow up will be reduced.
- Part of today's *non-submerged dense reed* will turn into *open reed and shrub vegetation*, which offers less fodder for livestock.
- *Open reed and shrub vegetation* will turn into shrub vegetation, which again offers less fodder for livestock.

Livestock herders from the upstream part of the delta reported during the interview campaign in 2015 that they already suffer from land degradation so that part of the livestock was moved to the downstream villages Jideli, Karoi, and Kuigan, while part of the herders already considered to give up herding.

Along with decreasing water inflow from upstream into the Ili Delta, the following changes in the ecosystem services included into this study can be expected:

- Provisioning of fodder will be compromised, because the area from which fodder is provided most likely will shrink. Furthermore, the productivity of the ecosystems that provide fodder will decrease.
- The ecosystem service provisioning of fish will decrease, because the spawning space and space for fish to grow up will shrink. On the other hand, the Kazakh National Fishery Research Institute proposes a long term annual upper limit of 8623 t fish catch from Lake Balkhash, which will be used for future scenarios in this study.
- Provisioning of biomass will decrease, too, because the area of submerged reed will be reduced.
- Tourism will be impacted to a minor extent. The large and expensive tourist bases are located at the major water bodies, which will carry water even if the inflow drops. Smaller tourist bases at the margin of the delta will lose customers when the nearby water bodies fall dry.

Against this background the following scenarios are displayed with their consequences for ecosystem services of the Ili Delta:

- Unchanged runoff of the Ili River and realizing current development plans (scenario *no runoff change*)
- Unchanged runoff of the Ili River and maximum utilization of ecosystem services (scenario *maximum use of ESS*)
- Moderately decreasing runoff of the Ili River with 20% reduction of water bodies and land cover classes relevant for ecosystem services (scenario *runoff decrease 20%*)
- Strongly decreasing runoff of the Ili River with 67% reduction of water bodies and land cover classes relevant for ecosystem services (scenario *runoff decrease 67%*)

Thereby, we assume a time span of 20 year from 2014. The following Tables, Tab. 8, 9, 12, and 13, thus reflect the annual net benefits of the ecosystem services at the end of this time span at 2014 prices, in order to be better able to compare the consequences for ecosystem services and their values under the scenarios assumed.

Unchanged runoff of the Ili River and realizing current development plans (scenario *no runoff change*)

This scenario (Tab. 8) grounds on the following assumptions: The runoff of the Ili River remains in the range of the past five years and the following current or planned developments become reality (Schäpe, 2015): The reed factory in Karoi plans to use 6,000 t reed biomass per year, once it has reached its full operation, which is production of fodder and production of reed chip-boards. In Zhideli, located at the southern river branch of the Ili Delta, it is planned to construct a pulp factory, which at full scale operation is planned to use 60,000 t reed biomass per year. The pulp is going to be exported to China as raw material for paper production. Most likely, the water quality of the Ili River downstream of Zhideli will deteriorate. Therefore, the wetlands downstream of Zhideli will lose their ecosystem service as spawning ground, but provide the ecosystem service of waste water purification. Finally, a cattle farm designed for 10,000 meat cattle is under construction next to Bakanas. This farm is going to use about 10,000 ha of reed pasture in the Ili Delta. Thus, the amount of livestock would increase to about 65,000 livestock units. Finally, an increase of tourism by 50% is envisioned.

Tab. 8: Net benefit from ecosystem services of the Ili Delta under stable river runoff of the Ili River and realization of current development plans (scenario *no runoff change*)

Ecosystem service	Calculation	Net benefit [million USD per year] as of 2014
Provisioning of fodder	Net benefit from current conditions (Tab. 6) and 3,000 cattle sold out annually at USD 753 each.	7.6
Provisioning of fish	8,883 ha water bodies and submerged dense reed downstream of Zhideli lose their service as spawning ground. This is 4.8% of the current spawning ground. Current net benefit is reduced by this 4.8%.	2.2
Provisioning of biomass	66,000 t of reed per year to both factories in Karoi and Zhideli. 1 t reed biomass is sold at 7,000 KZT to the factories, costs 59% of revenue.	1.1
Water purification	In addition to current conditions, 4,681 ha of submerged dense reed downstream of Zhideli purify waste water.	10.5
Basis for recreation – tourism	Current value increased by 50%	6.38

Diet for bird biodiversity	No change compared to current conditions	0.22
Total		**28.0**

Unchanged runoff of the Ili River and maximum utilization of ecosystem services (scenario *maximum use of ESS*)

This scenario (Tab. 9) grounds on the following assumptions: The runoff of the Ili River remains in the range of the past five years so that the land cover does not change significantly from the distribution and land cover classes given in Fig. 2 and Tab. 1. The submerged dense reed areas are harvested during winter except for a belt of 100 m around water bodies that are larger than 1 ha. Thus, habitat for birds and other wildlife as well as landscape esthetic for tourism is provided. As submerged reed areas are harvested during winter, those harvested areas provide habitat during spring, summer, and autumn, which for birdlife is the most important time, because most bird species migrate out during winter.

Livestock numbers are doubled compared to today, at the assumption that 75% of the fodder used stems from the Ili Delta. This is slightly less than the livestock number in the delta during Soviet Union times (Hirschelmann, 2014). The spawning ground for fish is unchanged from today, as it is assumed that the biomass utilization will be done in an environmentally sound way, i.e. without polluting the water bodies and wetlands of the delta. Furthermore, it is assumed that reed biomass is only harvested during winter so that wildlife during nesting and breeding will not be affected and so that nutrients from the reed beds will not be excessively exploited (Thevs et al., 2007). Water purification remains unchanged compared to today, as no deterioration of water quality is assumed. Numbers of tourists are doubled compared to current conditions.

Tab. 9: Maximum net benefits from ecosystem services of the Ili Delta under stable river runoff of the Ili River (scenario *maximum use of ESS*)

Ecosystem service	Calculation	Net benefit [million USD per year] as of 2014
Provisioning of fodder	Increase of livestock by 100% compared to today.	13.2
Provisioning of fish	Upper limit of fish catch 8623 t per year	2.3
Provisioning of biomass	603274 t biomass harvested (from an area of 55,633 ha) at a market price of 7,000 KZT/t, costs 59% of revenue.	9.8
Water purification	No change	5.1
Basis for recreation – tourism	Double of current value	8.5

Diet for bird biodiversity	No change compared to current conditions	0.22
Total		**39.12**

Decreasing runoff of the Ili River – the two scenarios *runoff decrease 20%* and *runoff decrease 67%*

Under the headline decreasing runoff of the Ili River two scenarios are developed: i) loss of open waters in the delta by 20%. During the past five years, the runoff of the Ili River into the delta has decreased, which was associated by a loss of open waters in the delta by 20%. This is reflected in losses of pasture land as reported during the interviews with livestock herders in summer 2015. For this scenario, we further assume as a basis for calculations that the other land cover classes relevant for ecosystem services decrease in area each by 20%, too (Tab. 10). ii) Extreme reduction of the Ili River's runoff similar to the conditions brought upon the Ili Delta through filling the Kapchagay Reservoir. During that time, the area of water bodies in the delta shrunk from 1209 km² to 354 km² from 1974 to 1985 (Kipshakbaev and Abdrasilov, 1994). Thus, for this second scenario, we assume that the area of open water bodies shrinks to one third of the current area, which results in an similar area as given by Kipshakbaev and Abdrasilov (1994) for 1985 (Tab. 10). Analogous to the first scenario under decreasing runoff, the other land cover classes relevant for ecosystem services decrease in area to one third of the current area, too (Tab. 10).

Tab. 10: Land cover class changes under decreasing runoff (scenarios *runoff decrease 20%* and *runoff decrease 67%*)

Land cover class	Area [ha]		
	Current conditions	Water bodies decrease by 20%	Water bodies decrease to one third of today
Water bodies in the delta	100,208	80,166	33,068
Submerged dense reed	85,400	68,320	28,182
Non-submerged dense reed	126,378	101,102	41,705
Open reed and shrub vegetation	138,400	110,720	45,672

For both scenarios under decreasing runoff of the Ili River, carbon dioxide emissions have to be included, because the water level in the delta will drop compared to today so that the upper layer of the organic matter inside the dense submerged reed will be exposed to the air. Thus, that upper layer will be decomposed and its carbon dioxide will be emitted.

For this study a carbon price from the voluntary market was used: 23 Euro / t CO_2eq (athmosfair (https://www.atmosfair.de/kompensieren/flug). This price is still at the lower end of carbon prices. But it was chosen, in order to avoid exaggerated monetary values attributed to carbon storage. This carbon price was calculated into a price of 2014 analogous to all other prices from 2015 and converted into USD with the average exchange rate for 2014 of 1.3289. A time span of 30 years was assumed for the carbon from the organic matter to decompose. Therefore, for the calculation here 1/30 of the total CO_2 was monetized according to Tab. 11 for the base year of this study.

Tab. 11: Carbon lost from organic matter under dense submerged reed through exposure to air and decomposition to CO_2

Calculation parameters	Scenario 20% reduction of water bodies	Scenario 67% reduction of water bodies
Area of dense submerged reed affected [ha]	85,400	85,400
Layer of decomposed organic matter [cm]	20	50
Carbon density [kg C/m³][1]	21.55	20.475
CO_2 emitted [million tons]	13.5	32
CO_2 emitted per year [tons per year][2]	449,050	1,066,625
Total value lost during first year [million USD]	13.1	31

[1]carbon densities form Eid and Shaltout (2013)

[2]one thirtieth of the total CO_2 emitted

For the two scenarios decreasing runoff of the Ili River with 20% reduction of water bodies and land cover classes relevant for ecosystem services and extremely decreasing runoff of the Ili River with 67% reduction of water bodies and land cover classes relevant for ecosystem services the monetary value form the potentially possible utilization of ecosystem services will be estimated.

Moderately decreasing runoff of the Ili River with 20% reduction of water bodies and land cover classes relevant for ecosystem services (scenario *runoff decrease 20%*)

Under this scenario (Tab. 12), the ongoing and planned developments, as listed in Tab. 8, can be realized with their associated ecosystem services. There will only be a slight reduction in provisioning of fish due to a reduction of spawning space. Most water bodies are lost under this scenario in the upstream part of the delta and at the margins of the current wetlands so that especially livestock herders in the upstream villages will be affected. Pasture degradation was reported by livestock herders of those villages already during data collection for this study so that herders purchase reed hay from unused downstream pastures (Hirschelmann, 2014) or move their herds there. Even under this scenario, there will be more than one hectare non-submerged dense reed area available for one livestock unit. Current tourist sites and regions, where further tourism most likely will be developed, are not significantly affected, because they are located further downstream amidst huge areas of lakes and reed beds.

Tab. 12: Net benefit from ecosystem services of the Ili Delta under decreasing river runoff of the Ili River and 20% reduction of land cover classes relevant for ecosystem services (scenario *runoff decrease 20%*)

Ecosystem service	Calculation	Net benefit [million USD per year] as of 2014
Provisioning of fodder	80% of Tab. 9	10.5
Provisioning of fish	80% of Tab. 9	1.8
Provisioning of biomass	80% of Tab. 9	7.8
Emission of CO_2	Tab. 11	-13.1
Water purification	No change from Tab. 9	5.1
Basis for recreation – tourism	No change from Tab. 9	8.5
Diet for bird biodiversity	No change compared to current conditions	0.22
Total		**20.82**

Strongly decreasing runoff of the Ili River with 67% reduction of water bodies and land cover classes relevant for ecosystem services (scenario *runoff decrease 67%*)

Under this scenario (Tab. 13), the planned number of livestock would exhaust pastures. The envisioned biomass harvest could be collected in the delta. Spawning ground for fish would shrink. Tourism is assumed not to develop further compared to the baseline year 2014, because part of the tourist bases lose access to water and wetlands so that both activities fishing and hunting cannot be pursued anymore from those bases. Other bases, which are located further downstream, though are assumed to enlarge and compensate tourist numbers from those abandoned bases. Diet of birds is not considered under this scenario, because the pressure from biomass harvest and grazing will shrink significantly the habitat untouched.

Tab. 13: Net benefits from ecosystem services of the Ili Delta under extremely decreasing river runoff of the Ili River and reduction of land cover classes relevant for ecosystem services to one third of the areas in the baseline year 2014 (scenario *runoff decrease 67%*)

Ecosystem service	Calculation	Net benefit [million USD per year] as of 2014
Provisioning of fodder	33% of Tab. 9	4.4
Provisioning of fish	33% of Tab. 9	0.77
Provisioning of biomass	33% of Tab. 9	3.3
Emission of CO_2	Tab. 11	-31
Water purification	No change	5.1

Basis for recreation – tourism	Current value	4.25
Diet for bird biodiversity	No change compared to current conditions	0.22
Total		**-12.96**

Compare the different scenarios

The net benefit of the current conditions, as listed in Tab. 6, were taken as a baseline to compare the scenarios over a time period of 20 years from 2014. Now, in this second step, the net benefits and incremental net benefit for the four other scenarios were calculated over this time period of 20 years. Thereby, investments in paper factories and reed factories were included as additional costs. Further costs for investments in livestock herding, fishery, or tourism were not included, as such investment costs are already included in the costs used for calculations in Tab. 6, 8, 9, and further Tables. The investments for one reed factory and paper factory were 525,000 USD and 6 million USD, respectively (Schäpe, 2015). Annuities were calculated with an interest rate of 5%, analogous to Baranowski (2016), and a life span of investment of 20 years.

Tab. 14: Calculation of additional investment costs and changes of net benefits and incremental net benefit for the four scenarios developed

Scenario	Calculation
No runoff change	The net benefits from ecosystem services (Tab. 6) approach the level of Tab. 8 linearly over five years and remain at the level of Tab. 8. Investment costs are accounted for one reed factory and one paper factory at the beginning of the time period.
Maximum use of ESS	The benefits from ecosystem services (Tab. 6) approach the level of Tab. 9 linearly over the time span of 20 years. Investment costs are accounted for one reed factory and one paper factory in each of the first ten years.
Runoff decrease 20%	The benefits from ecosystem services (Tab. 6) approach the level of Tab. 12 linearly over the time span of 20 years. Investment costs are accounted for one reed factory and one paper factory in each of the first ten years.
Runoff decrease 67%	The benefits from ecosystem services (Tab. 6) approach the level of Tab. 13 linearly over the time span of 20 years. Investment costs are accounted for one reed factory and one paper factory in each of the first ten years.

The accumulated net present values of the current conditions and each scenario developed are listed in Tab. 15. The net benefits were converted into net present values by applying a discount rate of 10%.

Tab. 15: Accumulated net present values over 20 years of the current conditions and the four scenarios

Scenario	Accumulated net present value [million USD]	Difference of accumulated net present value between current conditions and the four scenarios [million USD]
Current conditions and no further development	153.8	
No runoff change	213.9	60.1
Maximum use of ESS	193,5	39.7
Runoff decrease 20%	135,0	-18.8
Runoff decrease 67%	27,0	-126.8

Discussion and conclusion

The monetary values ecosystem services per area are given in Tab. 16. Thereby, values refer to the most optimistic scenario, i.e. the maximum amount of ecosystem services that is enjoyed under stable runoff of the Ili River (scenario maximum use of ESS).

Tab. 16: Net benefit of the ecosystem services provisioning of fodder, fish, biomass, and basis for recreation per area unit under the most optimistic scenario (*maximum use of ESS*) as given in Tab. 9.

Ecosystem service	Area attributed to	Net benefit [million USD]	Net benefit per area [USD/ha]	Net benefit per area [Int.$*/ha]
Provisioning of fodder	Grazed land	13.2	50	97
Provisioning of fish	Wetlands	1.9	12	24
Provisioning of biomass	Submerged dense reed (area as in Tab. 9)	9.8	176	342
Basis for recreation	Wetlands	8.5	46	89

* International Dollar (purchasing power corrected dollar: http://data.worldbank.org/indicator/PA.NUS.PPP?page=1

The net benefits found for biomass / raw material in this study is in the same range as the average value given by de Groot et al. (2012) for inland wetlands. In contrast, the net benefits from food (fodder and fish) and for recreation are lower than the corresponding average values by de Groot et al. (2012) for inland wetlands. The difference can be explained, because, the study of de Groot et al. (2012) includes wetlands, which are visited by very high numbers of tourists so that the net benefits of basis for recreation is higher than for the Ili Delta. Furthermore, de Groot et al. (2012)

included wetlands that yield more fish and which are cultivated (e.g. rice paddies) more intensively than the Ili Delta.

The highest monetary potential for ecosystem services among the use-values investigated here is offered by livestock herding, followed by biomass harvest. Under decreasing runoff, biomass harvest decreases most significantly, while tourism still may play an important role regarding monetary value of ecosystem services. Yet, the overall monetary value of ecosystem services in compromised by CO_2 emissions due to sinking water level and decomposition of the organic matter that is trapped in submerged reed beds. Both scenarios with a decreasing runoff of the Ili River show a lower accumulated net benefit over the next 20 years compared to current conditions (Tab. 15). Towards the end of the assumed 20 year period, the total annual net benefits from the ecosystem services turn negative (Tab. 12 and 13). On the other hand, both scenarios under current runoff conditions offer room for further development and show higher accumulated net benefit over the next 20 years compared to current conditions.

If one of those scenarios with reduced runoff and thus a sharp decrease of net benefits from ecosystem services became real, the causes for that would be partly agricultural or other economic development upstream along the Ili River. In other words, such agricultural or other economic development upstream along the Ili River inheres a substantial loss of ecosystem services and associated monetary values in the Ili Delta as an external effect. So far it is an open question, if a potentially increasing income from agricultural or other economic development upstream along the Ili River can compensate for possible losses of ecosystem services and associated monetary values, which means if enough additional income can be generated to compensate and if such compensation will be put onto the political agenda.

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