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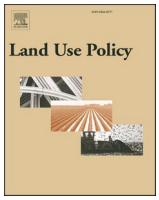

Exploring the human-nature nexus towards effective nature-based solutions: the Aral Sea case

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ABSTRACT

Incorporating societal challenges and values into the design of locally appropriate nature-based solutions (NbS) is an integral strategy for ensuring benefits for both communities and the environment. But how are human-nature relations impacted when the environments containing resources which are valued and relied on, undergo dramatic and sustained change on decadal timescales? To explore this interplay, we selected Muynak as a case study, once a thriving town on the shores of the former Aral Sea in Uzbekistan. We conducted a social survey among the residents to identify the use of natural resources and the values they assign to the most common and yet highly degraded resources in the area (wetlands, rangelands, afforested areas, the Aral Sea, and wildlife). The survey was complemented with expert interviews. Our study suggests that grasslands are the most frequently used of the resources under study, while wetlands and wildlife are generally more valued. Overall, resources were more culturally valued than financially, historically, or recreationally. The majority of respondents perceived a degradation in most natural resources over the past decade, particularly wetlands (79 %), followed by grasslands (48 %), and the Aral Sea (42 %). Wetlands were reported to be in a state of ongoing degradation by 79 % of respondents, which negatively affected the livelihoods of almost half of the households in the survey area. Afforested areas were the only resources reported to have a positive perceived change in both status and their effect on well-being. The vast majority of respondents (83 %) felt that human well-being was linked to environmental conditions. This study lays the foundation for future interventions to develop nature-based solutions to benefit both people and nature, and highlights the continuing value placed on nature by residents of an area that has suffered substantial anthropogenic degradation.

1. Introduction

Over the past five decades, humanity has extensively altered all ecosystems on Earth. On the one hand this has positively contributed to the well-being of people, but on the other has substantially diminished the extent and integrity of those ecosystems, compromising the sustainability of the services they provide. This is projected to potentially lead to dire consequences for human well-being, as humanity and nature are interlinked. Land use change, which in turn is triggered by socio-cultural and economic factors, among others, is a direct driving force of the global deterioration of biodiversity and ecosystems. At the same time, rural populations are among the most vulnerable to changes in ecosystems and the services they provide, as in many cases they directly rely on them (IPBES, 2018; IPBES, 2019; Summers et al., 2012; Shepherd et al., 2016; Powers and Jetz, 2019).

Current research aims to explore the concept of nature-based solutions through the lens of ecosystem services and human well-being interlinkages (Cohen-Shacham et al., 2019). NbS, a term which emerged relatively recently and was given a widely accepted definition in 2022 (United Nations Environment Assembly of the United Nations Environment Programme: Fifth session, 2022), is rapidly being included in multiple global agendas. For an approach to be considered as NbS, it should "*effectively address societal challenges*" (IUCN, 2020) along with multiple other criteria. This implies that NbS not only need to include local communities as part of the stakeholder engagement and decision-making processes but should also be locally adapted to the

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maximum extent possible, embracing local knowledge: *"NbS are determined by site-specific natural and cultural contexts that include traditional, local and scientific knowledge"* (World Conservation Congress, 2016).

The concept of human well-being is multidimensional and multidisciplinary, encompassing various components such as health, quality of life, security, education, social relations, happiness, freedom of choice, and others, according to different definitions of well-being (MEA, 2005b; Liu, et al., 2022; Dasgupta, 2001; Woodhouse et al., 2015). These elements, in turn, are influenced by cultural, social, economic and environmental factors, which influence either the objective or subjective well-being (Liu et al., 2022; Dasgupta, 2001; Woodhouse et al., 2015). In the context of the current research, focus centres on examining the impact of environmental changes and their implications on the overall satisfaction of local communities with their living conditions.

There is no predefined set of indicators or mechanisms that could directly measure the contributions of ecosystem condition to human well-being and vice versa, as the interaction is complex and non-uniform. However, understanding people's perceptions of the benefits derived from ecosystems can contribute towards elucidating the links between human well-being and nature's contributions, i.e., ecosystem services, as human culture and social interactions are strongly influenced by their environmental context (MEA, 2005a; MEA, 2005b; Costanza et al., 2014; Woodhouse et al., 2015). The importance of considering social and cultural values of ecosystems, and of nature in general, in assessing ecosystem services and, hence in designing NbS, is widely recognized among researchers and policymakers. Moreover, studies of valuations, perceptions and attitudes towards ecosystems can provide relevant information on the reliance of local communities on ecosystems and the influence of ecosystem condition on human well-being, towards understanding human-nature relations and nature's contributions to people, and ultimately making better and informed environmental decisions (Plieninger et al., 2013; Costanza et al., 2014; Stålhammar, 2021; Gould et al., 2019; MEA, 2005a; Pascual et al., 2017; Liu et al., 2022; Woodhouse et al., 2015).

Understanding people's values, perceptions and relations with nature is the first step in increasing acceptance of ecological interventions, including NbS, and conservation efforts in general (Dai et al., 2021; Lupp et al., 2021; Restall and Conrad, 2015). As part of local adaptation and improved acceptance, and thus subsequent success of conservation and restoration efforts, it is important to consider cultural values (Infield and Mugisha, 2013), the perception of nature and the surrounding environment by local communities who have long depended on natural resources (Karelakis et al., 2013; Dutcher et al., 2007). People's perception of nature often depends on their socio-economic background, political and religious beliefs, education, income, as well as their reliance on natural resources (Bennett, 2016; Nazarea et al., 1998; Bruun, 1995; Bergtold et al., 2022). All these aspects, in turn, define how individuals and groups of people from different social strata treat natural resources (Anderson et al., 2021; Mok et al., 2021).

Enhanced mainstreaming and integration of biodiversity conservation goals and sustainable provision of nature's contributions to people into policies and programs at all stages could yield more sustainable results. In doing so, consideration of all stakeholders and various aspects of valuation in the planning, decision-making and implementation processes is both important and essential, through, for example, "*taking various values into consideration, including those of … local communities*" (IPBES, 2018; Chan et al., 2012; Costanza et al., 2014). All groups of stakeholders, especially those who are "*particularly dependent on ecosystem services or affected by their degradation*" (MEA, 2005a) should be involved in the decision-making process. The approach of assessing socio-cultural values with respect to addressing nature's non-material contributions to people is a first step towards supporting this local-level policymaking (IPBES, 2018; Stålhammar, 2021).

IPBES (2018) highlights knowledge gaps in research towards better understanding of nature's contributions to people, specifically how those contributions are valued by people of various social groups, age, and genders. In addition, a recent study (Liu et al., 2022) documented a research gap in linking ecosystem services and land use land cover (LULC) change with human well-being, particularly at the community scale, which is crucial for informed decision-making within the context of implementing effective nature-based solutions and achieving the UN Sustainable Development Goals (SDGs). Moreover, additional studies reveal that there is a research gap in evaluating intangible benefits, those that cannot be or are very difficult to quantify in monetary terms, of nature-based solutions (Viti et al., 2022; Dicks et al., 2020). Although the "*impact of the loss of cultural services is particularly difficult to measure, but it is especially important for many people*" (MEA, 2005a).

The issue of degradation of resources and ecosystems is particularly acute in drylands, which support almost one-third of the Earth's human population and yet are particularly vulnerable due to limited water resources, increased land degradation and desertification, habitat conversion, climate change, and overexploitation of resources which can be triggered by rapid population growth (MEA, 2005a; MEA, 2005b). According to IPBES (2018) most biomes in Central Asia, including particularly the Aral Sea, wetlands, and grasslands, are in a state of constant deterioration caused mainly by land-use change and unsustainable use of resources. Moreover, communities in the region tend to have varying access to nature's contributions depending on their locality and social status, which in turn impacts their well-being.

Central Asia, and particularly the Aral Sea basin, containing extensive areas of dryland ecosystems, is also among the regions considered most susceptible to climate change. With average temperature increasing and drought events projected to accelerate during the coming decades, both people and the environment in the Aral Sea region will be increasingly vulnerable (Lioubimtseva and Henebry, 2009; Yushanjiang et al., 2021; Yang et al., 2019; Schlüter et al., 2013). The almost complete loss of the Aral Sea, which was once the world's fourth largest lake and served as a local climate regulator, has already had far-reaching socio-economic and ecological consequences in Uzbekistan, requiring urgent adaptation and mitigation measures (Lemly et al., 2000).

The former port town of Muynak, which is the closest residential area to the Aral Sea, was chosen as a case study to assess trends in regional human-nature relations in a highly degraded environment and their implications for human well-being, as well as to identify potential mismatches between local perceptions and values and higher-level environmental decision-making. Numerous local and internationally funded projects and interventions have been in place since the official announcement of the Aral Sea desiccation as a catastrophe on a regional scale, and yet we did not find any reports in the literature on the results of public surveys aimed at studying human-nature interactions and the implications for well-being of this ecological disaster. This suggests that people's reliance on ecosystems and their services is usually overlooked, and not included in national policies, let alone planning locally adapted NbS approaches.

This study is hence centred on the socio-cultural valuation of natural resources, representing non-monetary preferences (Stålhammar, 2021) of local communities and the links between ecosystems and human well-being. This focus aligns with the fundamental principles of nature-based solutions, which aim to holistically integrate societal priorities into nature-recovery actions to provide sustainable benefits both for society and the environment (IUCN, 2020). Specifically, our research objectives are:

1. Assess the reliance of local households on natural resources based on the frequency of use.
2. Determine the range of different values of various natural resources to local people.
3. Identify respondents' perceptions of changes in natural resources and their impact on well-being of the local communities.

Our findings provide a better understanding of the human-

environment nexus in the Aral Sea region of Uzbekistan, an exemplary dryland and distressed ecosystem, laying the groundwork for further NbS options supporting rehabilitation of environmental and socio-economic conditions in the region and beyond. It is unlikely that NbS can tackle all socio-ecological challenges in the case study region equally, given the complexity and multidimensionality of these challenges, and thus prioritizing certain objectives over others might be required.

2. Material and methods

2.1. Study area

The Aral Sea catastrophe has had far-reaching negative consequences both on the environment and the socio-economic situation of the region (Opp et al., 2016; Wiggs et al., 2003), which was especially acute in the region around the town of Muynak. The economy of Karakalpakstan was heavily dependent on the fishing industry, tourism and recreation, and animal husbandry until the late 1980s. In the 1960s the estimated annual fish catch in the Aral Sea in Uzbekistan alone was twenty-five thousand tons and there was a fish canning factory that exported canned produce to other countries of the former Soviet Union. When the fishing industry and agriculture collapsed due to the drastic shrinkage of the Aral Sea, leaving thousands of people unemployed, part of the population had to migrate to other regions or even countries in search of jobs (Karimov et al., 2005; Crighton et al., 2003). Those who stayed in Muynak, a former port town, remained without reliable sources of income. To date, the employment rate in Karakalpakstan is the lowest in all Uzbekistan with an estimated 60.9 % of the population in employment (The State Committee of the Republic of Uzbekistan on Statistics, 2023).

Muynak is the town most affected by the consequences of the desiccation of the former Sea. It is the closest residential area to the former seashore (Fig. 1) along with the adjacent Uchsay and Tokpakata settlements. Uchsay used to be a collective farm in the past (Crighton et al., 2003), and similar to Tokpakata, it is under the administrative management of Muynak regional authority (Muynak municipality, 2022).

According to statistical information from the municipality of Muynak region (Muynak municipality, 2022), the total number of people residing in the town of Muynak is 14,664, 57 % men and 43 % women, in 2658 households. The total registered number of people residing in Uchsay is 1671 in 246 households, where the gender ratio is roughly

Table 1
Data on socio-demographics from the local mayor's office of Muynak district (Muynak municipality, 2022).

Survey site	Number of households	Number of families	Population number	Gender	
				Male	Female
Muynak	2658	3396	14664	7565	7099
Uchsay	246	334	1671	858	813
Total	**2904**	**3730**	**16335**	**8423**	**7912**

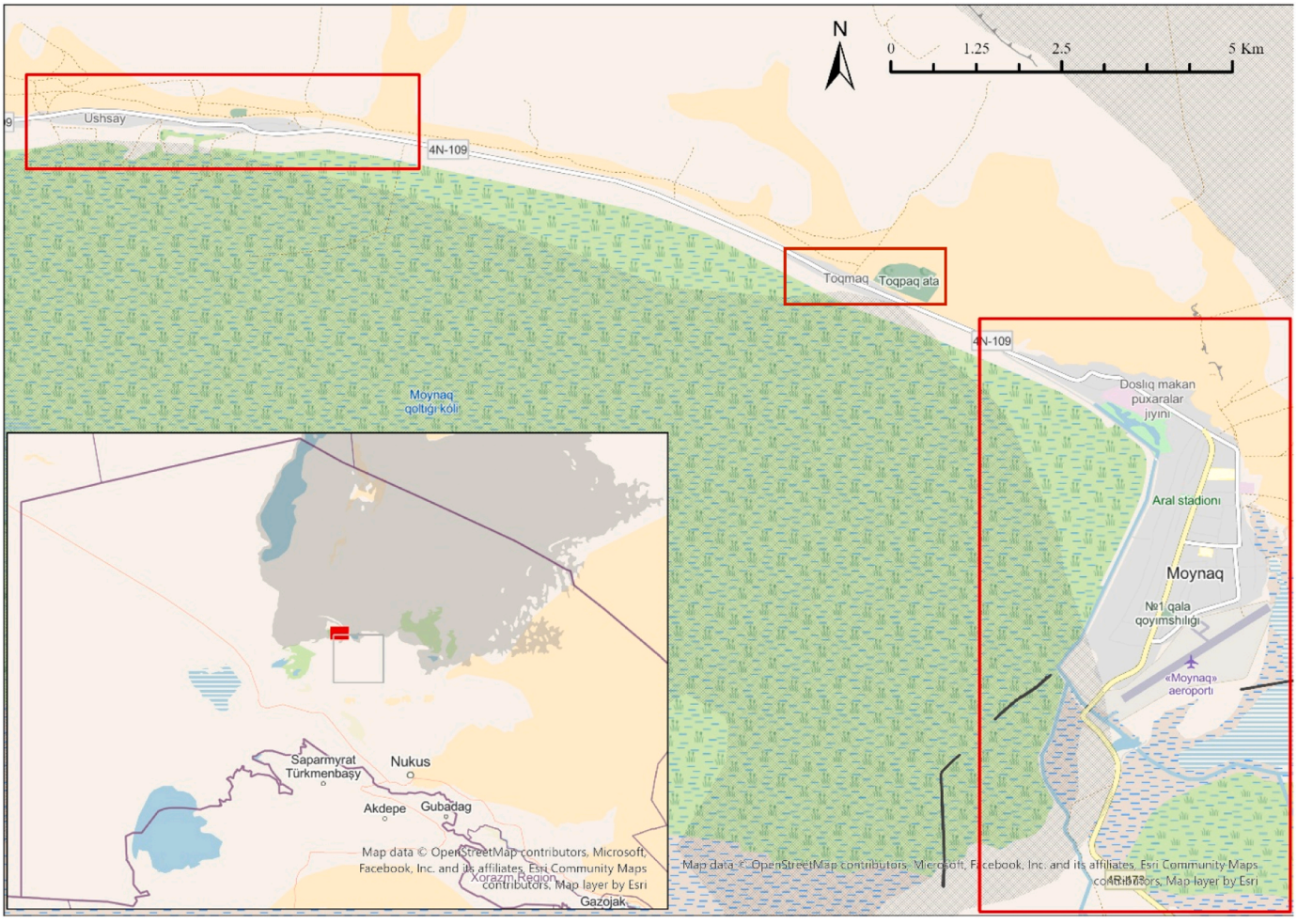

Fig. 1. Map of the study area, covering Muynak, the Uchsay and Tokpakata settlements. The blue colour represents the remains of the Aral Sea (the westernmost lobe), while the grey colour denotes the surface area as it was in the 1960s.

equal (51 % men, 49 % women; Table 1). There was no precise census data available for the Tokpakata settlement. However, the estimated population size in both Uchsay and Tokpakata settlements was suggested to be around 2000 people (Anonymous, 2022). The Muynak municipality (covering Muynak town, Uchsay and Tokpakata settlements) makes up 1.7 % of the total population of Karakalpakstan (Council of Ministers of the Republic of Karakalpakstan, 2022).

Due to the socio-economic and environmental conditions, Muynak region, and Karakalpakstan in general, have experienced massive outmigration either on a seasonal or a long-term basis. According to the data from the State Committee of Uzbekistan on Statistics (The State Committee of Uzbekistan on Statistics, 2023a, 2023b), in 2022 Karakalpakstan was the top region with the residents departing abroad.

Wetlands are continuing to shrink in the Aral Sea region (Li et al., 2019; Thorslund et al., 2017) for a number of reasons, mostly anthropogenic, among which are animal husbandry and unsustainable agricultural practices (Jiang et al., 2017; Kasprzykowski et al., 2014), as well as climate change impacts, which accelerated locally as a result of the desiccation of the Aral Sea (Ragab and Prudhomme, 2002; Kasprzykowski et al., 2014; Lemly et al., 2000; Schlüter et al., 2013) causing increased evapotranspiration in the region (Li et al., 2019). All these factors compromised the livelihoods of not only fishermen, but also of a number of households whose diets were consisted largely of fish, and of those who were occasionally involved in fishing for subsistence.

Grasslands and rangelands have been heavily affected by anthropogenic activities and water availability; their deteriorated condition has negatively impacted local livelihoods. The population of Karakalpakstan has traditionally engaged in pastoralism, which was a source of income and subsistence for local communities (Shaumarov, et al., 2012). Due to intensive agricultural and industrial activities, overexploitation of vegetation, depletion of water resources and sand deposition, over the past several decades the state of grasslands and rangelands in Uzbekistan has deteriorated considerably, namely 78 % of pastures are subject to various levels of degradation, and the trend is reported to be continuing (Convention on Biological Diversity, 2018; Li et al., 2019). Desert pastures (rangelands) constitute the largest area of pasture resources in Uzbekistan, making up over 80 % of the country's territory. Karakalpakstan has the second-largest area of pastures in the country (Convention on Biological Diversity, 2018).

Forested/afforested areas reportedly cover 7.3 % of Uzbekistan's total area with the largest area of forested lands being in Karakalpakstan (The State Committee of Uzbekistan on Statistics, 2020). Afforested areas are reportedly increasing in the Aral Sea region (Table 2), mostly thanks to planting of desert shrubs on the dried-out seabed to stabilise the sand.

In this study, we aim to identify the perceived state and importance of these three major ecosystems (wetlands, rangelands, afforested areas) and wildlife in the study region, the restoration or protection of which could potentially form the basis of nature-based solutions (Alikhanova and Bull, 2023), as well as the contribution of biodiversity and the remnant Aral Sea to the well-being of local communities. With nearly 60 % of the population of Uzbekistan under the age of 30 (UNICEF, 2020), and presuming that potential respondents would be too young to have observed longer-term environmental changes, we decided to consider the last 10 years (2012–2022) as a timespan for the purposes of the current research.

Table 2
Afforested areas on the Aral Seabed from 2014 to 2018. (Convention on Biological Diversity, 2018).

Year	Area in ha
2014	16800
2015	18000
2016	18200
2017	18800
2018	19040

2.2. Data collection

Data collection was undertaken using a mixed method approach based on a parallel strategy allowing different perspectives on socio-environmental issues in the research area to be investigated and triangulated (Kinnebrew et al., 2020). Based on this strategy, we conducted quantitative household surveys in Muynak, Uchsay and Tokpakata settlements, as well as key informant interviews consisting of open-ended questions with experts from the State Committee for Environment and Nature Conservation and the State Forestry Committee branch offices in Karakalpakstan to obtain qualitative data and expert knowledge.

Both the survey and interviews took place between 25 February and 5 March 2022.

2.2.1. Household surveys

The questionnaire for surveys comprised structured interview questions to obtain socio-demographic data (age, gender, education, employment), followed by questions on household use and perceptions of diverse types of natural resources (i.e., grasslands, forested areas, wetlands, the Aral Sea, wildlife). Likert scale response options were used to identify the level of agreement and frequency of use of natural resources and ecosystems (Vagias, 2006). An "I do not know" option was included to minimise response bias. The response options provided were in the first person, except for the questions on the use of natural resources and the impact of the latter on household incomes to which the respondents could report on behalf of any of their household members, i.e. the entire household. The survey questionnaire is provided in Appendix 1.

The sampling strategy for household surveys was designed considering the number of households and the population size in each survey site. We aimed to cover at least 375 Muynak households, producing an estimated sample size of 2064 people with 95 % confidence level and 2 % margin of error (based on an average household size of 5.5 people; Table 1). Similarly, the required sample size in Uchsay was estimated to be 145 households, covering 987 people assuming a household size of 6.8 (Table 1), again with 95 % confidence level and 2 % margin of error. To reach the estimated targets, we systematically surveyed every sixth household in Muynak and every third one in Uchsay. We included the Tokpakata settlement, located between Muynak and Uchsay, in the survey and followed the strategy used for Uchsay by surveying every third household given its small estimated population of fewer than 500 people. Overall, we aimed at surveying between 2.5 % and 3 % of participants, representing approximately 15 % of the households in the survey area, to ensure the representativeness of the results.

All survey sites have one central street that crosses through the whole area (Fig. 1). Eight enumerators divided into four groups of two carried out the survey on each side of the central streets in both settlements, starting from opposite ends and walking towards each other. Houses in side streets were counted and surveyed using the same pattern. Areas surveyed were marked either on digital or printed maps by each group at the end of the survey day to identify the starting points for the next survey day.

Muynak, Uchsay and Tokpakata were treated as a single survey area in this research and subsequent analysis due to their administrative affiliation and geographical proximity. All the data from the survey sites were stored in the cloud using the SurveyMonkey platform. Samsung Android tablets were used for data collection in the field. Where internet access was limited and the use of tablets was hindered, printed versions of questionnaires were filled out, which were later uploaded manually. In total, 426 questionnaires were completed over ten days, representing between 14 % and 15 % of the households (Table 1) in the survey area, which makes our results sufficiently representative to draw population-level inferences. Additionally, quite a few households were uninhabited,

so the total population size in fact may be less than reported in official statistics.

The survey interviews were conducted either in Uzbek, Russian or Karakalpak languages based on the preferences of interviewees and the language knowledge of the interviewer. Before the survey, all enumerators were provided comprehensive training on terms to be used during the interview and on interview ethics. Enumerators were strictly instructed before the survey started to not make potential respondents feel inclined to respond in a certain way. Translated questionnaires were double-checked and proof-read in each survey language. The questionnaire was piloted on several volunteers before the start of the survey to confirm that all questions and response options were understood, as well as to test the equipment used.

2.2.2. Expert interviews

In March 2022, in order to complement and contextualise the findings of the household survey, we conducted interviews with specialists from the Ministry of Natural Resources and the State Forestry Agency's branch offices in Karakalpakstan[3] to elicit expert knowledge on the state of the natural resources and most common issues associated with human-nature interaction in the study region. The list of questions is provided in Annex 2.

Questions were asked in Uzbek and Russian languages. Responses to interview questions by the government officials were taken as manual notes, and further translated into English. We deliberately did not use any electronic recording devices, as we were concerned that this would be sensitive and hinder open communication.

2.3. Data analysis

Household interview data pre-processing was conducted in Microsoft Excel and statistical analyses were performed in RStudio (RStudio Team, 2015). Data analysis was guided by our research questions. In case of attitudinal questions and Likert-type items, it is recommended to treat the responses as ordinal data (Tutz, 2020; Harpe, 2015; Boone and Boone, 2012). Non-parametric tests (Mann-Whitney U/Wilcoxon rank sum test), and logistic regressions were conducted with responses coded as binomial variables to examine the relationships between predictor and response variables.

3. Results

The gender ratio of the surveyed population is roughly 50:50, echoing the gender ratios in official statistics (Table 1). Most respondents were young, according to the WHO classification; in the 25–34 years and 35–44 years age groups (Fig. 2) (Dyussenbayev, 2017). General socio-demographic information on the survey participants is provided in Table 3.

3.1. Research question 1: reliance of local households on natural resources

The majority of the respondents replied that they currently never use any of the following resources: grasslands, wetlands, afforested lands, Aral Sea, or wildlife.

Based on the responses, wildlife and the remnant Aral Sea are least utilized: 87 % (n = 375) and 83 % (n = 353) of respondents indicated that none of their household members use wildlife resources or the Aral Sea, respectively. Conversely, grasslands are among the resources that are used "very often" and "often" as reported by 21 % (n = 89) and 15 % (n = 66) of households, respectively (Fig. 3).

We estimated the frequency of keywords that respondents used when answering the question on how they use certain natural resources (Question 6, Appendix 1). Based on the responses, grasslands are mostly used for animal grazing, wetlands for fishing, afforested areas for saxaul (*Haloxylon*) seed collection for further planting under the Government's afforestation programme, and the Aral Sea for brine shrimp (*Artemia*) harvesting (Appendix 3).

53 % of respondents stated that their household owned livestock. Of these, 75 % owned cattle, followed by poultry (36 %), sheep (24 %), and goats (16 %). 47 % of respondents did not specify which livestock species they owned. We hypothesised that people who owned livestock might be more dependent on natural resources, but there is no significant relationship between livestock ownership and the use of any terrestrial ecosystems [wetlands (Wilcoxon rank sum test with continuity correction, $W = 23182$, $p > 0.05$), forests ($W = 22985$, $p > 0.05$), barren lands ($W = 21302$, $p > 0.05$), or grasslands ($W = 21318$, $p > 0.05$)].

3.2. Research question 2: values assigned to natural resources by the local population

Each respondent was asked about the values (financial, recreational, cultural, and historical) they assigned to the four most accessible and in-demand natural resources (wetlands, afforested areas, grasslands, and wildlife). The majority of the respondents "agreed" or "strongly agreed" with the statements that natural resources have socio-cultural and economic values of importance for residents. The overall picture was similar between resources (Fig. 4). We hypothesised that the importance people assigned to different values (cultural, financial, recreational, and historical) might vary by age, gender, and occupation. A logistic regression (see Appendix 4, Table 1 for details) suggested that wetlands (*Coef.=0.6766, SE = 0.0855, p < 0.05*) and wildlife (*Coef.= 0.3693, SE = 0.0836, p < 0.05)* are more likely to be valued compared to afforested areas, while grasslands (*Coef.= −0.2839, SE = 0.0819, p < 0.05)* are less likely to be valued by the respondents. Additionally, the results indicate that natural resources, in general, are less likely to be valued financially (*Coef.=−0.5305, SE= 0.0851, p < 0.05*), historically (*Coef.=−0.1850, SE= 0.0862, p < 0.05*) and recreationally (*Coef.= −0.9729, SE = 0.0851, p < 0.05*) than culturally. Age, gender, or occupation did not significantly predict people's valuation for natural resources.

To examine the variation among socio-demographic parameters in relation to particular values for specific natural resources, we conducted an additional regression (see Annex 4, Table 2 for details). The results indicate that older people (65 + years) were less likely to value wetlands financially and recreationally than culturally, whereas those in the 35–44 years age group were less likely to value wetlands culturally compared to the younger group (25–34 years). Recreational value was more likely to be recognised by the elderly in the state pension category, while historical values of wetlands were more likely to be acknowledged by those who preferred not to disclose their occupation. Grasslands showed less socio-demographic variation, while wildlife was more likely to be associated with financial values by the employed compared to the unemployed. Afforested areas, notably, did not show any significant socio-demographic variation in response patterns.

3.3. Research question 3: perceived changes in the state of natural resources and their impact on well-being

Respondents unanimously stated that most natural resources in the Muynak region had become "somewhat degraded" or "considerably degraded" over the past decade. The list is topped by wetlands, with 79 % of respondents stating that they have "somewhat degraded" or "considerably degraded", followed by grasslands (48 %), and the Aral Sea (42 %). Forested/afforested areas are the only ones observed to have

[3] As of 31 May 2023, the State Committee for Environment and Nature Conservation and the State Forestry Committee merged into a single Ministry of Ecology, Environmental Protection and Climate Change of the Republic of Uzbekistan with the State Forestry Committee having turned into the State Forestry Agency under the Ministry (Lex.Uz, 2023).

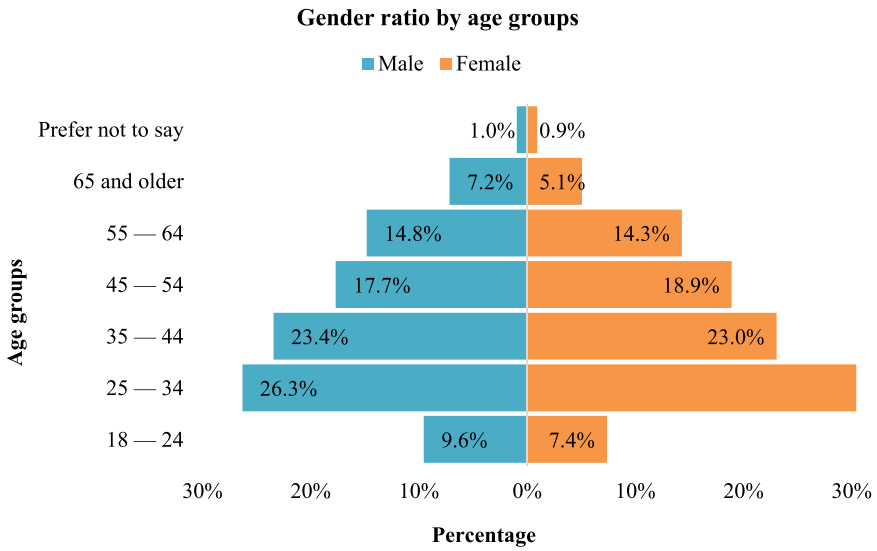

Fig. 2. Age group of the surveyed population aggregated by gender.

Table 3
Socio-demographic information on the population surveyed.

Age group	18 — 24	8.5 %
	25 — 34	28.4 %
	35 — 44	23.2 %
	45 — 54	18.3 %
	55 — 64	14.6 %
	65 and older	6.1 %
	Prefer not to say	0.9 %
Gender	Female	50.9 %
	Male	49.1 %
Level of education	Primary	1.4 %
	Secondary	85.5 %
	University degree/higher education	12.7 %
	Prefer not to say	0.00 %
	Other	0.5 %
Occupation	Employed/Self-employed	35.7 %
	Unemployed	37.1 %
	Homemaker	6.8 %
	State pension	18.1 %
	Student	2.4 %

improved (Fig. 5).

The majority of respondents suggested that over the past decade, changes in the state of grasslands, afforested areas, or the remaining part of the Aral Sea, had not impacted their households' incomes either positively or negatively. This result aligns with our initial findings that most of the population does not utilize the natural resources under study. The resource with the most impact on well-being was wetlands, changes in which had "considerably" or "somewhat" reduced incomes for 46 % of the respondents (Fig. 6). The resource with the most positive impact on incomes was afforested areas, for which about 20 % of households had seen some improvement. This is in line with the focus on afforestation in the Aral Sea region by government authorities. The results of the regression analysis conducted to identify the patterns of perceived impact of natural resources on household incomes based on socio-demographic data (Appendix 5), suggest that respondents in the "Prefer not to say" occupation group were more likely to benefit ($Coef.=1.0064$, $SE=0.4526$, $p < 0.05$) from the improved state of grasslands compared to the unemployed. Males, in turn, are more likely to report income increase ($Coef.=0.6447$, $SE=0.2641$, $p < 0.05$) from the improved state of afforested areas compared to females. Respondents in the age group 55–64 years were significantly less likely ($Coef.= -2.3953$, $SE=1.2137$, $p < 0.05$) to report positive changes in household incomes from the Aral Sea, while respondents in the "Prefer not to say" occupation category were more likely to report positive changes ($Coef.= 1.1524$, $SE=0.4491$, $p < 0.05$) in incomes related to the Aral Sea compared to the unemployed.

Half of the respondents indicated that an increase in wildlife would be highly beneficial for their household income, while 54 % responded that further decrease or disappearance of wildlife would be highly detrimental (Fig. 7). However, only a few respondents commented that

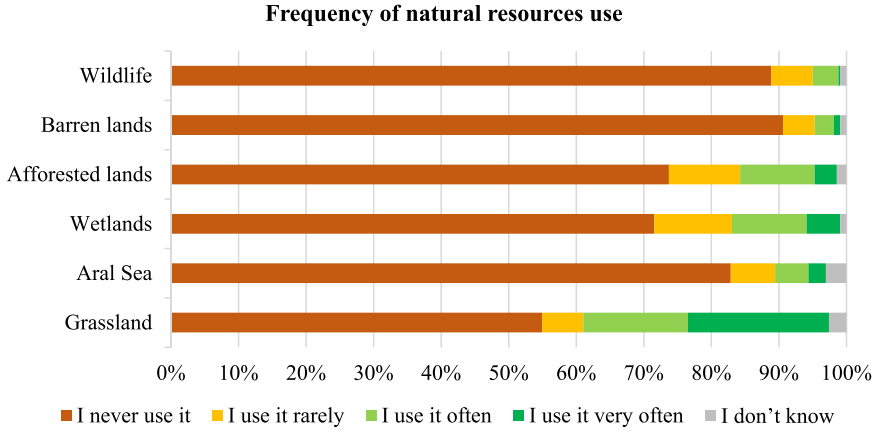

Fig. 3. Frequency and the type of natural resources used by the surveyed households.

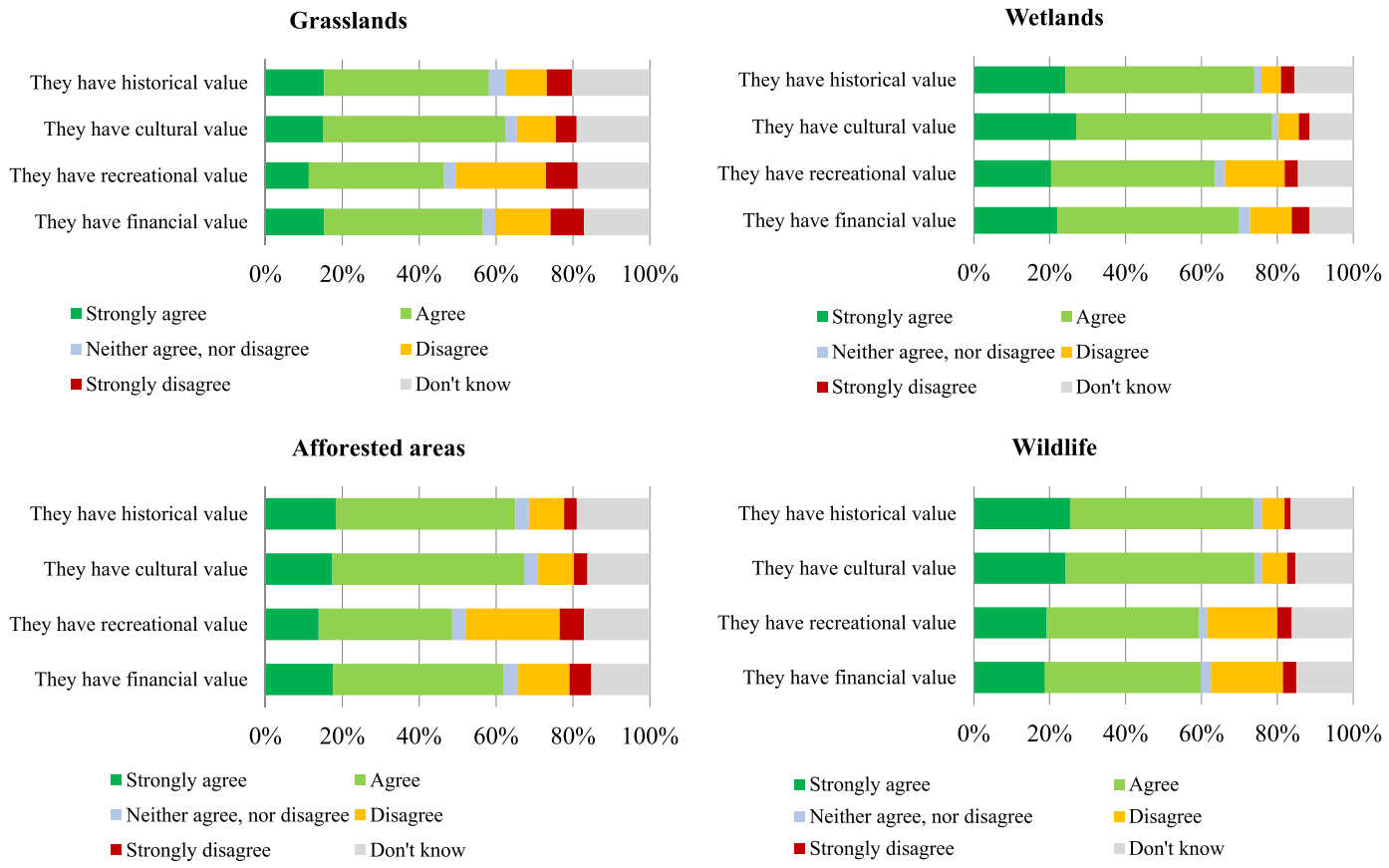

Fig. 4. Valuation of major natural resources by the respondents.

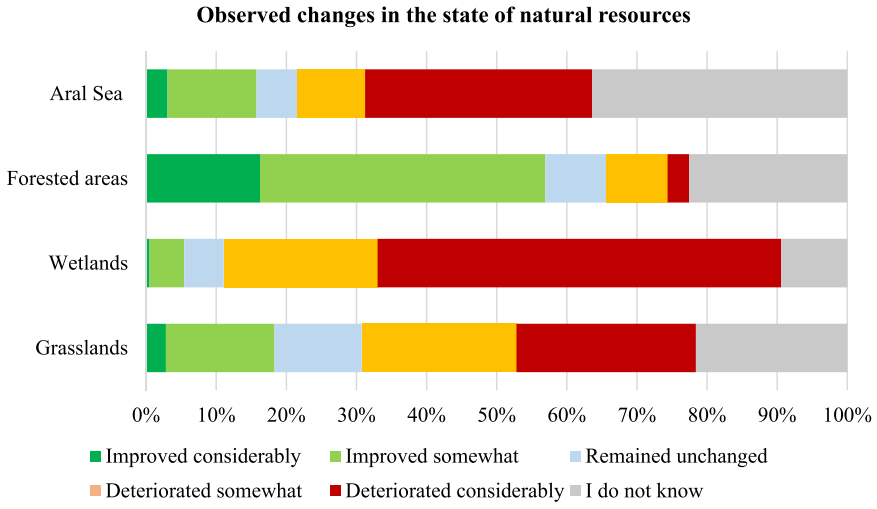

Fig. 5. Observed changes in the state of natural resources in the Aral Sea region of Uzbekistan according to the social survey results.

wildlife (mostly waterfowl and fish) is still a part of their diets. The results of the logistic regression (see Appendix 6 for more details) suggest that respondents in the 35–44 age group (*Coef.= 0.5695, SE=0.2809, $p < 0.05$*) and the 45–54 age group (*Coef.= 0.6582, SE=0.3076, $p < 0.05$*) were more likely to benefit from a potential increase in wildlife, including fish, compared to the reference group. At the same time, a decrease in wildlife would be detrimental to the incomes of respondents in these same age groups *Coef. = 0.5865, SE= 0.2825, $p < 0.05$* and *Coef.= 0.6721, SE= 0.3096, $p < 0.05$*, respectively). Those who are employed were less likely to report either benefitting (*Coef. = −0.5910, SE=0.2784, $p < 0.05$*) from an increase in wildlife, or losses to household incomes from a decrease in wildlife (*Coef. = −0.6983, SE=0.2777, $p < 0.05$*) compared to the unemployed respondents. Homemakers were also less likely (*Coef. =0.9251, SE=0.4342, $p < 0.05$*) to report any losses to household incomes if wildlife decreased.

We hypothesised that because men are hunters and fishers, they may be more likely to say that their household income depends on wildlife. However, there was no significant difference between male and female opinions about the impact of wildlife on their households' incomes if

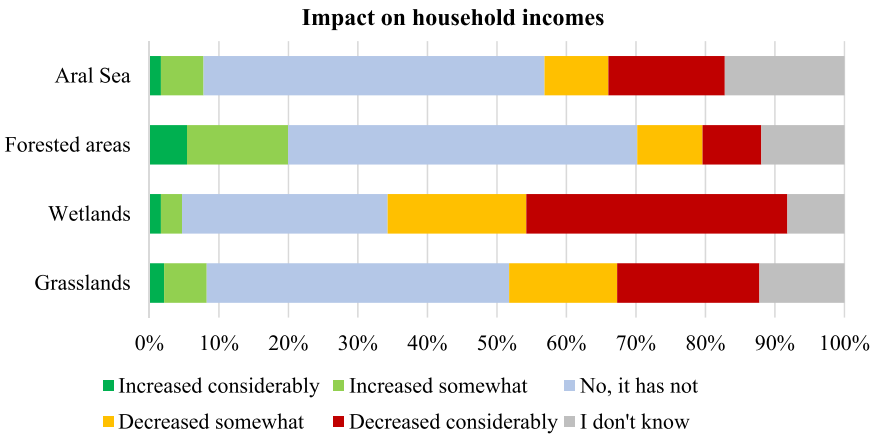

Fig. 6. Changes in incomes of the surveyed households according to the reported changes in the state of the natural resources (responses by resource type).

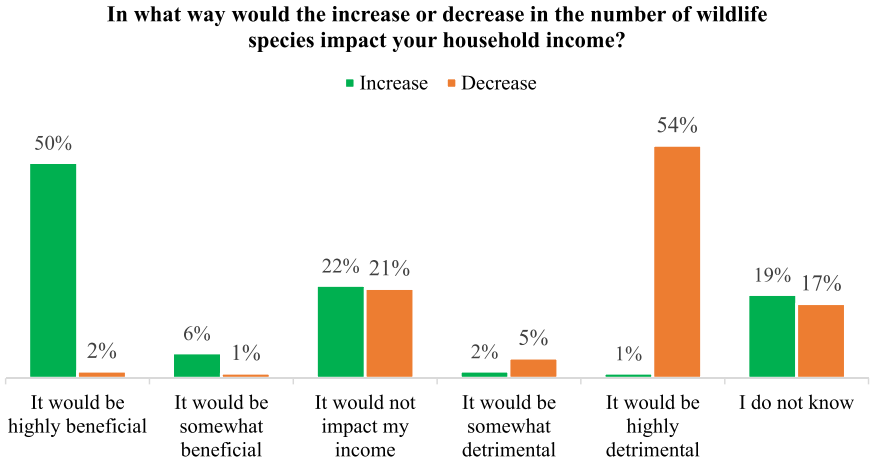

Fig. 7. Perception of potential increase vs potential decrease in the number of local wildlife species.

wildlife numbers increased (W = 15499, p > 0.05) or decreased (W = 15030, p > 0.05).

The overwhelming majority of respondents either "agreed" (47 %) or "strongly agreed" (36 %) with the statement that "*the well-being of people depends on the state of the environment*" (Fig. 8). A regression analysis was conducted to assess the relationship between age, gender, and occupation with perceptions of the link between the environment and human well-being. The coefficients, standard errors, and p-values are presented in Appendix 7. Neither age nor gender were significantly associated with differences in opinion on this topic. The only notable and statistically significant predictor was occupation. Specifically, employed respondents were more likely to agree (*Coef. = 1.170, SE=0.425, p < 0.05*) with the statement that human well-being is dependent on the state of the environment than the unemployed group.

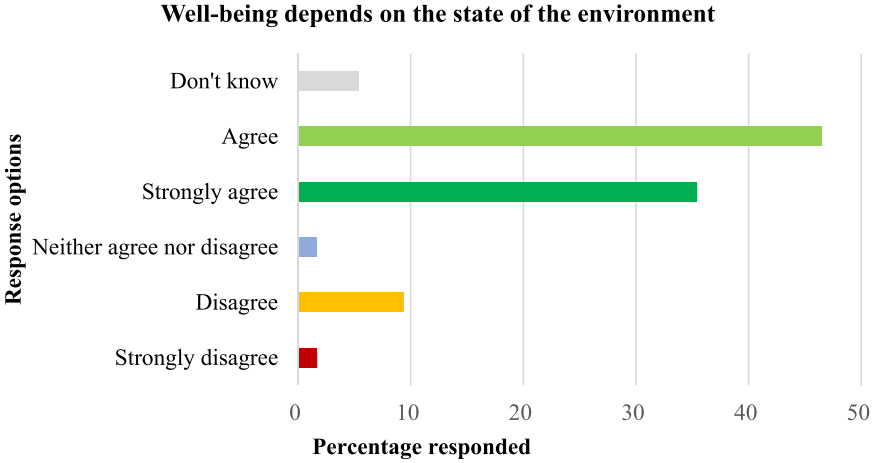

Fig. 8. Perceived dependence of human well-being on the state of the environment.

4. Discussion

4.1. Research question 1: reliance of local households on natural resources

The results of the survey confirmed that the vast majority of households do not use the key resources in the case study region as a direct source of income. Their limited engagement with the resources may reflect changing environmental conditions and the consequent physical unavailability of these resources. Among all the resources, disappearance of wetlands over the past decade has had the most negative impact on income opportunities of the local population. However, grasslands still have a role in supporting certain household activities. Given cultural norms and traditions, as well as geographic peculiarities, the people of Karakalpakstan have been long engaged in animal husbandry, and the majority still own livestock. However, the quality of grasslands and availability of water resources have substantially deteriorated over the past decade, so that the local population find it ever more difficult to keep animals on naturally available forage only. Considering the potential link between livestock ownership and resource dependence, we expected that livestock-owners might be more resource-dependent than others. However, we didn't find this relationship. Some residents noted that territories on the dried-out seabed, which were once used as pastures, have now been fenced off for afforestation, reducing the availability of grazing areas. Livestock are banned from afforested areas to protect the plantations, and vegetation is scarce to non-existent in barren lands for most of the year. Overall, our results suggest that because grasslands and wetlands are most used by the local population, they should be given a high restoration and conservation priority.

4.2. Research question 2: values assigned to natural resources by the local population

Natural resources are highly valued by the people of Muynak region. Only a few decades ago, the Aral Sea was an integral part of the daily lives of local people. Virtually every household was directly or indirectly involved in fishing, tourism, or the shipping industry.

In Central Asia, which is more agricultural than industrial, the prosperity of communities and the rise of civilizations have historically been closely tied to the abundance of natural resources. Rangelands in the Aral Sea region hold not only economic and environmental significance but also possess cultural value. One clear example of the cultural importance of these lands to the people of Karakalpakstan is how animals are embedded in local folklore (Shaumarov et al., 2012). This cultural value was reflected in the responses to our survey. Overall, natural resources were likely to be valued for their cultural significance than for their financial, recreational, or historical aspects.

Some respondents expressed "disagreement" or "strong disagreement" with the value statements in the survey, commenting that the resources are so degraded that they no longer hold much of their previous value. However, there was a prevailing sentiment that if these resources were restored to their former glory, their value, and by extension human well-being, would drastically improve. Interestingly, wetlands and wildlife, which have gone through most degradation over the past decade, are valued more than afforested areas and grasslands, even though these are still in use.

We found some interesting differences between demographic groups in their valuation of certain resources, which may influence the approach to planning nature-based solutions in the area. For example, older people are less likely to see financial value in wetlands, or to expect any positive impact of improvement in the Aral Sea on their incomes, while middle-aged residents are less likely to have cultural values for wetlands, than people in the 25–34 age group. People on state pensions were more likely to have recreational values for wetlands. The people who felt most strongly about the impacts of changes in wildlife numbers on their incomes were in the 35–54 age-group. These age-related differences are likely to be related to the experiences people of different ages have had of rapid ecosystem decline, as well as their ability to exploit resources at different life-stages. These differences need to be taken into account in the planning of nature-based solutions, as this will influence the responses of different segments of the community to restoration activities.

Although only relatively few people preferred not to say what their occupations were, their responses were significantly different to those of other occupations for a number of the questions in our survey. This included having less historical value for wetlands than others, and more expectation that improvements in the Aral Sea and grasslands would improve their incomes. Further investigation of the relationships that this group have with natural resources would be useful, to ensure that their needs and preferences are included in planning for nature-based solutions.

4.3. Research question 3: perceived changes in the state of natural resources and their impacts on well-being

Most respondents acknowledged ongoing degradation of natural resources in the Aral Sea region of Uzbekistan, with the exception of afforested areas. Grasslands and wetland degradation were identified as having the most negative impact on local household incomes. An alarming 79 % of participants observed deterioration in wetland conditions over the past decade, positioning wetlands as the primary resource impacting the well-being of the local population, mostly due to the reduction of valuable ecosystem services wetlands provide that are intrinsically linked to the quality of life, extending beyond mere economic implications (Pedersen et al., 2019). The decline of ecosystem services provided by wetlands not only exacerbates poverty and causes subsistence challenges but also impacts human well-being. The degradation of water bodies, in general, substantially affects local livelihoods, especially in dryland ecosystems that are grappling with water scarcity issues, resulting in an overall reduction in human well-being (Finlayson et al., 2005; Jogo and Hassan, 2010). Notably, grasslands that were reported to be mostly used for livestock grazing in the study region (Appendix 3), are directly affected by the hydrological conditions of wetlands (Pedersen et al., 2019). This interlinkage in ecosystems explains the trends of degradation observed by the local residents, demanding a holistic approach to managing natural resources and seeking NbS approaches.

The people of Muynak traditionally consider local fish and animal products essential dietary elements (Anonymous, 2022). This belief is reinforced by the survey results which revealed that wetlands are mostly used for fishing, while hunting is the primary activity associated with wildlife (more details provided in Appendix 4). This suggests that thriving wildlife populations, including fish, could bolster dietary diversity and provide varied income avenues.

The Government authorities who we interviewed confirmed widespread illegal activities such as poaching and unauthorized fishing in Karakalpakstan, even in protected zones (Anonymous, 2022). This could persist if unemployment remains high in Muynak, with easy prey such as fish and waterfowl being targeted alongside protected species. Given the recent fourfold expansion of protected areas in Karakalpakstan from 2020 to 2022 (The State Committee of Uzbekistan on Statistics, 2023a, 2023b), conflicts concerning access to natural resources might intensify, so a key and urgent requirement is participatory planning for the future of these protected areas for both nature and people. Importantly, the fact that employed people were less likely to report that their incomes were reliant on changes in wildlife numbers, while seeing that wildlife has financial value, and more likely to say that well-being and the environment are linked, suggests that stability of employment and income sources could decrease the reliance on natural resources, especially on wildlife, for household incomes. These people therefore could be strong allies when designing and implementing interventions, namely NbS, to improve their local environment.

Notably, interview participants eagerly provided comments even

when not required to do so. Notes made by all groups of enumerators suggest that a consistent concern raised by participants, regardless of gender or age, was the scarcity and the diminished quality of water resources. Some opined that if water availability were restored, other resources would naturally recover. These comments compelled us to conclude that the local population maintains a high level of awareness of, hence connectedness to, the surrounding environment, upon which they still heavily rely. Results of expert interviews validated the populations' perceptions, highlighting the severe degradation of water bodies in the Aral Sea region over the past decade (Anonymous, 2022).

Survey respondents also nostalgically recalled the prosperity of the Muynak region and better financial circumstances of their households in times when natural resources were abundant and accessible, especially the Aral Sea. Many shared stories of family members hunting for sustenance and income in the past. Hence, should wildlife numbers increase, they might offer alternative income and food sources for numerous households and restore their traditional diet and lifestyles. Nonetheless, optimism regarding this possibility is tempered by the widespread belief that the poor state of other resources will likely hinder wildlife resurgence.

The improvement in afforested areas observed by our respondents suggests that governmental initiatives promoting afforestation in the Aral Seabed are having a positive impact, exemplifying the potential of environmental restoration projects to have positive economic implications for the community.

In general, the socio-economic well-being of the region's inhabitants appears intrinsically linked to the state of its natural resources. Regardless of socio-demographic characteristics, there was broad acknowledgment by respondents of the significance and role of the general state of the environment in well-being, as observed across the study. The near-unanimous agreement on the symbiotic relationship between environmental health and human prosperity underscores the pronounced environmental consciousness among respondents. This bond suggests potential community backing for environmental projects. In summary, this study underscores the importance of local perspectives and resource dynamics when planning and executing NbS initiatives that benefit both the community and the environment.

5. Conclusions

The complex interplay between human activity, socio-cultural valuations, and nature is nowhere more starkly illustrated than in the Aral Sea case. The interrelationship between human well-being and the environment is not a novel concept. It has been long incorporated into international conservation and development agendas, such as the Aichi Biodiversity targets (CBD, 2011), the 2030 Agenda for Sustainable Development (UN General Assembly: Seventieth session, 2015), and now in the Kunming-Montreal Global Biodiversity Framework (CBD, 2022). However, the human-nature nexus has taken on new nuances and dimensions in the context of NbS, which are ultimately aimed at fostering transformative changes and reconnecting people and nature (Welden et al., 2021). Designing effective and locally tailored NbS requires underpinning research to understand local values, needs and priorities, hence inclusiveness of stakeholders. Our study provides a baseline in this regard; next steps in developing locally appropriate NbS interventions could involve community participation in scenario planning (Travers, et al., 2019) to explore and prioritise potential NbS options.

The Aral Sea case also brings forward the pressing issue of resource degradation in drylands, exacerbated by climate change and population pressures. This is not just a regional concern but a global one. As dryland habitats become increasingly stressed, understanding and integrating human values, perceptions, and needs will be paramount for the successful implementation of NbS in these regions. Our study is unusual in that it is situated in a highly degraded region, where rapid anthropogenic environmental change has had huge impacts on both nature and human well-being. However, even here, cultural, recreational, historical, and financial values for nature remain strong, as does the potential for nature-related well-being improvements. This gives hope for future restoration interventions in this region and similarly degraded areas worldwide. However, values assigned to natural resources, which shape people's perceptions of nature, are often neglected in land-use decision-making processes (Verschuuren, et al., 2021; Seymour et al., 2010), a gap particularly relevant to the Aral Sea region, and which this study begins to fill.

Ethical approval

The study received ethical approval by the review committee panel of the University of Kent with an Ethics ID of 2022164544534656. All participants in the survey were over 18 years old. No personal identifiable information associated with respondents was recorded during the surveys to guarantee complete anonymity of each participant. Before proceeding with the survey, each potential respondent was briefed about the survey purposes and verbal consent was obtained.

Authors confirm that all participants of the survey provided informed consent to participate in the study.

Authors' contributions

Shahzoda Alikhanova conceptualized the study, collected the data, performed the analysis, and wrote the manuscript. Professor EJ Milner-Gulland provided extensive guidance on data analysis and theoretical framing. Additionally, Professor Eleanor Jane Milner-Gulland and Dr Joseph Bull provided overall guidance to the concept of the manuscript and its critical revision.

CRediT authorship contribution statement

Alikhanova Shahzoda: Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Milner-Gulland Elenor Jane:** Writing – review & editing, Validation, Conceptualization. **Bull Joseph William:** Supervision, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data generated and analysed during the study are included in this published article. Additional datasets are not available.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.landusepol.2024.107073.

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