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Residents' resource uses and nature conservation in Band-e-Amir National Park, Afghanistan

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ABSTRACT

In 2009 the scenic Band-e-Amir Lakes and surrounding landscapes (2800–3800 m elevation) were declared Afghanistan's first national park (BANP) with the hope that the lakes will eventually attract tourists at levels as before the war period (1979–2001). The area is rich in plant species, and was formerly populated by ibex and urial. Today fauna is impoverished and vegetation (mostly mountain steppe) is degraded due to intensive livestock grazing, dryland agriculture, and shrub collection. BANP was created in collaboration with local residents (~800 families), and longer-term plans are to upgrade biological qualities of landscapes whilst improving residents' livelihoods. To provide baselines for adequate management plans, a survey of 116 households was conducted in 15 villages. Most families were subsistent agro-pastoralists. Population growth was ~2.2% annually. Estimates of mostly free-ranging livestock populations were ~19,900 sheep and goats, ~2500 cattle, and ~2100 donkeys and horses. Grazing impacts were evident, especially near villages. Families collected ~3.1 t of shrubs and ~0.4 t of cattle dung annually as biofuel. Estimates indicated that ≥0.7% of BANP area was cleared of shrubs annually. Dryland agriculture covered ~3.4% area. Other resource uses (collection of reed, medicinal plants, hunting, fishing) were assessed. Further research is needed on spatial patterns of resource exploitation and vegetation ecology. Promotion of alternative energy sources could alleviate pressures on shrub resources. Steep lands should be better protected (possibly fenced) from livestock

Abbreviations: Abi, irrigated crop land (mostly on alluvial plains); BANP, Band-e-Amir National Park; BAPAC, Band-e-Amir Protected Area Committee; *lalmi*, rain-fed crop land (in steppe areas); WCS, Wildlife Conservation Society

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and human impacts. Environmental workshops with residents and integration of locals in research projects could enhance management effectiveness and acceptance of park rules.

1. Introduction

The Band-e-Amir Lakes are situated at an elevation of ~2900 m above sea level in the Hazarajat in Central Afghanistan. Their crystal-blue waters embedded in a rugged rocky mountain landscape provide for stunning sights, instilling tranquility and mystery. The lakes have been a source of legends and inspiration for local Hazara people (Bourrouilh-Le Jan et al., 2007). During the 1950s to 1970s, scores of travelers from around the world were attracted to this place (Omrani and Leeming, 2005). Today few international travelers venture there, but the destination is popular again among many Afghans seeking respite from their daily work life.

Since the 1960s, proposals for conservation of the area were made, but plans have remained on hold due to political events and the ensuing wars (1979–2001). Finally in 2009, the lakes and surrounding high plateaus were declared as Afghanistan's first national park (BAPAC, 2011; Fig. 1). Originally, ‘national parks’ have been created to preserve wildlife and natural landscapes for posterity and as symbols of national pride and recreational enjoyment (Lockwood et al., 2006). In this spirit, Band-e-Amir National Park (BANP) may serve several functions, locally, regionally, and nationally. It may represent an icon of Afghanistan's natural landscapes which could attract domestic and international visitors again, thus contributing to national identification, peace and stability. In addition, revenues from visitors can be used for improved park management, conservation of representative fauna and flora, and – in a medium to longer term – the diversification and improvement of residents' livelihoods (Smallwood et al., 2011).

Already before the war, the vegetation around Band-e-Amir was degraded and the fauna was impoverished (Dieterle, 1973; Shank and Larsson, 1977). During the times of conflict, environmental degradation in many regions of Afghanistan was further aggravated through unchecked exploitation of natural resources, i.e. vegetation destruction through wood cutting, fires, and overgrazing, and excessive hunting of wildlife (UNEP, 2003; Formoli, 1995; Saba, 2001; Shank, 2006; Kanderian et al., 2011). If the new park can be adequately managed in the future, the ecosystems may partly recover and populations of large game could once again find suitable habitats and refuges in the area (BAPAC, 2011; Bedunah et al., 2010; WCS, 2011). Optimally, scientific research, which started in the area before the war, will be continued and the park may acquire demonstration functions for nature conservation and best-practice sustainable resource management. However, currently the park's management is at its beginning and conservation plans are still preliminary and in need of better baseline data.

Within BANP, ~800 families (~5000 people) live in 16 villages (MAIL, 2008; Fig. 1). The residents are mostly subsistence agro-pastoralists. The limited fertile alluvial areas at the valley bottoms have been intensively cultivated for generations on a hitherto fairly sustainable level. In contrast, the higher plateaus, which were traditionally used as rangelands and as a source for wild products, have been exposed to increasing pressures. Major impacts on the environment currently include (1) intensive livestock grazing, (2) collection of plant resources (for fuelwood, animal feed, and medicines), (3) expansion of rain-fed field cultivations in drylands (called *lalmi*), and (4) wildlife hunting (Bedunah et al., 2010).

Band-e-Amir is a landscape which over thousands of years has been inhabited and influenced by humans. The central objective of BANP is therefore not the setting-aside of a ‘pristine nature’, but the endowment of environmental stewardship, i.e. the establishment of a use regime which is sustainable and fulfils key requirements for nature conservation. Such regimes are practiced in many national parks in the United Kingdom which are in effect ‘protected landscapes’ (IUCN Protected area category V) that allow for controlled agricultural activities and limited development (Lockwood et al., 2006;

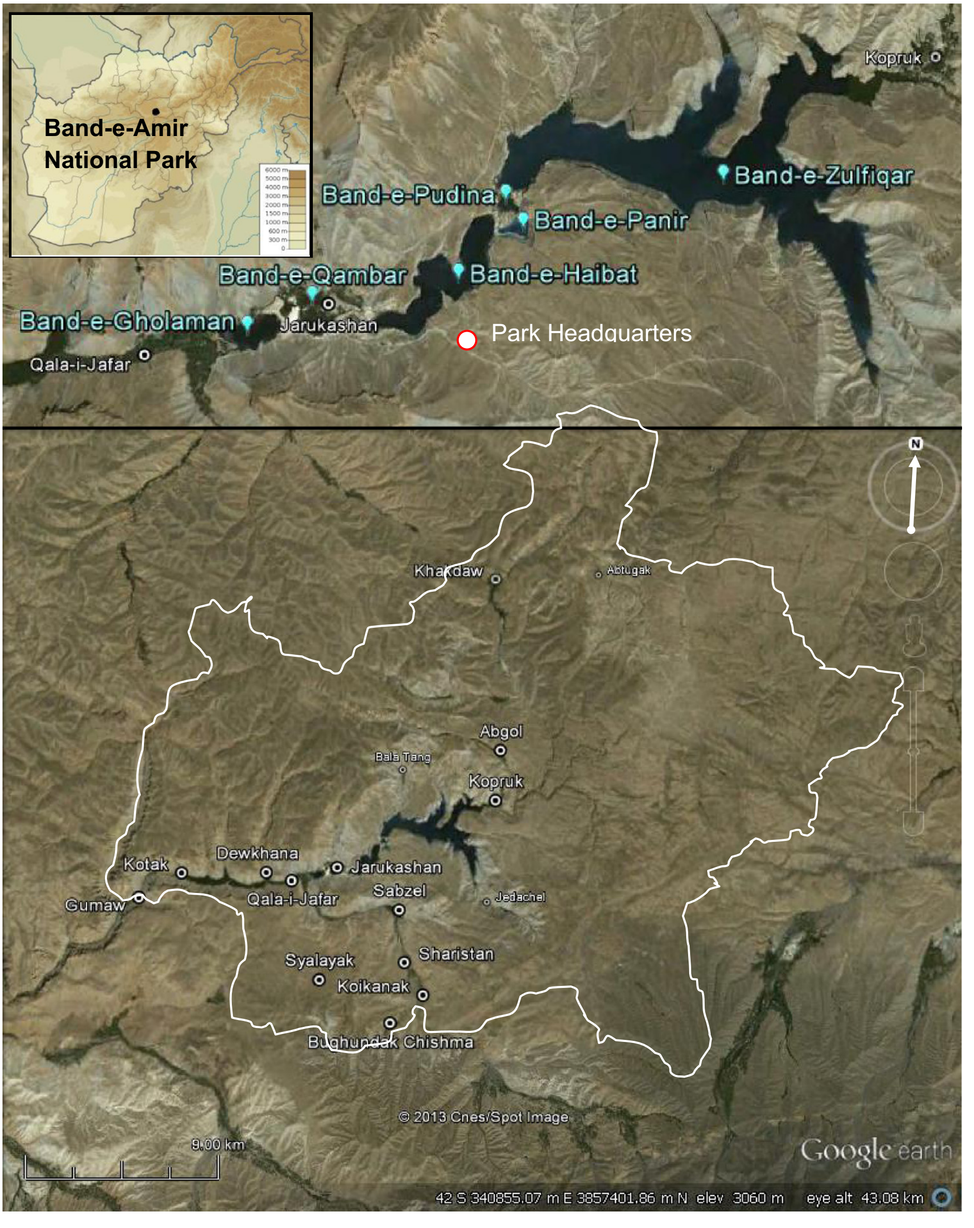

Fig. 1. Map of the six Band-e-Amir Lakes (top). The bottom map shows the newly created National Park (border indicated by white line) and the location of the studied villages.

UK ANPA, 2013). Accordingly, BAPAC (2011, p. 4) formulated the management vision for BANP as: "Vibrant, healthy communities living in harmony with, and engaged in maintaining, an intact lake system, an environment rich in natural beauty, pure water and wildlife that provides high-quality visitor experiences."

However, to establish such a sustainable regime, baseline data are needed about levels of current resource extraction by local residents. In this study, the following questions were addressed: What are the livelihoods of local residents? Which natural resources are needed and extracted from BANP area to fulfill the residents' livelihood needs? Which environmental impacts may arise from resource use regimes? In which ways could resource use regimes be improved to optimize benefits whilst preserving the resource bases? The last question, in particular, may be subject to further research in the future to which this current work may provide useful benchmarks.

2. The study site

The literature and data describing the area are still fragmentary, even though the area was comparatively (i.e. within Afghanistan) well documented before 1979 (literature summarized in Shank and Larsson, 1977; Dieterle, 1973). However, there are a few recent, very useful publications (e.g. Bedunah et al., 2010; Robinett et al., 2008; Shank, 2006) which are mainly based on consultancies mandated by the Wildlife Conservation Society (WCS). These, and the summaries provided in the Band-e-Amir National Park Management Plan (BAPAC, 2011), provide the main sources of descriptive information.

2.1. Geography, climate, vegetation and fauna

Band-e-Amir National Park (BANP) covers 613.3 km^2 in the western Hindu Kush mountain range in the Hazarajat (Yakawland District, Bamiyan Province), 250 km northwest of Kabul and 55 km west of Bamiyan town (Fig. 1). The six lakes (located in an east-west running valley at ~2900 m a.s.l.) cover an area of 600 ha and are contained by naturally formed travertine dams (called *band* in Dari; Fig. 2a). The surrounding mountains rise up to 3832 m at the highest point (BAPAC, 2011).

The climate is continental with low air humidity, high evaporation, and high temperature differences. There are no long-term climatic records for BANP, but by comparison to data from nearby stations (Bamiyan, Panjaw, Lal) average temperatures at 2900 m a.s.l. may range from about −14 °C in January to ~20 °C in July/August (up to −40 °C in winter, and 30 °C in summer). Average monthly precipitation may be at the extent of 25–35 mm with peaks in spring (March–May; up to ~90 mm) and minima in late summer (July–September; <3 mm) (cf. Bedunah et al., 2010; Shank, 2006; Dieterle, 1973). Winter snow and melt water is important for plant community formation and productivity, especially at higher elevations.

The region is part of the Irano-Turanian floral area, characterized by high altitude steppe plains and deserts. Reaching westernmost limits, components of Central Asian mountain flora are also found at BANP (Shank and Larsson, 1977). The steppe vegetation is dominated by dwarf shrubs (mainly *Artemisia* spp.), cushion shrubs (mainly *Acantholimon* and *Astragalus* spp.), and interspersed grasses (mostly perennials). Cushion shrubs tend to increase in dominance with higher elevation. Dieterle (1973), and other authors cited therein suggested that (on deeper soils) this is a secondary type of vegetation which replaced original grass steppe under prolonged livestock grazing. Bedunah et al. (2010) questioned this, noting that vegetation was similar in function and productivity to North American shrub-dominated dry grassland types. Interpretations may partly depend on the question under which grazing levels the vegetation initially evolved. In depressions and at canyon bottoms, other vegetation communities prevail. In basins with high evaporation, salt-tolerant species (e.g. *Zygophyllum* and *Haloxylon* spp.) predominate. Sedge communities (*Carex* and *Eleocharis* spp.) are found in more permanently moist depressions and are replaced by dense communities of reed (*Phragmites australis*) and cattail (*Typha beome*) in marshes near the lakes. Riparian bush communities (*Salix*, *Myricaria* and *Populus* spp.) grow along river courses and at the travertine dams (Bedunah et al., 2010; Dieterle, 1973; Breckle, 2007). Soils formed in a semi-desert environment with cold winters and are derived from calcareous rocks (sierozems or aridisols; cf. Bedunah et al., 2010).

The fauna of BANP is impoverished due to habitat degradation and hunting (MAIL, 2008). Until the 1970s, populations of Siberian ibex (*Capra sibirica*) and urial (*Ovis orientalis*) inhabited the mountainous parts of BANP, but the species apparently have not been seen for several years (Shank and Larsson, 1977, C. Shank, personal communication). The Afghan pika (*Ochotona rufescens*), long-tailed marmot (*Marmota caudata*) and desert rodents (e.g. jerboas) are still abundant in BANP and are major prey of wolves (*Canis lupus*) and foxes (*Vulpes vulpes*). BANP is an Important Bird Area (IBA),

Fig. 2. Illustration of resource uses in Band-e-Amir National Park. (a) View of Band-e-Haibat with the travertine dams in the foreground. In the lakeshore on the left is the Shrine of Imam Ali. (b) Ploughing of irrigated alluvial fields with oxen in the main valley (west). (c) Harvesting of dwarf shrubs on the higher plains in winter, and (d) transport with a donkey. (e) Collection of medicinal plants. (f) Winter storage of reed. (g and h) Impacts on the vegetation visible in the landscape. Impacts of livestock trampling and grazing are evident in the foreground. According to the new management plan (BAPAC, 2011) livestock grazing is now prohibited on the steep lands surrounding the lakes (strict protection area). In the background areas of *lalmi* cultivation are visible. Fields are on increasingly steeper slopes while productivity in lower areas have been exhausted. (images: A. Alawi and A. Mohibbi).

partly due to the lakes' importance to migrating waterfowl. In total, 152 bird species have been recorded, including the endemic Afghan Snowfinch (*Montifringilla theresae*) (Bedunah et al., 2010; Shank, 2006; BirdLife International, 2013).

2.2. The park residents and their uses of natural resources

Residents of the 16 villages within BANP (estimated ~5000 people) are all Hazara people (MAIL, 2008; Fig. 1, Table 1). The Hazaras are the dominant ethnic group in the Central Highlands of Afghanistan (Hazarajat), especially in Bamiyan Province. They are Persian (Dari) speaking but they also have ancient affinities to peoples of Inner Asia (Uhrig, 1999). They are adherents of Imami Shi'a Islam, whereby many (called Sayeeds) trace their descent to the founding imams. The Hazara have lived in the area as long as they can remember. In more ancient times the region has, however, seen the coming and going of other peoples and cultures, including invasions by early Indo-Iranians, Greeks (under Alexander), Arabs, Turks, Mongols (under Genghis Khan), and (again) Persians (Iranians) (Omrani and Leeming, 2005). Hence, people have been in the area for thousands of years, and

Table 1
Summary of the villages visited, including geographic region (cardinal direction from center), elevation above sea level, distances to the center village (km) and the lakes (minutes walking), the number of households recorded by BAPAC (2011) and visited/surveyed during this study, and main ethnicity/religion of the villages (Sayeed or non-Sayeed Hazara).

No.	Villages	Region (geogr. direct)	Elevation a.s.l. (m)[a]	Distance to center (km)[a,b]	Distance to a lake (min)[c]	House-holds 2008[d]	House-holds surveyed	Ethnicity/religion[e]
1	Jarukashan	Center	2890	0	5	60	20	Sayeed
2	Qala-i-Jafar	West	2890	0.5	10	60	5	Sayeed
3	Dewkhana	West	2860	3.0	40	70	6	Sayeed
4	Kotak and Naghumak	West	2850	6.2	50	30	6	Sayeed
5	Gumaw and Dare Buz Gola	West	2780	7.4	60	50	8	Sayeed
6	Sabzel	South	2940	3.5	20	55	3	Sayeed
7	Sharistan	South	2960	5.6	25	45	18	Hazara
8	Koikanak	South	2970	7.2	30	50	6	Hazara
9	Syalayak	South	3020	5.4	60	20	3	Hazara
10	Bughundak Chishma	South	3020	7.6	50	35	4	Hazara
11	Kupruk	East	3030	7.5	15	210	15	Sayeed
12	Abgol	East	3130	9.2	50	35	6	Sayeed
13	Khakdaw and Abtugak	North	3220	16.6	120	65	16	Hazara

[a] As measured from Google Earth[TM].
[b] Direct distance.
[c] Walking distance (time in minutes, as estimated by A. Mohibbi).
[d] One household had on average six members (*Source*: BAPAC, 2011).
[e] The predominant religion/ethnicity (> 80% of residents) (*Source*: BAPAC, 2011).

probably already then agro-pastoralism exerted significant influences on the environment and formation of rangeland vegetation communities (Robinett et al., 2008; Frachetti, 2013).

The Hazarajat was initially an autonomous region, but during the 1890s, it was forced under state control by the ruler Abdur Rahman. As many Afghans elsewhere, the Hazaras suffered under the sequence of wars, which followed the Soviet invasion in 1979. The Taliban occupied Bamiyan town in 1998 and during three years the Hazara endured severe persecutions. Just before the fall of the Taliban regime in late 2001, the Band-e-Amir area was a war front line which was heavily mined (minefields have been cleared after the war). At the time of occupation and fighting, a large proportion of the population fled to other regions, but since 2001 most families have returned. While in other parts of Afghanistan (mostly in eastern and southern provinces) conflicts have continued after 2001, Bamiyan Province has been one of the most peaceful and stable regions during the last decade. Nontheless, the wars and previous history left a legacy of mistrust towards the central government and concerns about land rights among local residents (Bedunah et al., 2010). Clearly, conservation projects in BANP will only achieve results if undertaken in accord with local residents.

Most residents in BANP live in the villages on the alluvial plains near to the lakes. Jarukashan lies in the center between Band-e-Haibat and Band-e-Qambar, at the cross-section of several roads (Fig. 1, Table 1). It harbors a major market place, visitor facilities, and is closest to the National Park Headquarters (situated 1 km south), as well as a site of religious importance to the Hazara (the Shrine of Imam Ali; Fig. 2a). Another four villages are situated in the main valley to the west, and five villages in the south. Two villages, including the largest (Kopruk), are situated east of Band-e-Zulfiqar. Only one major village (Khakdaw) is situated in the north. The extensive open plateaus in the east and northwest are used as pastures (Fig. 1, Table 1).

The irrigated alluvial fields (called *abi*) are mostly planted with wheat or barley, and sometimes potatoes or animal fodder species. Management of irrigation water (from rivers) is mediated by a traditional controller (called *mirab*). Wheat and barley are the main crops planted on rain-fed dryland fields (*lalmi*). Crops are typically planted around May and harvested by September. *Lalmi* fields are sometimes found on fairly steep slopes at elevations of up to 3300 m a.s.l. (BAPAC, 2011; Fig. 2). *Lalmi* often causes land degradation problems (see later discussion).

Livestock pasturing is a main economic activity at BANP. Livestock provide food, raw material for clothing, field manure and dung for biofuel. Oxen serve as draught and equines as pack animals, whereby animals are sometimes temporarily loaned/borrowed among villagers to fulfill certain tasks. Caprines (especially sheep) are mostly used for pasturing on remote and high steppes during summer, whereas cattle are more commonly grazed on rather nutritious alluvial areas, if available. Animals are kept in stalls and fed with fodder during winter. Already during the 1970s grazing on steppes was so high that no high-quality plant fodder could be collected from steppes. However, relatively unpalatable species (e.g. *Senecio* and *Cousinia* spp.) which are avoided by livestock in summer, are collected in autumn and used as winter fodder (Dieterle, 1973). Fodder is also specifically planted on some *abi* fields. In addition, plant residues collected from fields and reed (locally called *nai*) collected from lake margins also partly serve as fodder. Grazing pressure has changed natural plant communities, and this probably decreased the land carrying capacity (Bedunah et al., 2010).

Villagers collect shrubs and dung from pasture areas for heating and cooking, especially before and during winter (Fig. 2c and d) when probably $>65\%$ of annual energy consumption occurs (Hoeck et al., 2007). Shrub collection (mostly near villages) decreases vegetation biomass on pastures, changes plant communities, and may lead to soil erosion (typically shrubs are uprooted). Reed along lakeshores is commonly cut for livestock fodder and building materials (Fig. 2f). Since this is mostly done in autumn, there are only minor impacts on wildlife (Bedunah et al., 2010). Pastures (including *lalmi* fields) and reed beds are not legally owned by villagers, but communities claim traditional use rights. Until recently, hunting was still regularly practiced at some of the wetlands and on the escarpments. So far, only few villagers have found an income from visiting tourists.

2.3. Creation and management of Band-e-Amir National Park

The creation of BANP has a long and complex history, going back to first proposals in the 1970s, and re-emerging as an idea along with newly established institutions after 2001 (see MAIL, 2008; BAPAC, 2011). BANP was gazetted in April 2009 and currently there are still many challenges for park management. However, BANP may eventually serve as a model for other protected areas which are still in planning in Afghanistan, and which may also include arrangements for community-based natural resource management (Smallwood et al., 2011; Johnson et al., 2012). In 2006 the Band-e-Amir Protected Area Committee (BAPAC) was set up via a consultative process which was facilitated by WCS. It is composed of thirteen local representatives (elected in each of the 13 main villages within BANP; Table 1), three regional representatives (from the provincial council and from Yakowlang District, and the Governor of Bamiyan Province), three national representatives (from the National Environmental Protection Agency NEPA, the Ministry of Agriculture, Irrigation and Livestock MAIL, and the Afghan Tourism Organisation ATO) and further representatives from relevant, actively engaged non-government organisations (WCS and others). The first management plan for BANP (BAPAC, 2011) outlines six major goals: (1) preservation of the integrity of the travertine dams and lakes, (2) improvement of local communities' livelihoods, (3) maintenance of ecosystem integrity and recovery of biodiversity, (4) provision of opportunities for recreational, cultural and religious experiences for visitors, (5) provision of participation of local communities in BANP development and management, and (6) development of the capacity of BANP staff to manage the park.

3. Methods

3.1. Data collection

Using standard questionnaires, in total 116 households were surveyed in the 15 villages during autumn 2010 (September–November). The number of visited households (selected in a random fashion on computer, using Google Earth™ images) was in approximate relation to the total numbers of households in the villages (except for the center village Jarukashan, where proportionally more households were surveyed; Table 1). Only men ≥ 18 years old were interviewed; these were often but not always the heads of the households.

The questionnaire questions, and the data variables derived from them, are fully presented in Tables A1–A5 (Appendix A). Information was collected on (1) personal characteristics of the respondents (question variables Q1–Q8; ethnicity/religion, age, number of children, age of oldest and youngest children, number of older and younger dependents, residence time, emigration/residence during the war time), (2) respondents income sources and functions (Q10–Q13; main and sideline sources of income, honorary functions, positions in NGOs), (3) agricultural assets (Q14–Q15; possession of domestic animals, possession of irrigated and rain-fed farmland, types of crops planted on farmland), (4) possession of vehicles (Q22), (5) applications of fertilizers (manure or commercial fertilizer) and pesticides on fields (Q23–Q24), (6) energy needs and collection of wild plant resources (Q17–Q19; availability of electricity, collection of shrubs, cattle dung cakes, reed, medicinal plants), and (7) hunting (birds and other wildlife) and fishing (Q20).

3.2. Data analysis

Minitab 15 statistical software (Minitab Inc., State College, PA, USA) was used to summarize the data variables (i.e. frequencies, mean, standard deviation, etc.), and perform statistical analyses. Before analysis, the data were transformed as appropriate (e.g. natural logarithm or square root) to make them sufficiently normal for parametric tests. To work out optimal predictor subsets for multivariate models, we used the 'best subsets regression' (BSR) tool in Minitab, but we also used other information (e.g. correlation matrices) and specific testing of models. Multivariate linear regression (MLR), nominal (NLR), binary (BLR) and ordinal (OLR) logistic regression, and general linear models (GLM) were used for modeling, as appropriate regarding the various sets of data (i.e. interval and/or categorical data types) tested. Tools for detecting outliers (available for MLR, GLM, and BLR) were used, and in some cases severe outlier points were deleted to improve the models. Summaries of descriptive statistics (means $\pm$ standard deviations and the range, respectively frequencies of categories) and of all tested variables and of significant predictor variables as determined by multivariate analyses are provided in Tables A1–A5 in Appendix A.

4. Results and discussion

4.1. Respondents' profiles and residence in BANP, and demographic trends

Of the 116 respondents in the 15 villages, 60% were Sayeed and 40% commoner Hazara people. Normally villages were only inhabited by representatives of one ethnic/religious group, whereby Sayeeds' villages were mostly located near the lakes and along the fertile alluvial plains of the main valley, whereas commoners were mostly living in the more remote villages (Table 1). On average, the respondents (of both ethnic/religious groups) were 44 years old (range 18–74 years) and had five children (range 0–18). 14% of the households also supported at least one older dependent (maximally 2) and 10% at least one child (maximally 3) from other relatives. The average number of dependents (5) corresponded to those reported by BAPAC (2011), but was smaller than in other parts of Bamiyan Province (6–7 dependents) (CSO/UNFPA, 2006). Fertility rates in Afghanistan have fallen from 6.9 children per woman in the 1970s, to around 5.0–5.3 children today (Spoorenberg, 2013). This corresponds to an estimated population growth rate that is currently around 2.2% annually (i.e. population increases twofold around every 33 years, if growth rates remain constant).

The residence time of families in the villages ranged from 8 to 72 years (mean 39 ± 15 years). 64% of the villagers indicated that they had left the villages during the war period, whereas the others had stayed throughout the war. The duration of the exile ranged from 1 to 25 years (mean 7.8 ± 6.8 years), whereby 68% of the emigrants went to Iran, 11% to Pakistan, 12% to Kabul, and 9% to Behsod (a town in Wordak Province). The peak of emigration was during the Taliban regime, and most emigrants returned after 2001. According to informal information (heads of shura, personal communication) only a few families were still returning in recent years.

4.2. Respondents' income sources and honorary positions

91% of the respondents stated that their households' main source of income was agriculture, whereby some were exclusively engaged in crop farming (11%) or in pastoralism (2%), but most (78%) followed both activities. The remaining households gained their incomes from services, such as from various occasional labor (6%), house construction (1%), health services (1%), teaching (1%), and from support of governmental and non-governmental agencies (3%). Most respondents with service occupations lived at Jarukashan, whereas all respondents in the more remote villages in the north and south were agro-pastoralists (Table 2).

In Bamiyan Province average incomes per capita from agriculture may be less than 0.25 US$ (52 Afs) and about 0.5 US$ for other occupations (ADB, 2009). For this and other reasons, many respondents were engaged in sideline occupations, earning extra income in part time teaching (20%), agriculture (3% in farming and 6% in livestock keeping), tourism (2% hotel or house renting, and 1% boat renting), trading (7% shop keeping and bazaar), and other services (3% as park rangers, and 2% working for NGO's and as drivers). Only one household (1%) in Jarukashan earned no income from agriculture. In addition, some households possibly received remittances from relatives living in towns. However, such types of revenues were neither noted by respondents nor specifically appraised in the survey.

Some respondents (17%) occupied an honorary position in the village either as the head of the village council (1%), assistants of village councils (3%), or as representatives for several families (13%). 9% of the villagers were involved in NGO work (four national and three international NGOs).

4.3. Land ownership and cultivation, and potential impacts on rangeland resources

Some respondents (9%) at lower-lying villages, with comparatively mild climates and good irrigation, owned a home garden or orchard (average size of 0.3 ± 0.2 ha; range 0.1–0.6 ha; excluding non-owners). In contrast, 93% of respondents were cultivating irrigated *abi* fields (1.1 ± 0.9 ha; range 0.1–4 ha) and 91% rain-fed *lalmi* fields (2.8 ± 1.7 ha; range 0.4–8 ha). Households in villages close to the lakes (except Jarukashan), and especially in the main valley downstream (west) of the lakes, owned more *abi* lands than in other areas (Table 2). Households with much *abi* also tended to cultivate large areas of *lalmi*. In addition, older respondents, and those who had stayed through the war, tended to cultivate larger areas of *lalmi* as compared to the younger, and those who had emigrated intermittently (Table A3, Appendix A).

Extrapolations from the data (on a baseline of 830 households in the park; census by MAIL, 2008, adjusted for population growth) indicate that ~25 ha of land (0.04% of BANP area) were covered by home gardens/orchards, ~830 ha (1.4% of BANP area) were under irrigated cropping, and ~2092 ha (3.4%) were under rain-fed cropping. Areas designated by BAPAC (2011) as 'settlement zones' cover 1710 ha (2.8% of BANP area) and contain all *abi* and gardens/orchards.

At BANP agricultural yields are restricted due to difficult terrain, infertile soils, and harsh climatic conditions (including cold winters, spring flooding, summer droughts). *Abi* fields produce grain yields around 10–30 times the sown grains, whereas *lalmi* fields produce about half that amount (BAPAC, 2011). *Lalmi* agriculture is sensitive to rainfall variation, and during unusual years crops can fail entirely. In contrast, irrigated fields are usually maintained through careful management of snow melt water (Rathjens, 1975). No detailed data on crops was collected, but if all fields were planted with wheat a household's average grain harvest during one year may be ~3.4 t (i.e. ~680 kg per person). The highest yields ($\sim 5\ t\ hh^{-1}\ y^{-1}$ wheat equivalent) are likely to be collected by households in the western villages downstream from the lakes (Table 2). Annual per capita wheat consumption in Afghanistan has been >200 kg during recent years (Persaud, 2012).

Traditionally, *lalmi* agriculture operated on a rotational basis. According to Dieterle (1973) *lalmi* fields were mostly situated on even or slightly sloping lands on the higher plains, and fields were

Table 2
Summary of percentages of households (hh) with agricultural incomes, land cultivation (percentages of households and land area per owner), overall field productive output (annual 'wheat equivalent' yield estimates in tons), fertilizer and herbicide uses on fields, livestock keeping (percentages of households and animals per owner), and estimated annual livestock dung amassment (t) per household.

BANP region[a] (number villages v ¦ no. households hh)	Agricult. income ¦ main inc. (% hh)[b]	Land cultivation for grain production			Wheat yield index[c] ($t\ hh^{-1}$)	Fertilizers and herbicides		Livestock possession		Dung bio-mass index
		Cultivated land ¦ *abi* ¦ *lalmi* (% households)	*abi* Hectares/household mean ± stdev.[d]	*lalmi*		All f. ¦ manure ¦ urea ¦ am. nitr. (% household)[d]	2.4-D uses (% hh)[d]	Owner-ship (% hh)	Caprines ¦ bovines ¦ equines[e] mean counts (hh^{-1})	Cattle ¦ all[f] ($t\ hh^{-1}\ y^{-1}$)
Center (1 v ¦ 20 hh)	95 ¦ 55	90 ¦ 80 ¦ 90	0.5 ± 0.3	2.2 ± 1.9	~2.2	78 ¦ 61 ¦ 39 ¦ 17	22	70	23.8 ¦ 2.0 ¦ 2.4	~1.0 ¦ 4.2
West (5 v ¦ 25 hh)	100 ¦ 96	100 ¦ 100 ¦ 92	1.7 ± 1.1	3.6 ± 2.1	~5.0	100 ¦ 64 ¦ 76 ¦ 40	56	92	29.9 ¦ 4.7 ¦ 3.3	~3.1 ¦ 8.5
South (6 v ¦ 34 hh)	100 ¦ 100	97 ¦ 97 ¦ 94	1.2 ± 0.9	2.4 ± 1.1	~3.5	94 ¦ 79 ¦ 36 ¦ 17	33	97	21.7 ¦ 3.3 ¦ 2.6	~2.4 ¦ 6.7
East (2 v ¦ 21 hh)	100 ¦ 95	95 ¦ 90 ¦ 95	0.7 ± 0.5	2.6 ± 1.7	~2.8	80 ¦ 55 ¦ 25 ¦ 25	35	100	30.2 ¦ 3.4 ¦ 2.5	~2.5 ¦ 7.9
North (1 v ¦ 16 hh)	100 ¦ 100	94 ¦ 94 ¦ 75	0.9 ± 0.5	3.4 ± 1.6	~3.2	80 ¦ 40 ¦ 47 ¦ 40	20	94	27.8 ¦ 1.9 ¦ 2.9	~1.2 ¦ 5.8
All (15 v ¦ 116 hh)	99 ¦ 91	96 ¦ 93 ¦ 91	1.1 ± 0.9	2.8 ± 1.7	~3.4	88 ¦ 63 ¦ 45 ¦ 26	35	91	26.3 ¦ 3.3 ¦ 2.7	~2.2 ¦ 6.8

[a] Cf. Table 1.
[b] Percentage of households with any agriculture income, and with agriculture as main income.
[c] The 'wheat yield index' was calculated on a seasonal harvest baseline of ~1.4 t ha^{-1} wheat grains on *abi* fields and ~0.8 t ha^{-1} on *lalmi* (cf.Persaud, 2012).
[d] Calculation excluded households without fields. am. nitr. =ammonium nitrate.
[e] Calculation excluded households without livestock. 'Small' livestock were caprines (sheep and goats), and 'large' livestock were bovines (cattle) and equines (donkeys and horses). Cf.Table 3.
[f] Estimated annual dung dry biomass production per household. Included cattle (relevant for biofuels) and all livestock (relevant for manure). Average dung excretion (dry matter) per cow was estimated at 2 kg per day, calculated from a baseline of an average of ~10 kg wet dung produced per day (cf.Hoeck et al, 2007) and ~80% moisture content in dung (cf.Lysyk et al., 1985). Corresponding values for sheep, goats, donkeys and horses were 0.4, 0.32, 1.2 and 2.4 kg, respectively (based onRobinson, 2012, cf.Table 3).

cultivated about every 2–3 years with fallow periods in between. However, farmers have increased rotational rates, and cultivation is now sometimes on an annual basis. Fields are extended to increasingly steeper lands on slopes of up to 20% inclination, whereas other areas which have become unproductive are abandoned (BAPAC, 2011; Bedunah et al., 2010; cf. Fig. 2g). No detailed studies have as of yet been conducted at BANP about soil carbon and nutrient budgets under cultivation, and rates of natural regeneration when fields are abandoned. Nonetheless, *lalmi* cultivation emerges as a major risk to BANP resources, as the practice destroys rangeland vegetation and diminishes plant diversity in the longer term via affecting the soil resources (causing erosion and nutrient losses, especially on steep slopes) (BAPAC, 2011). Abandoned fields are often covered with hardy unpalatable weeds (Robinett et al., 2008).

4.4. Fertilizers and pesticides applied on fields, and risks of land and water pollution

No detailed research has been conducted at BANP on bio-geochemical processes within the lakes. However, as is known from studies around the world (Pentecost, 2005), formation of travertine dams on the lakes depends on biological processes by algae, plankton and bacteria, as well as higher plants (bryophytes and tracheophytes) and fungi. A major concern at BANP is water pollution, which could (possibly over extended periods) affect these organisms and alter sensitive ecosystem balances. Erosion due to unsustainable land uses may lead to increased emissions of sediments and nutrients into the lakes. Other concerns are household wastes (e.g. phosphorus in soaps) and spills (e.g. oil leaks), and increased uses of agro-chemicals (BAPAC, 2011).

84% of respondents (88% of those cultivating crops) used fertilizers on their fields, whereof 40% applied only livestock manure, 18% a combination of manure and urea, 24% urea and ammonium nitrate, and 2% only ammonium nitrate. Furthermore, 36% of the respondents used the herbicide 2,4-D (2,4-Dichlorophenoxyacetic acid) and one farmer used (in addition to 2,4-D) the insecticide Metasystox (active ingredient: oxydemeton-methyl). Farmers with large fields (especially *abi*) were more likely to use herbicides, as well as fertilizers (especially cattle manure), than farmers with small fields (Table A3, Appendix A); this partly explained differences between regions. In addition, urea and ammonium nitrate were mostly applied on fields in western and northern regions. In villages closer to the lakes, fewer farmers used these fertilizers, possibly due to an awareness of pollution issues (Table 2).

Under current regimes substantial amounts of nutrients may be lost from the fields and rangelands through erosion and grazing. Hence, the currently limited inputs of (primarily organic) fertilizers on fields probably represent a comparatively minor, additional threat to the wetland ecosystems. 2,4-D is a herbicide which is particularly effective against dryland weeds (e.g. knotweeds, camomiles, thistles) (Perkow, 1985). Reportedly, it is not highly soluble in water, fairly degradable, and toxic effects on plankton may be limited (cf. Extoxnet, 2013; Okay and Gaines, 1996). In contrast, the insecticide Metasystox may represent a hazard to aquatic environments, if released in significant quantities (Gestis, 2013), but its use was only recorded downstream from the lakes at Dewkhana. No knowledge exists about the breakdown and secondary products of the chemicals in the local soils. More detailed research and monitoring should be conducted to better assess the potential longer-term hazards posed by pesticides and fertilizers. Investigations may also be done on the role of external actors, including the provision of extension and subsidies for agro-chemicals.

4.5. Ownership of livestock, and grazing impacts on BANP rangelands

Most households owned cattle (87%, including oxen used for field ploughing), sheep (82%) and goats (74%). Stocking with sheep was highest, i.e. 24.7 per owner on average. Cattle and goats were fewer per owner (i.e. 3.4 and 5.1, respectively), with cattle being the most expensive animals (Table 3). Livestock composition reflects the cold and dry climate at BANP, with 5–15 times more sheep, but near half as many cattle and goats as in pastoral communities in the Western Himalaya to Hindu Kush mountains (cf. Nüsser et al., 2012; Cochard and Dar, 2014). Livestock numbers per household were generally lowest at Jarukashan (center); more cattle were kept in the main valley (west) and fewest in

Table 3
Frequencies (occurrence per household), numbers, densities, estimated plant consumption (annual feed on rangelands) and economic values of livestock and other domestic animals (dogs, poultry and ducks) at BANP.

Animal type	House-holds (%)	Animal counts per household			Est. total count in BANP[a]	Stock density (km^{-2})[b]	Annual feed ($kg\ ha^{-1}$)[c]	Animal price Afs[d]	Mean live-stock value Afs (hh^{-1})[d]
		Mean ± stdev All respondents	owners	max					
Sheep	82	20.2 ± 19.3	24.7 ± 18.5	120	~16,766	~27.3	~99.6	3499	70.680
Goats	74	3.8 ± 3.7	5.1 ± 3.4	20	~3154	~5.1	~15.0	2242	6520
Cattle	87	3.0 ± 2.3	3.4 ± 2.1	12	~2490	~4.1	~74.8	16,435	49,305
Donkeys	91	2.2 ± 1.3	2.4 ± 1.1	7	~1826	~3.0	~32.8	3630	7623
Horses	25	0.3 ± 0.4	1	1	~249	~0.4	~8.8	14,736	4421
Dogs	27	0.3 ± 0.5	1.1 ± 0.3	2	~249	(~0.4)	–	–	–
Chicken	76	4.1 ± 3.6	5.4 ± 3.2	20	~3403	(~5.5)	–	300	1230
Ducks	1	0.1	6	6	~45	(~0.1)	–	350	21

[a] Calculated based on an estimate (MAIL, 2008, adjusted for growth) of a total of 830 families living in BANP.
[b] Calculated based on BANP area of 613.3 km^2.
[c] Based on data byRobinson (2012): average plant dry matter intake day^{-1}: sheep (1 kg), goat (0.8 kg), cow (5 kg), donkey (3 kg), horse (6 kg).
[d] Information collected by A. Mohibbi. One Afs (Afghani) equaled 0.023 US$ (2010 exchange rate). hh = household.

remote Khakdaw (Table 2). Furthermore, Sayeeds owned on average 1.3 times more sheep and cattle than commoner Hazara, and cattle numbers were also higher (×1.3) in households of respondents with honorary positions. Large families which owned much *abi* land, and which had stayed for a long time in the area, typically owned large herds of livestock (Table A2, Appendix A).

Donkeys were a common transport animal owned by most households (91%; 2.4 per owner), whereas only 25% owned a horse (Table 3). In relation to horses, the donkeys were more abundant (×12) in the outer villages as compared to the main valley (×7; west and center), but otherwise no differences were noticeable among regions. Larger families generally owned more equines. In addition, horses were mainly kept by those who cultivated large fields of *lalmi*, possibly due to more fodder resources available (wheat residues) (Table A2, Appendix A). Most households (76%) also owned chicken, and some (27%) at least one dog. Average cumulative value of animal possessions per household was ~139,800 Afs (~3200 US$). This is about twice the average livestock assets (~1650 US$) of smallholder farmers in mountain areas of Azad Kashmir (Cochard and Dar, 2014).

Extrapolations from the data (on a baseline of 830 households) suggest that, averaged over the entire BANP area, livestock densities were ~32.4 caprines km^{-2}, ~4.1 cattle km^{-2}, and ~3.4 equines km^{-2} (Table 3). These figures largely correspond with those by MAIL (2008), which implies ~32.4 caprines, ~6.5 cattle, and ~3.9 equines km^{-2}, respectively. Based on figures by Shank and Larsson (1977), livestock densities were ~16.3 caprines and ~2.9 cattle km^{-2} during the 1970s. The figures include only local livestock, but due to legacies of previous insecurity and conflict, nowadays few nomadic pastoralists pass through the area with their herds (MAIL, 2008; cf. Schütte, 2012).

Livestock may consume ~230 kg dry plant matter ha^{-1} annually, averaged over entire BANP (Table 3). However, grazing pressures are considerably greater in some areas (close to settlements and migration routes, near the lakes, and in comparatively nutritious pastures) and lesser in other more marginal areas. On steep lands, impacts often lead to soil erosion (cf. Behnke et al., 2006; cf. Fig. 2h). No detailed surveys have been done on plant productivity in relation to grazing patterns at BANP. Data derived from satellite (MODIS) images indicate an overall average annual net primary productivity (ANPP) of ~2160 kg ha^{-1}, with maximum green vegetation at the end of June (Bedunah et al., 2010). *Artemisia*-dominated steppes may reach >4500 kg ha^{-1} in standing above-ground biomass in some regions of Afghanistan, but are commonly <2000 kg ha^{-1} (Breckle, 1983). A large proportion (typically 80–94%) of plant biomass of dwarf shrub communities is, however, stored below-ground in roots. Typically <50% of above-ground plant matter is edible for livestock, and many plants are equipped with physical and chemical defenses (Walter and Box, 1983; Robinson, 2012). *Artemisia* spp., for example, are not very palatable due to high levels of terpenes, and are often only browsed under resource scarcity in late winter (Robinett et al., 2008). Livestock mainly forage for palatable herbs and grasses (preferably perennials), and these could potentially be promoted through careful management (Breckle, 2007). Detailed field observations and grazing exclusion experiments could be of value to assess the impacts of grazing on vegetation productivity and species composition. For example, in Khirthar National Park (Pakistan) species richness of desert grasses and herbs was significantly higher (88 species on average) in grazing exclosures (fencing for 6 years) than in open research quadrats (50 species) (Enright and Miller, 2007). At Khirthar NP, the soil seed or bud bank of most species persisted under heavy grazing, but at BANP more complex species shifts may be observed. Authorities (Bedunah et al., 2010; Ostrowski et al., 2007; BAPAC, 2011) concurred in their (mainly qualitative) assessments that BANP rangelands are heavily grazed (evident from very low grass cover) and in many places show signs of severe degradation (cf. Fig. 2h).

4.6. Possessions of vehicle assets

Material and personal transport was mostly done with equines, but 41% of respondents' households owned at least one vehicle. Most vehicle owners owned one (34%) or two (3%) motorbikes (value per bike ~30,000 Afs or ~690 US$), whereof many (13%) also owned a bicycle (value ~3000 Afs). A few (5%) owned a car (~500,000 Afs). Motorbikes and other vehicles were mostly owned by respondents in the main valley, mostly by the younger, and the better-placed (those engaged in service occupations, or owners of cattle and irrigated fields, and those with an honorary position) (Table 4, Table A3, Appendix A). Ploughing of fields was mostly done with the use of oxen (Fig. 2b). One respondent (in Dewkhana), however, stated that he owned a tractor (~1000,000 Afs).

4.7. Energy needs, and collection of shrubs and dung for biofuel consumption

Households followed several strategies to cover their energy needs, depending on respective resource availabilities and specific tradeoffs in management (e.g. cattle dung used or not as manure). Electricity generated from micro-hydropower stations was mostly used for lighting and electronic appliances, and if sufficiently available sometimes for water heating and rarely for cooking. Most households (91%) had access to electricity, but half the residents at Khakdaw and 9% in the southern region were without electricity (Table 4). Nonetheless, all the households also collected shrubs (on average 63 ± 26 shrub bundles annually; range 20–250) to use as fuelwood for cooking and heating (especially in winter), and partly as fooder admixture for livestock. There were no significant differences between regions, but households with motorbikes and other vehicles tended to collect more shrubs (72.6 ± 35.6 bundles) than those with no vehicles (58.4 ± 26.1) (Table A4, Appendix A). This possibly reflects two factors: more assets for which energy was needed (e.g. livestock), and better means of transport to obtain shrubs. Notably, households with many cattle (> 2) used more shrubs (71 ± 27) than those with 0–2 cattle (54 ± 22). This is probably because more heating (and/or fodder) was necessary for keeping many cattle through winter in larger stalls. Particularly large amounts of shrubs (68 ± 22) were collected by those who cultivated large fields of *lalmi* (> 2 ha) as compared to those with no or small (< 2 ha) fields (57 ± 28). Presumably new *lalmi* fields were cultivated in areas previously cleared of bushes, but the correlation may also reflect respondents' general capacities and tendencies to exploit remaining available natural resources (i.e. utilization of shrub and land resources for expanding cultivations).

Assessments indicated that a typical 'bundle' (~donkey load) contained ~750 shrubs (mostly *Artemisia* spp. and *Acantholimon* spp.) of ~50 kg weight at harvest. For such harvest, a relatively productive shrubland area of up to ~100 m^2 was cleared (biomass largely included partly dug-out below-ground parts of plants; cf. Fig. 2c). Extrapolations from such figures thus indicate that one household consumed ~3.1 t of shrubs annually. This is less than half of household consumption of teresken shrubs (*Krascheninnikovia* and *Artemisia* spp.; > 7.2 t y^{-1}) reported from villages at similar altitudes in the Pamir mountains in Tajikistan (Hoeck et al., 2007). In the Pamir region, a fairly abrupt 'resource consumption switch' to teresken biofuels occurred after the demise of the Soviet Union (Hoeck et al., 2007). At Band-e-Amir, harvesting of dwarf shrubs was already witnessed by Dieterle

Table 4
Summary of transport means, electricity access (frequencies of households hh with access to electricity), biofuel uses (shrub and dung collection), collection of other wild plant resources (reed and medicinal plants), and fish catch by residents in the different regions of BANP.

BANP region[a]	Transport	Electric househ. supply (% hh)	Shrub collection		Dung collection			Biofuel energy index[f] ($GJ\ hh^{-1}\ y^{-1}$)	Reed collection		Medicinal plants		Fish
	Bicycle ¦ motorbike ¦ car I (% hh)		Number bundles ($hh^{-1}\ y^{-1}$)[b]	Biomass index[c] ($kg\ hh^{-1}\ y^{-1}$)	Collect dung (% hh)	No. dung cakes[d] ($hh^{-1}\ day^{-1}$)	Biomass index[e] ($kg\ hh^{-1}\ y^{-1}$)		Collect reed (% hh)	Number bundles ($hh^{-1}\ y^{-1}$)[d]	Collect plants (% hh)	Approx. weight ($kg\ y^{-1}$)[d]	Snag catch (% hh)
Center	5 ¦ 20 ¦ 0	100	51 ± 20	~2527	25	14 ± 6	~175	~40.0	70	15 ± 9	60	3.5 ± 1.9	40
West	28 ¦ 64 ¦ 12	100	69 ± 28	~3450	48	13 ± 2	~342	~55.9	92	59 ± 41	24	3.3 ± 1.9	40
South	18 ¦ 35 ¦ 3	91	63 ± 26	~3154	76	13 ± 3	~531	~53.7	18	21 ± 10	26	3.3 ± 1.5	0
East	5 ¦ 38 ¦ 5	100	65 ± 24	~3238	67	12 ± 2	~443	~53.9	81	23 ± 13	14	4.7 ± 1.5	5
North	0 ¦ 19 ¦ 0	50	64 ± 28	~3203	12	14 ± 2	~92	~49.1	6	(10)	13	6.5 ± 2.1	0
All	13 ¦ 37 ¦ 4	91	63 ± 26	~3126	51	13 ± 3	~353	~51.1	53	34 ± 29	28	3.7 ± 1.9	16

[a] Cf.Tables 1 and 2.
[b] All households collected shrubs.
[c] Based on assessments by A. Mohibbi a typical ‘bundle’ (~donkey load) contained ~750 shrubs and weighted ~50 kg at harvest (mostly dry biomass; literature figures are in the range of 30–70 kg;Hoeck et al., 2007, Bedunah et al., 2010).
[d] Calculations exclude non-collecting households.
[e] The average weight of a cow dung cake was estimated at ~0.15 kg, calculated based on the 2 kg d^{-1} baseline (cf.Table 2) and a defecation rate of ~13 per day (cf.Smith and Frost, 2000).
[f] Gigajoules calculated on the basis of 1 kg dry shrub biomass converting to ~15 MJ fire energy and 1 kg dry dung ~12 MJ (cf.Hoeck et al., 2007).

(1973), who stated that (p. 60) the "hoeing does not appear to strongly influence the [shrub species] composition on the high escarpments." Nonetheless, he noted that shrub cushions near Band-e-Amir "rarely reach 0.5 m in diameter", but in areas more remote from villages they were often much larger. Extrapolations from our data (baseline 830 households) indicate that up to ~500 ha (~0.7% of BANP area) of shrublands may now be cleared annually by local residents for private fuel consumption, but additional areas are reportedly cleared by 'outsiders' either for private uses or export to nearby markets (Bedunah et al., 2010; cf. Robinett et al., 2008).

In total, the respondents of our study listed 12 plant types (by local name) which were used as fuelwood, including dwarf and cushion shrubs, and thistles (Table B1, Appendix B). Many of the types were also listed by Dieterle (1973), but four plant names in our survey were new. Furthermore, five names listed by Dieterle (1973) were not noted by respondents in our survey, including teresken shrubs (locally called *bujighana*) (Table B1, Appendix B). It is possible that this was a favoured fuelwood species at Band-e-Amir 40 years earlier (as it still is today in the Pamir region) which may eventually have become overexploited and 'economically' extinct. Disappearance of this and other species from the list may signal rangeland degradation since the 1970s. Patterns of species collected in different regions also indicated that some shrubs (e.g. *Artemisia*, *Acantholimon* and *Cousinia*) were more depleted near densely populated areas, especially at Jarukashan and Kopruk (Table B1, Appendix B).

In the Pamir mountains, restoration of *Artemisia* pastures may take around 20–30 years (if soil resources remained intact), and often restoration is impeded by invasive thorny cushions of *Acantholimon* and *Cousinia* spp. (Breckle and Wucherer, 2006). No detailed data exist on vegetation regeneration potentials and species dynamics at BANP, but provided that livestock grazing is also considerably high, serious land degradation problems are an obvious consequence in many areas (cf. Bedunah et al., 2010; BAPAC, 2011). On the other hand, enough space may be available to introduce a regime which could potentially be sustainable, provided further baseline research (cf. Kraudzun et al., 2014). Especially on mountain slopes, shrub cover is important to maintain the soils' physical protection, porosity and structure, as well as carbon and nutrient balances. In addition, the shrubs trap snow and by shading delay snow melting in spring. Removal of shrubs could thus lead to changes in local climates and compound the effects of droughts (Robinett et al., 2008; Cochard, 2013; Liston and Hiemstra, 2011).

In addition to shrubs, dung of cattle (and occasionally equines) was used at least sometimes as biofuel (mostly in winter) by almost all households (98%). However, only 51% of respondents stated that household members actively collected dung (including outside of stables). Analyses of these data indicated that dung cakes were mostly collected by owners of cattle, but those using manure as field fertilizers were less likely to collect dung for biofuel (Table A4, Appendix A). Households near the lakes were more likely to collect cattle dung than households in more remote villages; this is because near the lakes cattle numbers were higher, and probably shrub resources were more difficult to obtain (Table 4). Controlling for spatial trends, however, households of older and better-off respondents (Sayeeds, those with honorary positions, owning large *lalmi* fields, or working in service occupations) were less likely than households of younger and commoner respondents to collect dung (Table A4, Appendix A).

On average, households (excluding non-collectors) collected 12.9 ± 4.2 dung cakes daily (range 9–40), and extrapolations indicated that households burnt on average ~353 kg dung annually (Table 4). Calculation only includes information from households which collected dung regularly; overall uses are likely higher since most households probably used dung for fuel during times when other energy sources were at risk to run short (e.g. deep winter). At any rate, the estimates compare well to those recorded for households in villages of the high Pamir (i.e. 400–535 kg y^{-1}; Hoeck et al., 2007); more than two times these amounts may be used per capita in lowland regions of rural Pakistan (cf. Amur and Bhattacharya, 1999). Average annual biomass-based household energy consumption may therefore be estimated at ~51.1 GJ, whereby ~90% of the energy stems from shrubs and ~10% from dung. Consumption is considerably less than values determined for the Pamir villages (115–127 GJ), and dung fractions are higher (4–6% energy from dung at the Pamir villages) (cf. Hoeck et al., 2007). Furthermore, calculations indicate that at least ~16% of all cattle dung and ~5% of total livestock dung were collected by BANP residents for biofuel uses. In the long term, this may lead to relevant losses of soil nutrients via volatilization (cf. Boerner, 1982).

4.8. Collection of other plant resources

Reed was collected for fodder and bedding of livestock during winter. It was also used for building materials and occasionally as fuel during shrub supply shortfalls in winter. Many households (70–92%) in villages in the main valley (especially close to the lakes), but also a few households (6–18%) from the outer villages, collected reed (Table 4, Fig. 2f). On average 34 ± 29 bundles of reed were collected by households (excluding non-collectors), whereby particularly large amounts (maximally 150 bundles) were collected by owners of horses and motorbikes (Table A4, Appendix A). Communities have established reed cutting rights and reed cutting was done since generations each year in autumn. Hence, the practice does not affect breeding of wetland birds, and it appears sustainable under the current regime (cf. Dieterle, 1973; BAPAC, 2011).

At Jarukashan, plants of medicinal uses are sold or traded on the market, hence, many households (60%) were collecting medicinal plants (as stated around 3.5 ± 1.9 bundles annually; excluding non-collectors). In contrast, much fewer households collected medicinal plants in the other villages (13–24%), whereby generally higher harvests (>4 bundles) were stated by collectors in villages located at higher altitudes (Table 4, Table A4, Appendix A). In total, 12 different plants were noted down by various respondents (Table B2, Appendix B), but more would probably be recorded following further investigations. In the Pamir and Western Himalayan mountains, >55 primarily wild plant species were identified by villagers (Kassam et al., 2010; Dar et al., 2012). The impact of herb collection on wild species populations at BANP is not known, but probably it is and has been significant (cf. Kala, 2005).

4.9. Wildlife hunting and fishing

Mostly young respondents living close to the lakes (16% of all) were fishing on a regular basis, with an average stated catch of 2.8 ± 1.0 fishes per day (excluding non-fishers; Table 4, Table A5, Appendix A). Levels of fishing were probably not affecting fish populations in significant ways (cf. Mail, 2008).

Three respondents (3%) stated that they were hunting birds, i.e. either waterfowl (2%; either 1 or 4 birds per week), rock doves (1%; 6 per week), or smaller birds (1%; about 50 per week during bird migration times). If such figures are representative, in total >30 waterfowl, >40 doves, and dozens of small birds may thus be hunted or caught per week (baseline 830 households). This is not insubstantial, especially in the case of large waterfowl whose habitats and populations are limited (cf. Kanderian et al., 2011).

Questions about hunting of other animals were answered negatively by all respondents. Most large species of wildlife were probably eradicated during the war, and newly immigrating populations may no longer be able to establish permanently due to high resource competition from livestock. Threats for wildlife may also come from livestock diseases, which thrive in certain areas (Bedunah et al., 2010; Ostrowski et al., 2007). Discussion with residents indicated that human-wildlife conflicts had increased, because in the absence of large wildlife, predators (mainly wolves) increasingly prey on livestock. This may partly explain why many of the relatively richer respondents (Sayeeds, owners of horses and large irrigated fields) kept dogs to defend their livestock and other assets, and particularly in villages at relatively higher elevations (Table A2, Appendix A). Attitudes towards wildlife and hunting may be ambivalent, but wildlife conservation will likely gain if economic incentives and better insurances against livestock losses (e.g. due to predators) can be established (cf. Huber, 2012).

5. Conclusions and recommendations

The socio-economic and environmental situation in newly created Band-e-Amir National Park reflects conditions in other parts of Central Afghanistan. However, intentions are to transform BANP into a model for responsible environmental stewardship in Afghanistan. First steps are to identify and better describe issues of resource uses and environmental impacts. This paper provides some baseline information and reference points for planning of projects which promote new approaches of improved resource management. It also provides some direction for further scientific investigations.

Conservation objectives in BANP will only have a prospect of success if undertaken with the consent and close participation of local residents. It demands a considerate stepwise approach since environmental and socio-economic issues are inevitably intricate, and diverse interests exist among communities. Land rights are not clearly regulated, especially in the case of *lalmi* agriculture and rangeland resources. Resident composition and demography is still in flux. Nonetheless, prospects for improvements exist. BAPAC provides major representation for the main 13 villages of BANP, in addition to delegates from state, provincial and district agencies and selected NGO's. If further support and extension is provided (with an international spotlight set on the area), communities may gain confidence in arrangements and processes, exercise their responsibilities, and follow rules and regulations. Although many residents are cautious to acknowledge environmental issues (probably due to persistent mistrust towards outsiders), it is also increasingly obvious to them that resources are further declining if no actions are taken. Residents thus appear to be receptive for new livelihood options and ideas for improving regimes of resource management, including to a certain extent, aspects of biodiversity conservation (cf. Adams et al., 2004).

Due to Afghanistan's security situation, the potentials for BANP to generate revenues and new jobs from international tourism will probably remain limited in the coming years. On the other hand, if national and international attention and support are maintained, BANP could serve as a ‘field laboratory’ for scientists and practitioners to study and improve both—local people's livelihoods and the natural quality and biotic diversity of the area. Within Afghanistan, BANP is one of the best-studied areas, even if much research has been conducted before 1979. In the current context, there is a long list of new issues for which solutions need to be found, and for which in-depth research is critical. Many research projects could be undertaken in partnership with local residents, whereby locals benefit from additional incomes and from collaborative workshops. In such projects locals could also actively participate and contribute in developing feasible approaches to more sustainable land management and nature conservation. As partly outlined elsewhere (BAPAC, 2011, Bedunah et al., 2010), further research should focus on following issues:

1) *Surveys and databases.* Systematic vegetation surveys should be undertaken and compared to earlier surveys (e.g. Dieterle, 1973). A database of plant species should be established, and the relative abundance and palatability of plant species for livestock should be determined via direct observations during different seasons. Information should be gathered on the ecology of the main plant species. The question should be addressed whether some useful/palatable species could be promoted, e.g. via breeding and seed dispersal. Animal species recorded for the area should be catalogued.
2) *Vegetation patterns under intensive grazing and other impacts.* Movements and patterns of grazing should be observed in the field. Further vegetation patterns and impacts may be identified using aerial/satellite images and geographical information systems (cf. Tobler et al., 2003). Ways to improve rangeland use regimes should thus be studied.
3) *Experiments of grazing exclusion.* With the consent and collaboration of local residents small areas (replicated in different vegetation types) should be permanently and/or seasonally fenced to study vegetation development in the absence of grazing pressure (cf. Bork et al., 1998). Relevant research questions are: To what degree do small protected areas increase overall plant diversity and productivity? Do they contribute to increase productivity also in the surrounding grazed vegetation (e.g. via increasing propagule density and dispersion)? Can protection of areas during certain seasons (e.g. growth period until seed set) help to increase overall productivity with tangible benefits for livestock and/or wildlife?
4) *Shrub cutting practices and impacts.* These should be studied in field surveys and experiments (cf. Kraudzun et al., 2014). Relevant research questions are: Where and in which ways do locals and/or outsiders preferably collect shrubs? What are the impacts on soils (erosion, nutrient losses) in various terrain? Could alternative approaches of shrub extraction (e.g. selective as compared to complete clearing, protection of steep lands) mitigate against negative effects on vegetation and soils? What are the regeneration rates in cleared areas in different terrain and various use regimes? How could regeneration be aided by management measures (e.g. seeding of propagules, grazing exclusion, etc.)?
5) *Practices of dryland farming (lalmi) and environmental impacts*. In addition to similar research questions as above for shrub collection, traditional systems of land tenure should be investigated.

6) *Practices of biofuel uses and energy efficiency.* Relevant research questions are: Can biofuel consumption be decreased via improvements of cooking stoves, bread ovens, or better isolation of houses during winter (cf. Wiedemann et al., 2012)? Are there practical alternatives to biofuels? Would establishment of tree plantations (e.g. poplars) in lower-lying areas (e.g. marginal areas along *abi* fields) be a cost-effective and efficient option to replace shrub uses?
7) *Wildlife refuges.* More information needs to be gathered about wildlife in BANP. Remote areas suitable for urial or ibex should be surveyed and possibly patrolled to prevent hunting. Hunting of waterfowl at the lakes should, if possible, be prohibited.

Crucial issues of land degradation should be addressed without much time delay. Bedunah et al. (2010) suggested to (1) develop 'community shrub collection areas' which can be protected against outside collectors, (2) develop land classification and reach some (initial) agreements on which areas may be unsuitable for plowing for *lalmi*, and (3) establish agreed-on grazing management plans for villages which can alleviate pressures on rangelands in space and during certain bottleneck periods (e.g. droughts). If possible, any new management programs may be drawn up sufficiently flexible in order to incorporate new insights from ongoing research and lessons learned from project evaluations (cf. Williams, 2011).

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Appendix A. Supplementary data

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.envdev.2014.04.003.

Appendix B. Specific data on plant species collected for biofuel and for medicinal uses

See Tables B1 and B2.

Table B1
Listing of commonly collected plant species used for fuelwood. The frequencies of respondents collecting a species are provided as well as whether or not the plant was listed byDieterle (1973) as a fuelwood species.

Local name[a]	Total Freq.[b] (%)	Collecting households per region					Record 1970[c]	Genus (likely species)[d]	Plant family	Description
		Center (%)	West (%)	South (%)	East (%)	North (%)				
ghuzba	96	90	92	100	95	100	Yes	*Acantholimon* spp.	Plumbaginaceae	Cushion shrub
seyabota[e]	80	70	88	85	71	81	Yes	*Artemisia* spp.	Asteraceae	Dwarf shrub
surkhpycha	58	50	56	50	67	75	Yes	*Polygonum* (*podlechii*)	Polygonaceae	Cushion shrub
kherpak	38	35	40	50	33	19	Yes	*Cousinia* spp.	Asteraceae	Thistle-like plant
dom shtor	29	30	40	29	24	19	Yes	*Astragalus* spp.	Fabaceae	Dwarf shrub
yama	5	10	8	0	10	0	Yes	*Ephedra* (*gerardiana*)	Ephedraceae	Dwarf shrub
khar aho	5	0	4	12	5	0	No	Unknown	Unknown	Unknown

Table B1 (*continued*)

Local name[a]	Total Freq.[b] (%)	Collecting households per region					Record 1970[c]	Genus (likely species)[d]	Plant family	Description
		Center (%)	West (%)	South (%)	East (%)	North (%)				
ghawog bota	4	15	4	0	5	0	Yes	*Semenovia* (*lasiocarpa*)	Apiaceae	Cushion shrub
bar bota	4	5	8	0	5	6	No	Unknown	Unknown	Unknown
khero	3	0	0	9	0	0	No	Unknown	Unknown	Unknown
arghusha[f]	2	0	8	0	0	0	Yes	*Senecio* (*khorassanicus*)	Asteraceae	Ragwort-like plant
kharsamboo	1	5	0	0	0	0	No	Unknown	Unknown	Unknown

Further species which were listed byDieterle (1973) but were not recorded in this survey: *bujighana* (*Krascheninnikovia pungens*), *jaka* (*Cerasus bifrons*), *attarghan* (*Ceragana aurantiaca*), *oilak* (various bunch grass species), ?(*Trigonella*).

[a] Plant name listed by the respondents.

[b] Frequency of respondents noting the plant in this survey.

[c] Indicates whether or not the species was listed byDieterle (1973).

[d] Often several species are referred to under a local plant name (species names in brackets are indicative but may not be reliable).

[e] The local name listed byDieterle (1973) was *safed buta*.

[f] The local name listed byDieterle (1973) was *gush-argali*.

Table B2
Listing of commonly collected plant species used for medicinal purposes.

Local name[a]	Total Freq.[b] (%)	Collecting households per region					Genus (likely species)[c]	Plant family	Description
		Center (%)	West (%)	South (%)	East (%)	North (%)			
bosraq bota	22	45	24	18	14	13	Unknown	Unknown	Unknown
mint	20	55	16	12	95	13	*Mentha* (*longifolia*)	Lamiaceae	Mint herb
boe baran	20	5	0	9	0	0	*Achillea* (*wilhelmsii*)	Asteraceae	Yarrow herb
kuza tani	18	55	12	15	10	0	Unknown	Unknown	Unknown
sang ghazak	6	15	8	3	0	6	*Acantholimon* sp.	Plumbaginaceae	Cushion shrub
yama	3	5	4	3	0	0	*Ephedra* (*gerardiana*)	Ephedraceae	Dwarf shrub
dom gosala	3	0	0	9	0	0	Unknown	Unknown	Unknown
kakoti	3	5	0	0	5	6	*Ziziphora clinopodioides*	Lamiaceae	Mint herb
gol caw zaban	3	5	4	3	0	0	*Borago officinalis*	Boraginaceae	Borage
bozbash	2	0	4	0	0	6	*Rosa brunonii*	Rosaceae	Shrub
piyaz kohi	1	0	0	3	0	0	*Allium* sp.	Alliaceae	Field garlic
gul bota	1	5	0	0	0	0	Unknown	Unknown	Unknown

[a] Plant name listed by the respondents.

[b] Frequency of respondents noting the plant in this survey.

[c] Often several species are referred to under a local plant name, i.e. species in brackets may not be reliable.

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