Stakeholder Perceptions of Climate Extremes' Effects on Management of Protected Grasslands in a Central European Area

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Since meteorological data have been regularly recorded in Hungary, 2010 has been the rainiest year, whereas 2011 and 2012 have been the driest years. Protected grasslands and their management by low-intensity livestock farming are seriously affected by climatic changes. This paper seeks to shed light on stakeholder perceptions of recent extreme weather events, in order to better understand how to adapt the management of vulnerable habitats to anticipated changes. The status of vulnerable habitats is strongly affected by land use change as well; therefore, this process requires stakeholder involvement. Opinions on what aspects are presumed to be affected most by changes in climate were gathered during semistructured interviews from farmers and conservationists in the Körös-Maros National Park in Hungary. Stakeholders revealed negative impacts resulting from extreme floods, droughts, and changes in rainfall and temperature, and they highlighted challenges relating to conflicting management objectives and perverse incentives arising from policy-level issues (such as regulatory structures and implementation). Subjects noted that years with high precipitation caused adverse conditions for livestock, late mowing due to inaccessible pastures, poor quality of hay, and undergrazing (but still compaction damage). Years with negative precipitation records show decreased quantity and quality of hay, loss of valuable forage, winter shortage of green fodder, land degradation, increased water demand, shifting grazing seasons, decreasing carrying capacity, overgrazing, heat stress, declines in physical activities, expansion of invasive alien species, and conflicts between economic interests and nature conservation objectives. In only a few cases was the awareness of these issues converted into practical adaptation or mitigation activities.

1. Introduction

Climate change is likely to have impacts on the agricultural sector as well as on nature conservation, including grassland-based livestock production in many regions of the world (IPCC 2007). These sectors will be more sensitive to climate change than manufacturing and retail and the effects will be more negative in marginal regions aggravating current economic and social problems (Maracchi et al. 2005). Although intensive agricultural systems generally have a low sensitivity to climate extremes, because changes in temperature or rainfall have modest impact, some low-intensity farming systems located in marginal areas may be severely affected (Darwin and Kennedy 2000). This fact greatly affects biodiversity conservation, as low-intensity farming systems, especially pastures and hayfields on grasslands, are critical to nature conservation and the protection of the rural environment (Bignal and McCracken 1996).

The area of grasslands in Europe is likely to decrease by the end of this century and their productivity is likely to be reduced by temperature and precipitation changes (Falloon and Betts 2010). While the agricultural sector has already adapted to some seasonal variability, in recent years climatic effects have resulted in several management problems. Grassland-based livestock production may be influenced by climate change directly by means of effects on animal welfare, heat stress, and reproduction, and indirectly through impacts on productivity of pastures and forage crops (Maracchi et al. 2005).

The agricultural sector, as well as nature conservation, is affected by various pressures in Hungary. Agricultural predictions using climate model ensembles indicate that Hungary is a hotspot, especially for precipitation (the

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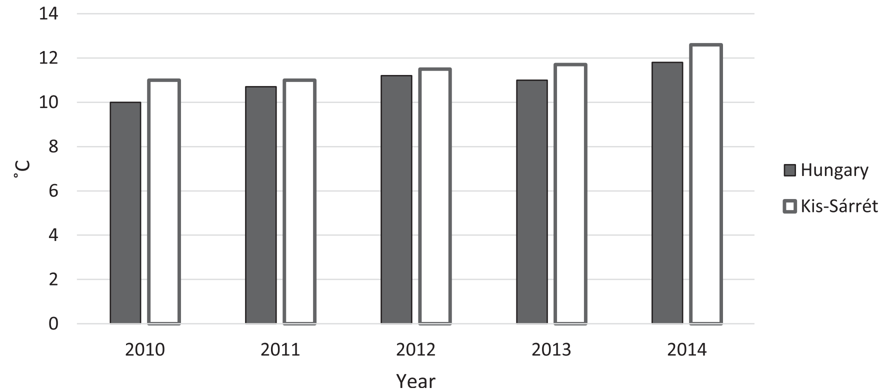

FIG. 1. Average annual temperature in Hungary and the study area from 2010 to 2014. Source: Hungarian Meteorological Service.

only one in Europe to date) and temperature (Fraser et al. 2013). Winters are likely to become wetter and springs and summers drier according to the Regional Climate Model System (RegCM) and the Providing Regional Climates for Impacts Studies (PRECIS) regional climate model. The annual mean temperature in Hungary is expected to increase within each landscape unit by 1.2°–2°C for the period of 2021–50 and by 3.4°–3.7°C for the period of 2071–2100, compared to the reference period of 1961–90 based on the Aire Limitée Adaptation Dynamique Développement International (ALADIN) model and the MPI regional model (REMO) suitable for climate modeling and weather forecasting (Krüzselyi et al. 2011). During the first decade of the twenty-first century, annual mean temperature of every year except for 2005 exceeded the long-term average (i.e., 1971–2000), and 2012 was the second warmest year on record since 1901 (Mezősi et al. 2014). With a massive annual precipitation of 959 mm, 2010 was the rainiest year since 1901, whereas 2011 was the driest one; precipitation totals show greater than 100% difference between these two consecutive years. Only 6% of the normal precipitation amount was registered for March 2012 and 14% for August 2012, making these the driest months since 1901. The minister of rural affairs announced drought status for nearly the entire country from 1 November 2012 to 31 October 2013. The average annual temperature and precipitation in Hungary and the study area from 2010 to 2014 are shown in Figs. 1 and 2.

The warming trend in Hungary is obvious on the harmonized, gridded data for the period of 1961–2010. The changes in the number of days with precipitation above 20 mm show substantial decrease (or increase only in small areas of the region) in this 50-yr-long period (Lakatos et al. 2013). Because of the small area of the country, there are only slight spatial differences in the future changes of the temperature, on the basis of the models. However, a characteristic positive trend can be observed from north to south during the summer months. The highest precipitation decrease can be observed on the southern part of the country during the summer months (Bartholy et al. 2007).

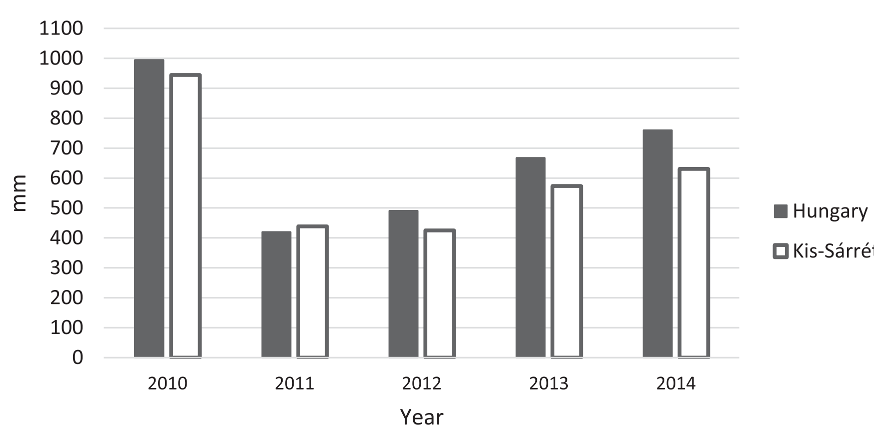

FIG. 2. Average annual precipitation in Hungary and the study area from 2010 to 2014. Source: Hungarian Meteorological Service.

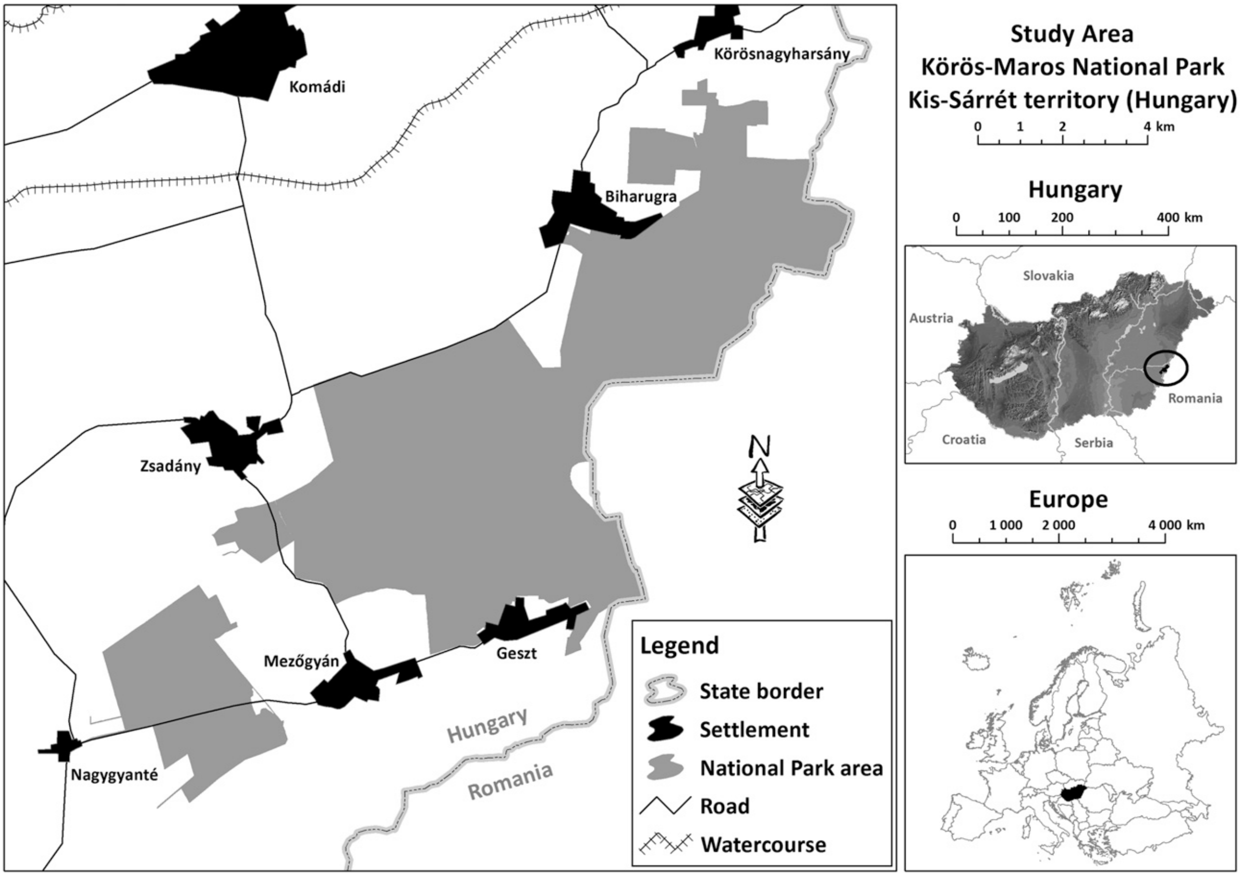

FIG. 3. Map of the study area.

The increased occurrence and duration of droughts could have many negative impacts such as reduced pasture productivity, increased livestock deaths, soil erosion, and land degradation (Barczi et al. 1998). Reduction in surface runoff, soil moisture, and recharge to groundwater were additional elements on the Great Hungarian Plain, which had been already facing problems of water shortage (Podmaniczky et al. 2011). Birkás et al. (2013) give various solutions for adapting Hungarian soil tillage practices to climate extremes.

The aim of the study was to explore stakeholder perceptions of the problems encountered in relation to recent extreme weather events and land management in a nature protected site in southeast Hungary, which was one of the most affected areas by the recent weather extremes (see Figs. 1 and 2 for comparison with countrywide trends). Bignal and McCracken (1996) state that climate change processes are critical to nature conservation and protection of the rural environment in areas with traditional low-intensity farming systems. The study area has been managed and its natural values and habitats sustained by traditional low-intensity systems since historical times (Saláta 2011).

2. Materials and methods

a. Study area

This study was carried out in the Kis-Sárrét area, which is located in southeastern Hungary very close to the Romanian border, near the GPS coordinates 46.93256°N, 21.58438°E (Fig. 3). The landscape here has undergone dramatic changes during the past 200 years. Once extensive marshes have been reduced and altered as a result of water regulations between 1856 and 1879. In consequence, many areas under constant or temporal water cover disappeared, and the traditional management changed. Some parts are still under constant water coverage. Those patches that only have seasonal water coverage due to slightly higher elevation ensure appropriate conditions for alkaline habitats. These are used for livestock grazing (Hungarian gray cattle, racka sheep, and water buffalo) and hay mowing. The grazing season traditionally lasts 191 days, from 24 April until late October.

The area belongs to a national park, and it hosts numerous plants, animals, and habitat types of European Union community importance. Some areas are privately

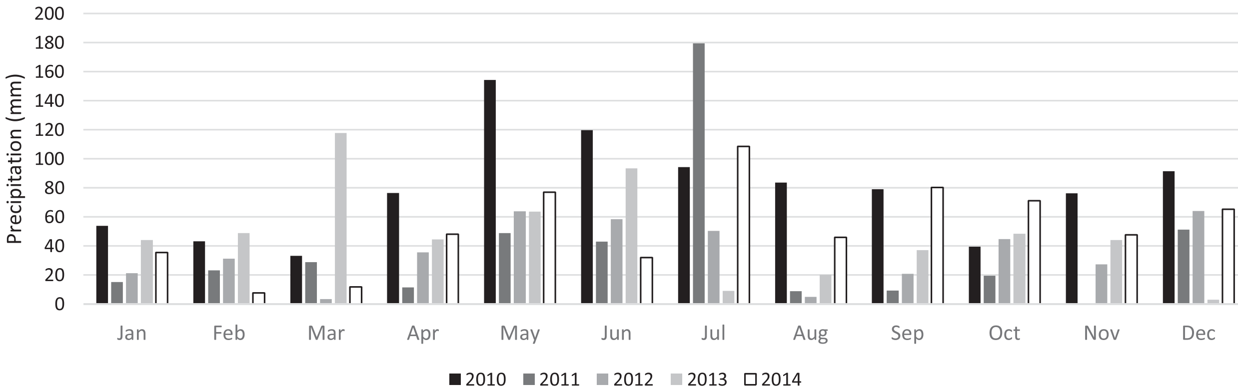

FIG. 4. Average monthly precipitation in the Kis-Sárrét area from 2010 to 2014. Source: Hungarian Meteorological Service, Körösszakál station.

owned, while other land is owned by the state and leased to local farmers. The farmers who rent the land from the state have to follow specific nature conservation restrictions. The number of residents employed in agricultural sector is higher than the national average (Malatinszky et al. 2013).

The average monthly precipitation in the Kis-Sárrét area from 2010 to 2014 is shown in Fig. 4. Trends of decreasing summer precipitation and increasing temperature during the same months were registered in the area during the past decades, causing a high climatic water balance deficit during June, July, and August (i.e., the most critical months for grazing) (Fig. 5). As trends continued, negative precipitation records were broken in Hungary during 2011 and 2012. This hot and dry spell resulted in low summer precipitation that failed to compensate for the accumulated evapotranspiration, creating a cumulative water balance deficit of up to 200 mm (Stagl and Hattermann 2011).

b. Identifying stakeholders

Following the methodology of Reed et al. (2009), stakeholders in this study are defined as persons, groups, or institutions that directly influence the state of an area. Their experience might help to explore climate change–induced problems.

A planning team was composed of three park rangers who organize and control management of the study area (with considerable experience with regard to natural values, local communities, land owners, and land managers) along with an ecologist and an agricultural officer at the National Park, and the leader of a nongovernmental organization (NGO). A two-dimensional stakeholder classification matrix was prepared following

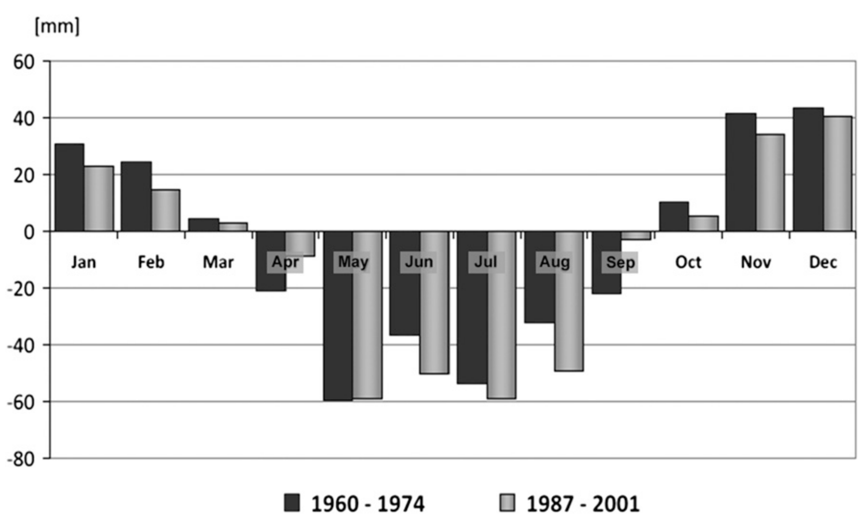

FIG. 5. Climatic water balance trends in the study area. Source: Stagl and Hattermann (2011) (with permission).

TABLE 1. Stakeholder classification matrix for management of protected areas in the Kis-Sárrét, Hungary.

	Low influence	High influence
High interest	Subjects • Local NGOs • Students	Key players • Farmers: land owners and/or hired land managers, shepherds • National Park: rangers and staff responsible for management
Low interest	Crowd • Tourists, birdwatchers • Fishing company • Hunters • Local residents of surrounding villages	Context setters • Local governments • Trans Tisza Water Directorate • Regional Water Management Association

the method suggested by MacArthur (1997), naming the stakeholders with low or high interest and low or high influence (Table 1). Following Reed et al. (2009), we used interest and influence to classify stakeholders into "key players," "context setters," "subjects," and "crowd." Key players are stakeholders who have high interest in and influence over a particular phenomenon. Context setters are highly influential but have little interest. Subjects have high interest but low influence; by definition they are supportive, but they lack the capacity for impact, although they may become influential by forming alliances with other stakeholders. The crowd is composed of stakeholders who have little interest in or influence over desired outcomes and there is arguably little need to consider them in much detail or to engage with them (Reed et al. 2009).

Among the stakeholders defined as key players in the management of protected areas, are farmers (land and grazing livestock owners who directly manage land, land managers who rent the land from the state, and shepherds) and National Park rangers and directorate staff. Crop production does not take place close to the natural areas; thus, arable farming does not significantly affect wetlands and grasslands. Therefore, these mentioned actors are those stakeholders who play a crucial role in grassland maintenance and have to face challenges of climatic changes and recent extreme weather events. This is why context setters and subjects, like the crowd, are not the focus of this study.

c. Interviews

In person, semistructured interviews with key players were conducted between the autumn of 2012 and the summer of 2013. Stakeholders' names and addressed were provided by the directorate and the park rangers. Study participants ($n = 34$) included 3 park rangers; 3 members of National Park directorate with expertise in botany, ecology, and agriculture; 7 farmers who own their land; 18 farmers who lease their land; and 3 shepherds. Approximately 85% of the individuals who were contacted for interviews participated in the study. This means a very high representation for the study area (as the list of key players contained all the farmers who deal with grassland management), making this study representative at the level of the region.

The interviews were usually done on the spot with individual responses given in person during dialogues that give scope for discussion. A series of semistructured interviews (between 1.5 and 2.5 h in length) based on 17 open-ended questions [following the method of Leech (2002)] were carried out. These followed a basic script, which contained questions pertaining to impacts of recent extreme weather events (e.g., drought and excessive precipitation), the qualitative and quantitative conditions these caused for livestock and hay/forage management (with keywords such as harvest yield, extra costs, water demand, grazing season, carrying capacity, land degradation, overgrazing, invasive alien species, health and heat stress of livestock), the challenges these caused to uphold nature conservation regulations, and expectations of agri-environmental incentives. Additionally, the respondents' local management concerns and past or planned adaptation strategies were discussed.

The answers were recorded and detailed notes taken. Text fragments were compared according to the method of Ryan and Bernard (2003) to identify themes. Reported features were divided onto those that are linked directly to weather and climate and those that result from nonclimatic pressures (e.g., land use).

3. Results

The main themes and concepts that were identified through data analysis are negative impacts resulting from extreme floods, droughts, and heat waves, adverse conditions for livestock, decreased quantity and quality of hay, winter shortage of green fodder, increased water demand, shifting grazing season, overgrazing due to decreasing carrying capacity, expansion of invasive alien species, and conflicts between economic interests and nature conservation objectives.

a. Excess precipitation (2010)

Annual precipitation had a sum of 944.2 mm in the study area and a national average of 994.9 mm in 2010, exceeding the record so far (824 mm in 1940; measurements since 1901).

One-quarter of all study participants reported that the high levels of standing water made meadows, hayfields, and even pastures inaccessible for mowing machines. Thus, one park scientist emphasized that ''they [the fields] were mowed too late resulting in poor quality hay [because it was too old].'' Some farmers expressed concern that excess water caused soil waterlogging and reduction in fodder. They also noted that some pastures were not suitable for grazing ''because of adverse conditions for animals.''

According to another park scientist, ''excess precipitation in the summer of 2010 caused physical barriers even on some roads. Thus, the mowed hay could not be transported away from some meadows managed by the park staff, causing biomass accumulation. [These] parts [that] remained wet, blocked mowing even on areas that usually dry up [enough by] late summer.''

On the other hand, some farmers favor spring water stagnation, as it results in better hay quality and bigger forage quantity. In terms of adapting to changing conditions, one of them noted that ''Climate change is an irreversible process, unfortunately. Therefore, it is us, people, who have to adapt to it.''

b. Drought (2011, 2012)

Extreme conditions decreased the quantity and quality of the harvests during 2011 and 2012. All farmers (as they manage national park areas) were not allowed by nature conservation regulations to start hay harvest until mid-June (when forage value was significantly lower), which is contrary to nonprotected areas where early-May harvest was common. Interviewed farmers faced a lack of green fodder and an increase of compound feed prices during the winter, especially if they used their winter hay meadow as a complementary pasture.

Several study participants experienced that the grazing animals lost weight because of forage reduction in two of the past three years (2011 and 2012), and one of them said, ''Thanks to the ample autumn precipitation, however, they could prepare for the winter on the aftermath.''

The National Park was forced by climatic pressures to purchase water in 2011 (from the nearby river) to stop wet meadows drying up in autumn; this required cooperation with the adjacent fishery. This was the first time this was needed in autumn (a supplementary spring water supply had been provided in 2004, 2008, and 2009) and was caused by extreme low end-summer water level and lack of autumn rains (reported by a park scientist).

Some interviewees were worried that drier summers would also increase fire risks. Arid climatic effects were harmful on arable land management as well, and indirectly caused overuse of grasslands as in the case of lower fodder production on arable lands, where grasslands were overgrazed (reported by an officer at the National Park). During the past two decades, the park staff noticed that only every third or fourth year was rainy enough. However, a park ranger argued that ''[No matter what] kind of weather comes, some native plants and animals will benefit from it.''

c. Freshwater supply

A park scientist reported that frequent drought events resulted in reduction in surface runoff, soil moisture, and recharge to groundwater. This led to less water available for the increased water demand. As a consequence of water shortage, bird fauna have changed significantly in the study area; for example, northern lapwing (*Vanellus vanellus*) and pied avocet (*Recurvirostra avosetta*) have disappeared in several localities since the 1990s, while great bustard (*Otis tarda*) and red-footed falcon (*Falco vespertinus*) have appeared, as noted by park rangers. A park officer added that ''this trend was also caused by the abandonment of rice production, i.e. that system does not heighten the groundwater level any more.'' Three farmers even mentioned that flooding irrigation was a general practice in some areas in the 1970s and it could have a positive effect on soil moisture and groundwater recharge even today.

d. Need for water retention

Several study participants urged water retention in wet areas and the improvement of landscape water supply. They also noted that the regional water directorate and the water management association usually aim to lead inland waters away, without caring for the demand of wet habitats. One of the park scientists added that this approach dominates even the new national water strategy, which ''urges a stronger defense against floods by building higher dams in parallel with the establishment of efficient irrigation systems for arable fields instead of water retention, which could serve as the solution of both problems.''

e. Shifting grazing season

Because of the mild late-autumn and early-winter weather, grazing animals remained on the pastures even into November and December in 2011, 2012, and 2013, contrary to the late-October end of grazing in the previous years and historic times (as corroborated by one-third of all interviewees). This has not caused any problems for nature conservation according to the rangers, as it has happened only two or three times so far and took place principally in the vicinity of the stables and thus it did not harm the migratory and wintering birds; ''however, winter grazing may hinder the renewal of the grasslands in the long run, and is not acceptable on wet soils that are not frozen,'' as one of the park scientists added.

f. Changes in the quality of hay

Two farmers worried that the suitable conditions for the production of some fodder plants are shifting northward and therefore new varieties should be sown. A park scientist added that an increase in summer temperatures may induce alterations in the physiological requirements, and this may result in a change of vegetation period durations, and phenological phases of the grazed lawn.

g. Changes in the quantity of hay

Excess precipitation during 2010 had a beneficial effect on grasslands in early 2011, but the drought caused a low amount, albeit good quality, of hay in 2011, as reported by a park officer. Because of the lack of hay in 2012, some farmers fed livestock with two-year-old hay during early 2013, which had a lower forage value. Conversely, 2013 gave a suitable amount of hay. The majority of the study participants experienced that there have not been any average (ordinary) years during the past decade: ''hay yield was either very good (up to 13 bales per hectare), or very unfavorable (1 to 2 bales per hectare), [which] causes severe shortages of winter forage,'' as one of them added.

One farmer stated that a few decades ago, alfalfa produced a good harvest five or six years in a row even on alkaline soils, but recent years have been unfavorable as alfalfa tolerates neither water stagnation nor drought. ''It is very hard to adapt to these phenomena,'' he said.

Some farmers faced the problem of so much hay in 2010 that a significant portion was not able to be stored sufficiently.

h. Overgrazing

Because of the several previously mentioned effects, the carrying capacity is decreasing. Especially in dry years such as 2011, 2012, and part of 2013, overgrazing affected some patches, but fortunately only smaller ones so far, such as livestock routes and the areas surrounding stables, as observed by the park staff. This was partly due to sparse vegetation caused by heat and drought. A park scientist noted that overgrazing also may strengthen erosion of salt steppes: ''This process leads to the formation of a special landscape form called 'shoulder', which hosts an altered habitat type.''

According to the Agri-Environment Program (AEP) under the Rural Development Program [regulated by the 150/2004 (X.12.) FVM decree], the maximum load is 0.5 livestock unit per hectare on alkaline pastures, as explained by a park officer.

i. The effects of temperature extremes on the grazing livestock

Some farmers (mostly shepherds) reported that extremely hot days and very strong sunshine was hardly tolerated by the livestock, especially young calves. Higher temperatures resulted in greater water consumption, which caused declines in physical activities, including eating and grazing. This is why they let their livestock graze in the early mornings, between 4 and 8 o'clock, and made serious efforts to ensure drinking water even in distant areas.

On the other hand, warming during the winter season was beneficial due to reduced feed requirements, increased survival, and lower energy costs, as experienced by a tenth of the farmers. ''I didn't feel sorrow for spending less for fodder,'' one of them said.

j. Invasive alien species

The increasing weed infestation is harmful not only from the aspects of nature conservation, but these plants may also be detrimental to grass and forage as they overrun (and ultimately replace) indigenous species. Farmers in the sample area so far have had to combat giant goldenrod (*Solidago gigantea*) and Russian olive (*Eleagnus angustifolia*). Several study participants agreed that balanced, smooth grazing maintained the pastures in earlier times, but that the current weed infestation processes require harder efforts.

k. Side effects of the requirement to keep land in good agricultural condition

Because of the requirement to keep land in good agricultural condition, some farmers mow those abandoned fields that would otherwise have become overgrown. This is positive for the farmland communities. Because of the too-strict authority control, however, one farmer removed even the hedgerows to avoid punishment. ''It is impossible to observe all regulations'', he said.

l. Conflicts with authorities

It was detected in several interviews (both from farmers and park staff) that interests of nature conservation interfere with those of the farmers in the case of mowing habitats that host nesting birds until June. Altered weather conditions also affect the development of hay, flowering time, and, thus, the optimal mowing time. If farmers cannot mow in proper time because of weather conditions (e.g., heavy tractors cannot enter flooded patches), it causes both the accumulation of biomass on the meadow (accelerating succession, harmful for natural values) and the lack of forage. Moreover, land managers who take part in agro-environmental programs or receive Natura 2000 (the nature conservation program of the European Union) compensations might be punished (by a fine or forced to pay back the compensation) by inspectors for mowing earlier (when the forage value is optimal) than stated in their permission. Earlier flowering time requires an earlier mowing of the hay; however, the nesting period of strictly protected birds is not necessarily shifting.

Some farmers argued that goats should be considered on alkaline pastures as they resist heat stress and tolerate poor quality hay. They state that goats do not degrade these habitats more than other grazing livestock; in addition, they are more effective against invasive alien species. The directorate however, ''permits goats only as accompanying sheep,'' as explained by a park officer.

m. *Flexibility of authorities and regulations*

There are also some challenges that arise due to conflicts between objectives of nature conservation authorities and the farmers' economic interests. A park officer who was asked after the interviews with farmers underscored that flexibility is needed when ordering certain management restrictions for farmers on nature protected or environmentally sensitive areas; the regulations should be revised every year or even within a year, for example, ''the time of mowing should be tied to vegetation phenophase instead of [an] exact date.'' Currently there is a lack of such flexibility due to strict legal regulations. He also reported that there is a need for [a] regular sharing of knowledge and information.

n. *Farming as a contributor of climatic variations*

The majority of the study participants clearly see that the agricultural systems are not only sensitive to climate change but also among its main contributors through emissions of several greenhouse gases and feel responsibility for mitigation strategies within the sector. As one farmer said, ''There is no outsider in this topic, everyone should cooperate.''

4. Discussion and conclusions

The summer droughts of 2011 and 2012 have been taken in many parts of the society as an indicator of the climate change that might come, and it may be used as an eye-opener to convince the farmers on the need for adaptation. Every interviewed stakeholder presented problems caused by extreme weather events, which have impacts both on their socioeconomic interests and on nature conservation. As annual precipitation in 2011 was 30% below normal, the amount of grass was not enough for the grazing livestock in several habitat patches used as pastures. The same phenomenon was recorded during 2012.

The need for water retention is underscored by temperature and precipitation data gained for the area, which show that the summer months (May–August) were drier and warmer during the recent decades (data between 1987 and 2001) as compared to previous ones (data between 1960 and 1974), resulting in decreasing average monthly total values of the climatic water balance (Fig. 5). As the difference between precipitation and the potential evapotranspiration of vegetation is higher during the summer months, this may create a critical situation for livestock, and thus needs climate-adapted management measures on the pastures.

Although it is still controversial, if species migration is able to keep pace with climatic changes (Garamvölgyi and Hufnagel 2013), the interviewees worry that suitability for the production of some fodder plants is shifting northward, which supports the need for research on this topic; Bede-Fazekas et al. (2014) provides a suitable methodology for doing so. Considering lower forage composition, the drought significantly reduces the CO_2 uptake potential of grasslands, leading to lower annual net primary production and potential plant productivity (Czóbel et al. 2012).

Considering the answers that extremely hot days and very strong sunshine were barely tolerated by the livestock, it is likely that extreme events and weather variability will have a far greater impact on livestock productivity than general climatic effects (Parsons et al. 2001). The establishment of shaded places for drinking and resting is strongly advised.

Kovács et al. (2015) stated that Hungarian farmers are generally aware of the most obvious expressions of biodiversity. In addition, climate literacy is low in rural Hungary. Therefore, I presumed that farmers have a lack of knowledge and interest in these topics. Contrary to this belief, the research showed that they do connect several difficulties with climate extremes and human-driven alterations. However, that awareness of these issues was converted into practical adaptation or mitigation activities only in a few cases. These are the redirecting of water from rivers (an action taken by the national park; i.e., not by the farmers) and changes to the timing of grazing. Although there was knowledge of and interest in climate, it was surprising for some farmers that the predictions of different models vary, even if the scenarios are based on scientific data. This stresses the need for ongoing education about climate issues.

The next Common Agricultural Policy (CAP) of the European Union will focus, among other things, on adaptation to climate change, good land management, and rural development. The current process of decoupling subsidies from the primary production is a prerequisite for increasing the adaptive capacity of managed areas. A greater appreciation of extensive pastures is needed throughout the European Union, including funding systems. In parallel, immediate action is needed to stop the massive trend of decrease in the area of grasslands in Hungary. Local-scale prevention and mitigation of climatic effects (such as establishment of shaded and forested areas, and ventilation in and insulation of stables) will significantly increase the costs of livestock keeping.

An improved dialogue between stakeholders at all levels and the provision of sufficient funding to implement different management approaches are recommended. As the maintenance of most nature conservation sites strongly relies on the collaboration of stakeholders, their active participation in the planning process of future management measures will serve both nature conservation and social and economic interests.

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