Matthias Krebs, Andreas Kaffke, Pim de Klerk, Izolda Matchutadze, Hans Joosten:

A future for Ispani 2 (Kolkheti, Georgia) and adjacent lands

International Mire Conservation Group Newsletter 2009/2: 3-14

Correction in references, p. 13:
De Klerk, P., Haberl, A., Kaffke, A. Krebs, M., Matchutadze, I., Minke, M., Schulz, J. & Joosten, H. (2009): Vegetation history and environmental development since ca 6000 cal yr BP in and around Ispani 2 (Kolkheti lowlands, Georgia). Quaternary Science Reviews 28: 890–910.

A future for Ispani 2 (Kolkheti, Georgia) and adjacent lands

by Matthias Krebs, Andreas Kaffke, Pim de Klerk, Izolda Machutadze, Hans Joosten

Introduction

The Kolkheti Lowlands constitute a region of global importance for biodiversity conservation, especially with respect to its mires and relict forests. It is the only warm-temperate region in the World where *Sphagnum* dominated rain-fed peatlands occur. This has led to the distinction of a special "Kolkheti Peatland Region" within Eurasia (Botch & Masing 1983, Succow & Joosten 2001), which is the smallest peatland region in the world.

The Kolkheti Lowlands has obtained this position because of the occurrence of a unique mire type: the *percolation bog* with special characteristics with respect to vegetation, micro-relief, hydrology, and peat stratigraphy. Until now, only two well-developed specimen of this type have been identified worldwide: the Ispani 2 bog near Kobuleti and the Imnati bog east of Lake Paleostomi. Ispani 2 was the first discovered percolation bog and has been intensively studied by the Department of Peatland Studies and Palaeoecology (Institute of Botany and Landscape Ecology, Greifswald University, Germany) and associated Georgian scientists (cf. Kaffke 2008, De Klerk et al. 2009). It may be considered as the "type locality" of this mire type worldwide.

Since its designation as Wetland of International Importance (Ramsar Site N°894 "Ispani II Marshes") in 1996 Ispani 2 is one of the two Ramsar sites of Georgia. Since 1999 the bog is protected in the Kobuleti Nature and Managed Reserve (KNR/KMR).

In the last years the condition of the reserve has substantially improved. The marginal zones that until some years ago were severely damaged by cow grazing have regained a full *Sphagnum* cover and invasive species are being suppressed. Also the rest of the mire is in good condition and shows even better the full characteristics of a percolation bog than when we 'discovered' it in 1999. These improvements are clearly attributable to the internal management of the last years, especially the exclusion of cow grazing. Also the tourist guiding provisions made in the framework of the ICZM project are a real benefit to the reserve.

Regretfully, the improvement of internal management has not been accompanied by a similar improvement in the external management. Directly outside the reserve some developments are being planned that may have a damaging impact on the bog: the privatisation and the intensification of land use in the agricultural area north and northeast of the bog, and the construction of a highway to the east of the reserve. Until recently the failing of adequate external management has not been so urgent because of economic collapse and consequent decreased environmental stress. But a country that is actively striving for economic recovery should have adequate instruments in place to safeguard its natural and cultural heritage. Only the establishment of a buffer zone with appropriate location and size to minimise possible damaging effects to the Ispani 2 bog from the outside can ensure its conservation on the long term (cf. Joosten 1997).

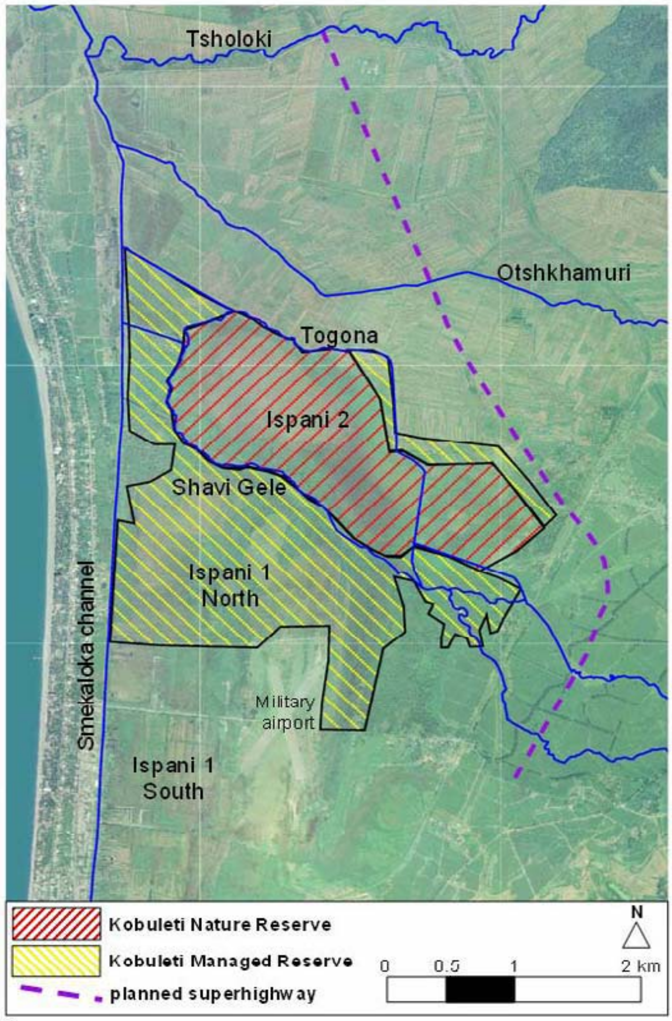

Figure 1: The Ispani 2 bog, its location in the Kobuleti Nature and Managed Reserve and the adjacent cultural land, the main rivers and channels.

This paper discusses the necessity and opportunities of establishing an ecologically effective buffer zone and combining its installation with strengthening eco-tourism in the region.

Characteristics of bogs

Water is the key component of mires and bogs (Ingram 1992) because only permanently high water levels enable peat accumulation. Bogs receive water and nutrients solely by atmospheric input (precipitation) (Proctor 1995) whereas their margins may additionally be fed by water from the mineral surroundings (Ingram 1995). Next to shallow water tables, little water level fluctuations are characteristic for the hydrology of bogs (Ingram 1992). As a bog is functioning as a hydraulic entity, disturbing the

hydrology of one part of the bog will have an effect everywhere else in the system (Ingram 1992).
A very close relationship exists between the hydrology, the peat and the vegetation of a bog (fig. 2) so that a change in one of the components will have an influence on the others. A change in vegetation by a higher nutrient supply, for example, will lead to other plant species accumulating another type of peat. This peat may – because of different mineralisation characteristics of the plant material – have a different porosity, a different permeability and a different storage coefficient, which again affects the hydrology (Succow & Joosten 2001).

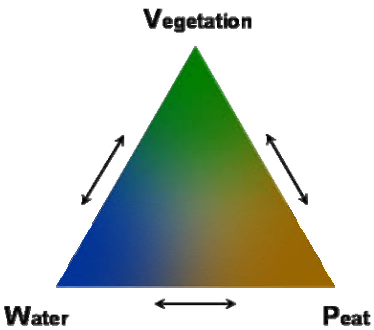

Figure 2: Relationships between water, peat and vegetation in mires.

Because a bog is only fed by precipitation, the nutrient concentrations of the bog water are generally very low. Bogs are acid and nutrient poor ecosystems, with nitrogen (N) or phosphorus (P) being the limiting nutrients for plant growth (Ingram 1992, Aerts et al. 2001, Bragazza et al. 2004, Malmer & Wallen 2005). The plant species in bogs are strongly adapted to these nutrient poor conditions and very sensitive to any increase in nutrient supply (Limpens et al. 2003).

The special character of Ispani 2

The Ispani 2 bog (N 41°51.9' E 41°47.9', 1.5–6.5 m asl.) is located near the town of Kobuleti (Autonomous Republic of Adjara) in the south-western part of the Kolkheti Lowlands on 1–3 km distance from the Black Sea coast (fig. 1). The bog (approx. 250 ha) consists of a 160 ha large open part, surrounded by a margin of alder (*Alnus barbata)* shrubland.
The Ispani 2 bog is an extraordinary bog (fig. 1 & 3). It shares many characteristics with 'normal' raised bogs, including its dome shape, its ombrotrophic (solely rain-fed) water and nutrient supply, and its acid and nutrient poor site conditions (Kaffke 2008, De Klerk et al. 2009). In contrast to all other bogs, however, Ispani 2 does not show surficial water flow and – as a consequence - no explicit microtope patterning (Couwenberg & Joosten 2005). Percolation bogs have no acrotelm with horizontal water flow like other raised bogs, but a predominantly vertical water flow through the entire peat body. Ispani 2 is the type locality of percolation bogs (Kaffke et al. 2000), i.e. it was the first mire in the world identified as a 'percolation bog' (Couwenberg & Joosten 1999, 2005, Kaffke et al. 2000, Haberl et al. 2006). Only two well-developed bogs of this type are known to exist worldwide, both in the Kolkheti Lowlands. The Ispani 1 bog south of Ispani 2 has probably been a third, but is currently strongly damaged. The Grigoleti mire might be a percolation bog in statu nascendi
The Ispani 2 bog has been subject to modest human impact only. It holds the last remnant of the original vegetation of the Kolkheti bogs before intensive land reclamation started in the first decades of the 20th century. Dominating plant species are *Sphagnum papillosum*, *S. austinii*, and *S. palustre* (fig. 3) (Joosten et al. 2003, Kaffke 2008). The vegetation further comprises amazingly few species, including *Molinia litoralis*, *Rhynchospora alba*, *R. caucasica*, *Rhododendron ponticum*, *R. luteum*, *Vaccinium arctostaphyllos*, and *Drosera rotundifolia*. This monotony makes the Ispani 2 bog to a paradigm example of low internal (α-) diversity that contributes substantially to global ecosystem (β- and γ-) biodiversity (Joosten et al. 2003).
Furthermore the Ispani 2 bog harbours - next to Tertiary relict species like *Rhododendron ponticum* – (sub)mediterranean, temperate, and boreal relict species (cf. Denk et al. 2001). A considerable part of its plant species is included in the Red Data Book of Georgia. The regular occurrence of *Sphagnum austinii* in Ispani 2 is remarkable because the species is since decades nearly absent from North- and Northwest- European bogs (Green 1968, Overbeck 1975) and also does not occur in other Kolkheti bogs (beside few individuals in the Imnati bog, own observations).
The Kolkheti bogs with up to 12 m peat (Dokturowski 1931, 1936) belong to the thickest *Sphagnum* mires of the World (cf. Nejštadt et al. 1965). With up to 4 mm yr^{-1} the Ispani 2 bog has an extraordinarily high peat accumulation rate (Kaffke et al. 2000, De Klerk et al. 2009).
All this illustrates the global significance of the Ispani 2 bog and the urgent need of its effective conservation.

Human impact on the Ispani 2 bog

Bogs are very sensitive to changes in water and nutrient supply. Recent research has shown that Ispani 2 had been substantially damaged in the 20^{th} century by land use intensification in the surroundings of the bog (Kaffke 2008, De Klerk et al. 2009).
The synchronous presence of man and mires over many millennia, and the fact that archaeological settlements have been found adjoining large mire complexes (e.g. under the Ispani 1 bog) point at a possibly intense interaction of human cultures with the development of the Kolkheti mires (Joosten et al. 2003). Ispani 2 suffered its first large-scaled anthropogenic changes in the late 19^{th} century by deforestation of its surroundings (Komakhidze 1996, Joosten et al. 2003). The wood, especially boxwood (*Buxus colchica*) and oak timber (*Quercus* spec.), was even exported to Germany, Great Britain and Belgium (Komakhidze 1996). This destructive land use is reflected in the name of the River Togona, which is bordering the Ispani 2 bog in the north. In Kobuletian dialect togona means "tree stump".

Figure 3: Natural, nearly undisturbed vegetation in the Ispani 2 bog: a good example of the original Kolkheti bog vegetation.

Hydrology

Huge impacts began with socialist agricultural development in Kolkheti since the 1920s (fig. 4). Wetlands were massively deforested, drained and converted to plantations of citrus, tea, and tung tree (Berg 1952, Kobulina 1974, Joosten et al. 2003).

The cutting down of forest in the close surroundings of Ispani 2 had a negative impact on the bog's hydrology, because it increased evapotranspiration from the bog (Edom & Wendel 1998). The forest had elevated the humidity of the air, lowered the regional temperature by evapotranspiration cooling, reduced the movement of airmasses and decreased wind velocity over the bog, and screened off radiation from the margins of the bog. The impact of forest removal on the hydrology of the bog can not be quantified, but the drier conditions probably promoted other damaging effects including fire and cow grazing.

The area north of Ispani 2 was in the 1920s for a short period used as a rice plantation, whereas the areas northeast of Ispani 2 were used for cultivating corn. North of the Otshkhamuri River vegetables like tomato were produced, partly in greenhouses.

In the middle of the 20th century the huge 'Kolchida' project started with reclaiming the Kolkheti Lowlands for agriculture (K. Kontselidze, Adjarian Department of Drainage, pers. comm.). In 1951 the first channels were excavated including the major South to North collector channel 'Smekaloka' west between Ispani 2 and the settlement of Kobuleti. The areas north of the Otshkhamuri River were drained in the 1960s. In the Ispani 1 bog (south of Ispani 2, fig. 1) a channel system was established at the end of the 1950s to enable peat extraction (Menagarišvili 1949) which in 1962 took place over an area of 37 ha (Report 2006 of the Adjarian Department of Geology and Mining).

Figure 4 shows that the meliorations and the intensive use of the areas surrounding Ispani 2 activities have resulted in an increased aeolian input of mineral materials into the bog. The lower boundary of the ash enriched top layer was dated to 1925–1929 AD, i.e. simultaneously with the start of the melioration works in the Kolkheti Lowlands (Berg 1952, Kobulina 1974) that made the vast opened-up agricultural lands to a source of dust input. The decrease in organic matter (fig. 4) and increase in the ash content in the peat (fig. 7) will have negatively affected the oscillation capacity of the mire, i.e. the major hydrologic self-regulation device of a percolation bog (cf. Haberl et al. 2006).

The establishment of the channel system draining into the Togona River (directly north of the Ispani 2 bog, fig. 1) also had a major direct impact on the Ispani 2 bog, in particular the excavation in 1956 of the channel through the eastern part of the Ispani 2 bog (fig. 1). The ineffective channels were deepened and broadened in 1974 (K. Kontselidze, Adjarian Department of Drainage, pers. comm.). The part east of the channel was totally destroyed by these and later meliorations and reclaimed for Bur Marigold (*Bidens tripartita*) cultivation (fig. 5).

Although a dam was erected to reduce direct drainage of the mire, the part west of the channel is up to the present day negatively affected by the channel. Up to a distance of several hundred meters from the channel (fig. 6) – i.e. over almost one quarter of the bog – conditions are too dry. This is not only apparent in the hydrology, but also in the vegetation and peat characteristics. The drier conditions lead to a higher incidence of fires. The affected area differs from the less disturbed parts by other and higher densities of vascular plant species, a lower peat moss cover, and the virtual absence of the rare and endangered peatmoss species *Sphagnum austinii*. The abundance of species indicating fire in the southeastern part of the Ispani 2 (fig. 6) shows that changes in the hydrological regime not only have local effects (Ingram 1992) but may affect huge parts of the mire and even the entire ecosystem (cf. Poelman & Joosten 1992).

It illustrates that changes in the hydrology of the surroundings of a bog (incl. melioration for agricultural purposes) may have a negative effect on the entire bog.

Despite these impacts the hydrology of the bog is still in a rather good condition (Kaffke 2008).

Nutrient input

The agricultural use of the surrounding areas had a major impact on the nutrient conditions of the Ispani 2 bog. The increase in ash content is accompanied by higher nitrogen (N) contents (fig. 7) and lower C/N values in the peat (fig. 4 and 7), indicating that the agricultural use of the surrounding areas also led to an increased nutrient supply to the sensitive Ispani 2 bog. The additional input of nitrogen and phosphorous from the adjacent fields lead, amongst others, to a substantial decrease of the rare and special *Sphagnum austinii* (a species almost extinct in Europe, Van Geel & Middeldorp 1988, Lee et al. 1993) and its replacement by more common *Sphagnum* species. The macrofossil diagram (fig. 4) shows how in the bog centre 4 m of *Sphagnum austinii* peat has accumulated over the last 1000 years, but that the top layer of the peat is dominated

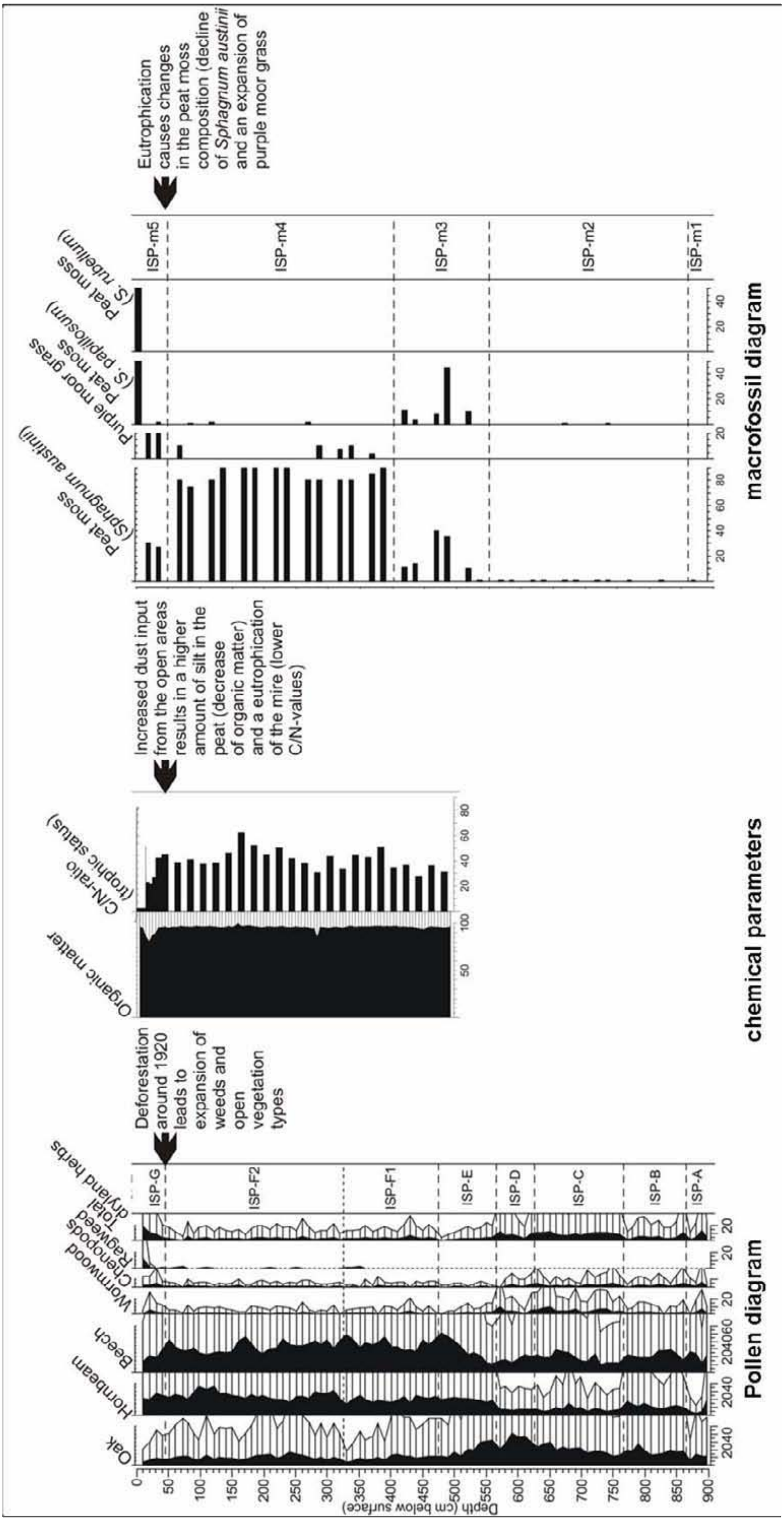

Figure 4: Pollen diagram of selected species compared with chemical parameters of the peat section and macrofossil diagram, with special attention to the time after 1920 (changed after De Klerk et al. 2009).

Figure 5: View of the destroyed eastern part of Ispani 2 with the invasive Miscanthus sinensis and without any peatmoss.

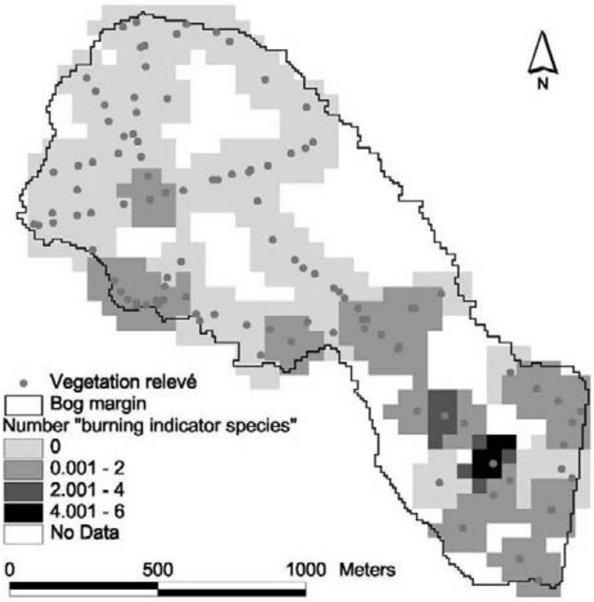

Figure 6: Distribution (50 x 50 m grid) of „burning indicator species" in Ispani 2. Species were counted within a 100 m radius around each grid cell. White grid cells lack relevés within the 100 m radius (Kaffke 2008).

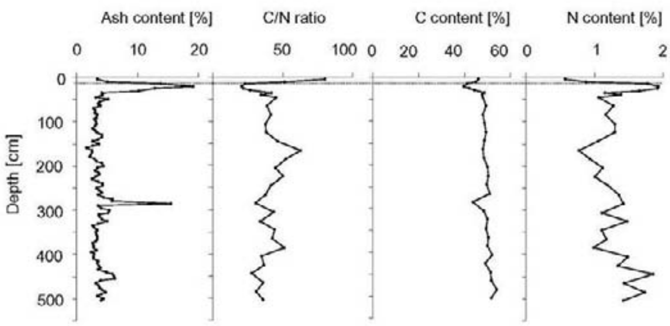

Figure 7: C/N ratio, ash-, C-, and N- content of a peat profile from the centre of Ispani 2 bog. The dotted line indicates the soil surface. The uppermost two samples originate from living vegetation (Kaffke 2008).

by *Sphagnum papillosum* (De Klerk et al. 2009). Furthermore the diagram shows increasing remains of purple moor-grass (*Molinia litoralis*) in the upper 50 cm. Purple moor-grass is promoted by higher nutrient availability (Limpens et al. 2003, Tomassen et al. 2004). Its higher densities again cause higher susceptibility to fires in the Ispani 2 bog (fig. 6, see chapter fire) and increased evapotranspiration (Schouwenaars 1990, Dierssen 1992).

Since the 1990s the situation has become better again as a result of decreased agricultural activities and improved management. Both a superhighway along the northeastern part and resumed agricultural land use north of the Ispani 2 bog after privatisation will, however, again deteriorate the nutrient conditions in the bog by the increased input of nitrogen from vehicle exhaust fumes and land fertilization.

Fire

One of the most important threats to the Ispani 2 bog is fire. It could destroy the last remnants of original vegetation and stimulates the expansion of untypical (non-Colchidean) bog species (Kaffke 2008).

Fires are caused by accidental/deliberate burning by hunters in spring and by spreading of fire from neighbouring fields where litter is burned after harvest. It destroys the dense peatmoss cover and harms the other natural vegetation (fig. 8). Less competition by the affected peatmosses and higher nutrient availability after fire promote the expansion of purple moor-grass (*Molinia litoralis*). Its higher coverage produces more inflammable litter and increases the water losses from the bog by higher transpiration (Dierssen 1992); a positive feedback resulting in higher susceptibility to fire. Furthermore, its increased biomass outcompetes the peatmosses by shadowing. As a result the main peat builder *Sphagnum* is affected, which will change the new accumulating peat and again affects the hydrology (cf. fig. 2).

Fires are frequent in the eastern part of Ispani 2 (where drier conditions prevail due to the adjacent channel) and furthermore everywhere in the bog where additional man-made nutrient supply has lead to higher densities of purple moor-grass (fig. 6).

The peatmoss species *Sphagnum austinii* is not only harmed by higher nutrient supply but is also sensitive to frequent fires (Daniels & Eddy 1985, Kaffke 2008). It consequently has nearly disappeared from the fire affected parts of the bog (cf. Kaffke 2008).

Wood cutting

Our research has shown that the stands of alder (*Alnus barbata*) at the margins of the Ispani 2 bog have been frequently cut since the 1980s (Kaffke 2008, De Klerk et al. 2009) (fig. 9). The removal of this forest 'filter' will have promoted the input of nutrients and the spreading of fire from neighbouring fields.

Grazing

A main threat to the mire also has been cattle grazing at the bog's edges (Krebs & Resagk 2002, Kaffke 2008). Especially in dry summers cows entered deeply into the bog. The most important effect of grazing is the trampling, which leads to peat compaction, increased surface water run-off, larger water level fluctuations, and consequently to a disturbance of peat accumulation. The strong influence of grazing on microtopography becomes apparent when comparing an intensively grazed with a non-grazed area (fig. 10). In intensively grazed areas the vegetation may be destroyed completely and "muddy ground areas" appear. This leads on the sloping margin to superficial run-off after heavy rains. In non-grazed areas surface run-off was never observed, even not after heavy rains (Kaffke 2008).

Recent situation

In the last years we have observed a substantial improvement in the condition of the Ispani 2 bog. This is attributable to the less intensive land use in the surroundings after the collapse of the Soviet Union and to the good management of the Kobuleti Nature and Managed Reserve. After cattle grazing was excluded in 2006, the margins of the bog have recovered spectacularly and luxurious *Sphagnum* growth is driving back the dominance of *Juncus effusus* and the invasive *Polygonum thunbergii* (Joosten 2007). The Protected Areas management has also stopped alder cutting at the margins and the bushes are becoming trees again. After re-growth of the marginal forest its filter function will help lowering the input of harmful nutrients. The lower incidence of fires is probably attributable to the fact that hunting is recently strictly prohibited in the Nature Reserve. Also the destroyed eastern part of the Ispani 2 bog has recently been included in the Kobuleti Nature and Managed Reserve (R. Moistrapishvili, Director of the KNR/KMR, pers. comm.). This opens the possibility of its restoration.

The Ispani 2 bog has thus benefited from the collapse of the Soviet Union and the consequent lowered intensity of agricultural land use. It is crucial to guarantee that the transition to market economy and the re-organisation of agricultural land use, including a privatisation of areas north and northeast of the Ispani 2 bog, will not again lead to unacceptable changes to the ecological functioning of the bog. A renewed intensified use of the lands directly bordering and hydrologically connected to Ispani 2 may bring again large threats to the unique mire, by impacts on its hydrology (the lands cannot be hydrologically regulated without affecting the mire) and by increased used of fertilizers and pesticides/insecticides. The current suspension of the privatisation plan offers a good opportunity to develop integrated land use options that will benefit all stakeholders and interests groups, including government, local population, tourists, and nature conservationists.

Figure 8: Fire damage on the peatmosses and other plant species in the Ispani 2 bog.

Figure 9: Cutting of alder (Alnus barbata) at the margin of the Ispani 2 bog

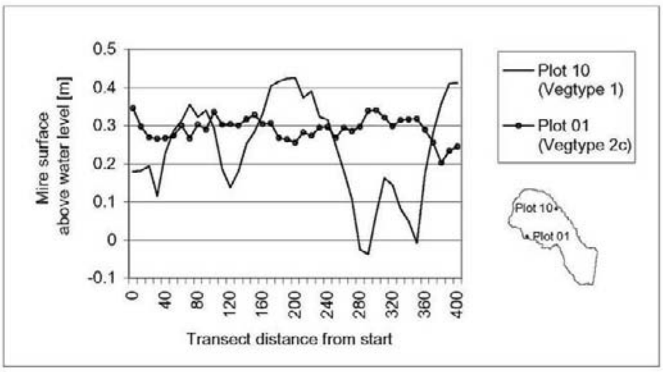

Figure 10: Microtopography of an intensively grazed (Plot 10) and a non-grazed (Plot 01) transect in the bog margin zone (distance in cm) (Kaffke 2008).

Buffer zones

The former damage to the Ispani 2 bog has proven that the area as such is too small for being effectively protected against impacts from the surrounding areas, which leads to conflicts between neighbouring types of land use. A society that takes nature conservation serious has to aim for a strict separation of incompatible interests (Van Walsum & Joosten 1994). This implies that it is necessary to install and effectively manage protective buffer zones between the Ispani 2 bog conservation area and the agricultural land. The buffer zones must fulfil different requirements (e.g. protecting against water losses and nutrient input) and must thus include adequate form, size and legal regulations to guarantee their effective functioning (BUWAL 1992, Turner et al. 2003, Van Walsum & Joosten 1994).

Such buffer zones must take care of (fig. 11):

1. Supply of all things the reserve *has to receive* from the outside world.
2. Disposal of all things the reserve *has to get rid off* to the outside world
3. Resistance against all things that the reserve *may not receive* from the outside world
4. Retention of all things the reserve *may not get rid off* to the outside world (Van Wirdum 1979, Van Leeuwen 1981).

Supply and disposal relate to the functions that the reserve *minimally requires*, whereas resistance and retention relate to what the system can *maximally cope with*.

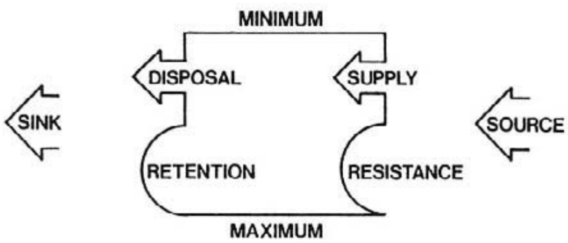

Figure 11: The basic four relationships of a system with its environment (modified from Van Wirdum 1979)

The following urgently needed buffer zones can be identified:

a) A genetic exchange zone to facilitate exchange of genetic information;
b) A hydrological buffer zone to minimize hydrological impact from the outside;
c) An immission buffer zone to reduce the input of fertilizers, harmful substance and noise.

The spatial extent of such buffer zones is shown in fig. 12.

a) The genetic exchange zone (BUWAL 1992)

This zone must facilitate the genetic exchange between populations of rare plant and animal species in order to maintain sufficient genetic diversity in the populations.

For Ispani 2 especially Ispani 1, south of Ispani 2, is important in this respect. The Ispani 1 bog is in its northern part still largely intact, shows similar habitats as Ispani 2 and is thus very important for ensuring genetic exchange with Ispani 2. It is already included in the Kobuleti Nature and Managed Reserve and can be managed accordingly.

The habitats north, northwest and east of Ispani 2 are strongly altered by forest cutting and agricultural use. Recently, the areas are fallow or are transformed into secondary meadow habitats with many invasive plant species. The re-establishment of Kolkheti forest on these lands would strengthen the forest plant and tree species in the currently too narrow tree and shrub zone surrounding Ispani 2.

b) The hydrological buffer zone (Edom & Wendel 1998, Joosten 1994)

Bog reserves need a hydrological buffer zone to shield the reserve from the negative effects of draining surrounding (agricultural) lands. Several studies have identified the extent of the surrounding area in which hydrological interventions may interfere with the water level in the reserve (Poelman & Joosten 1992). Depending on the local hydrogeological conditions and the approach followed, buffer zones widths have been proposed of 5-30 m wide (Turner et al. 2003), 30-80m wide for deep bogs, 120-150m wide for shallow bogs on a subsoil with fine sand (Eggelsmann 1980, Van der Molen 1981), 30-350m wide depending on subsoil and site (BUWAL 1992), and 2 km wide, like the hydrological buffer zone installed around the Groote Peel National Park peatland (The Netherlands). In the latter no further drainage and sprinkling from groundwater is allowed (Vermeer & Joosten 1992). Also an expansion of groundwater pumping for drinking-water-supply on a distance of 6 km of the reserve has been forbidden because of expected negative hydrological consequences for the bog reserve (Joosten 1994).

As the hydrology of the Ispani 2 bog has clearly been harmed in the past by changing the hydrology of the adjacent lands, it is relevant to recognize the importance of the Togona and Otshkhamuri Rivers for the hydrology of the Ispani 2 bog.

The type of land use between Ispani 2 and Otshkhamuri River determines the water management of river Togona, which directly borders the peatland. It is therefore crucial that the use of this area and therewith the hydrological management of River Togona is controlled and remain in public hands, preferably in that of the Protected Areas management. Only then lands and river can be managed according to the requirements of the Ispani 2 bog. In this area any kind of drainage should be forbidden.

To ensure the overall control of the hydrological regime of the Togona (and thus the peatland) it is desirable to have also control over the Otshkhamuri River and the channels north of the river draining into it. It is at this moment unclear to what extent the areas north of Otshkhamuri River determine the water regime and which drainage depths can still be allowed. This should be subject of further research, but until this question is satisfactorily cleared a policy of prudence should be followed. Furthermore, it is important to have control on the water quality and quantity of the Shavi Gele brooklet directly south of Ispani 2.

The forest that in former times surrounded the bog had an important function in preventing atmospheric water losses from the bog. The bog would certainly benefit hydrologically from restoring the forest north of the bog which would result in raising air humidity, and lowering wind velocity, temperature and incident radiation (Edom & Wendel 1998).

c) The immission buffer zone

An immission buffer zone is very important for bogs because these ecosystems are very sensitive to any kind of nutrient input, pollution and visual and acoustic disturbance.

Nutrients can be transported by air or water. Main sources are agriculture, industry and traffic.

The vegetation of Ispani 2 (and with that its entire character) has in the past suffered from nutrient input from the adjacent agricultural lands that were fertilized for the production of corn, rice and vegetables. For that reason professional agriculture with high nutrient application cannot be situated close to the peatland and should as a minimum be restricted to areas north of the Otshkhamuri River. This is important to prevent the atmospheric input of nutrients but also their transport by the rivers and channels to the bog.

Eutrophication and acidification of mires are also caused by atmospheric deposition of ammonia and ammonium sulphate from cattle and other domestic animals kept in high concentrations. Therefore intensive livestock breeding should be forbidden in the direct surroundings of the bog.

Since 1989, the already mentioned Groote Peel National Park peatland (The Netherlands) has a 600 m wide 'immission resistance zone' to reduce the harmful effects of atmospheric ammonium input. In this zone the establishment of new farms with intensive cattle husbandry and the expansion of existing farms are forbidden. In the same zone, conversion of grasslands into arable fields is no longer allowed without prior consent in order to maintain suitable forage areas for breeding, hibernating and transmigrating birds (Joosten 1994).

Fertilizing nitrogen oxides (NO_x) are also produced by traffic and industry. It is therefore important to plan motorways and industry as far as possible from the bog reserve. This also applies to the planned superhighway northeast of Ispani 2. In case of already existing constructions, legal regulations and mitigation measures must minimise their negative impact.

Also *pesticides* are transported by wind or water. The impacts of pesticides to the bog are difficult to assess. As pesticides are developed to kill, banish or block the development of certain plant or animal species and groups a negative impact of incoming pesticides on bog species is obvious. A buffer zone between the agricultural land and the reserve, in which the use of pesticides is forbidden, can minimize the input of pesticides into the bog.

Such buffer zone will also shield off fire sparks transported by wind from adjacent fields and thus decrease the incidence of fire in the reserve.

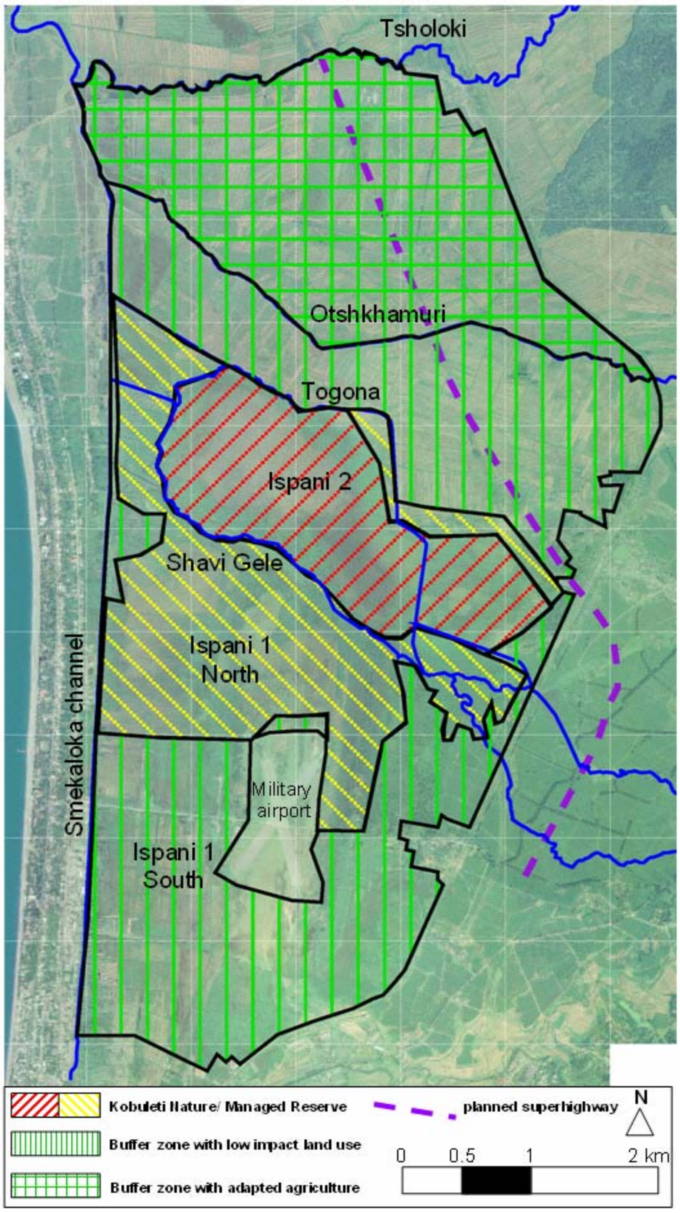

Figure 12: Location of the proposed buffer zones around Ispani 2 and the Kobuleti Nature and Managed Reserve.

The Ispani 2 bog as a Ramsar site is important for nesting and migrating birds that can (similar to visiting tourists!) easily be disturbed by *noise and visual disturbance*. These may especially be generated by the superhighway planned northeast of Ispani 2. Although its effect cannot yet be quantified, it is important to take these possible disturbances into consideration when planning the location and design of the motorway. Adequate buffer zones can to some extent shield off these disturbances. In case of Ispani 2 this can again be brought about by reforestation of the area between the road and the bog

Figure 13: Archaeological open-air museum Gross Raden in North Germany, reconstructing an ancient settlement from the 9th- 10th century (http://www.gross-raden.de/, 26.06.2009).

Location, design and management of buffer zones around Ispani 2

Buffer zones are essential to protect and maintain the Ispani 2 bog. But this does not imply that all use of these areas is prohibited and that they have to be transferred into unused wilderness areas. Land use should, however, be limited to forms that do not negatively affect the bog.

The location of the lands adjacent to the globally important Ispani 2 Nature Reserve and the easy access from the nationally important tourist centre Kobuleti open opportunities for synergies that few other sites in Adjara have. The development of the necessary buffer zone as a multi-functional use area will bring benefits to the local communities that may widely exceed their use as 'standard' agricultural lands and will substantially strengthen the attractiveness of the region for tourists, especially ecotourists.

The following low-impact land use can be envisaged in the buffer zone:

Ecotourism

- (Re-)establishment of Kolkheti wet forest on the most sensitive areas. This will enable tourists to visit and enjoy the two main characteristic Kolkheti landscape types – forest and mire – in one easily accessible location;
- Reconstruction of a prehistoric Kolkheti settlement with wooden houses and boardwalks in the newly growing forest with people really living there during the tourists season to show how ancient cultures in former times lived and worked with the forest and peatland (using reconstructed ancient tools for farming, gardening etc.). The reconstruction could be based on the archaeological investigations of the settlements Pichvnari and Ispani 1 (fig, 13).
- Creation of special products of the region e.g. cheese from water buffalos.

Reforestation

- Establishment of native fast growing tree species like alder in part of the area to satisfy the demand for fuel and timber of local stakeholders.
- Re-establishment of the former Kolkheti forest to support this globally unique forest ecosystem in combination with the recreation for tourists (see Ecotourism).
- Carbon sequestration and sales of carbon credits on the Kyoto Protocol compliance market (Clean Development Mechanism) and the Voluntary Carbon Market. There is a large interest in afforestation and reforestation projects for climate mitigation. Reforestation of the buffer zone areas areas (certainly with the substantial ecological and social benefits involved) would make a very attractive carbon project that could yield several thousands of euros (gross) per ha.

The reforestation areas would allow a promising combination of immission buffer zone, hydrological buffer zone and economic income in a synergetic way.

Grazing

- To do justice to the demand for cattle grazing land for the livelihood of local communities it is necessary to provide improved grazing land. Grazing is largely compatible with the requirements of the buffer zone, as there is no need for fertilizers or pesticides and periodic flooding is not so problematic as for other agricultural land use. Large areas north of and directly adjacent to Ispani 2 are regularly flooded (fig. 14), a situation that will only become more serious with climate change. Because of their height very close to sea level and the enormous and rapid water discharge from the mountains, only very expensive and energy-intensive water management will be able to fulfil the hydrologic demands of modern intensive agriculture. Such management would, however, severely impact the hydrology of Ispani 2.
- The maintenance of grazing lands would also protect the resting areas for migrating wader birds north of Ispani 2 (cf. table 1: List of observed birds).

Sphagnum farming

- Currently the perspectives of this new kind of agriculture that combines ecological and economic needs are investigated in the areas bordering the Ispani 2 bog. Sphagnum peatmoss is in high demand in Europe for special cultures (e.g. orchids, bromelias, carnivorous plants…) and is currently unsustainably collected in Chile and New Zealand. Because of its ideal climate, Kolkheti is extraordinarily suitable for the sustainable cultivation of Sphagnum, with large market benefits. Produced in large quantities and adequately prepared, it is ideal to supply greenhouses with the necessary substrates.

Table 1: List of observed bird species in the Ispani 2 bog and its surroundings (observations: Andreas Kaffke, Christian Gönner and Matthias Krebs, 2000-2008).

Accipiter gentilis	*Gallinago gallinago*
Accipiter nisus	*Gallinago media*
Alauda arvensis	*Grus grus*
Alcedo atthis	*Haliaetus albicilla*
Anas platyrhynchos	*Hieraaetus pennatus*
Anas querquedula	*Himantopus himantopus*
Aquila pomarina	*Ixobrychus minutus*
Ardea cinerea	*Lanius collurio*
Ardea purpurea	*Lanius excubitor*
Ardeola ralloides	*Luscinia svecica*
Asio flammeus	*Merops apiaster*
Bubulcus ibis	*Milvus migrans*
Buteo vulpinus	*Motacilla citreola*
Caprimulgus europaeus	*Motacilla feldegg*
Carduelis chloris	*Motacilla flava*
Chlidonias leucopterus	*Netta rufina*
Chlidonia niger	*Numenius arquata*
Circus aeruginosus	*Nycticorax nycticorax*
Circus cyaneus	*Oenanthe oenanthe*
Circus macrourus	*Pernis apivorus*
Circus pygargus	*Philomachus pugnax*
Coracias garrulus	*Plegadis falcinellus*
Corvus corone	*Porphyrio porphyrio*
Coturnix coturnix	*Porzana porzana*
Crex crex	*Rallus aquaticus*
Cuculus canorus	*Saxicola rubetra*
Cygnus olor	*Saxicola torquata*
Egretta alba	*Streptopelia turtur*
Egretta garzetta	*Tachibaptus ruficollis*
Erithacus rubecola	*Tadorna ferruginea*
Falco subbuteo	*Tringa glareola*
Falco tinnuculus	*Tringa ochropus*
Falco vespertinus	*Tringa totanus*
Fulica atra	

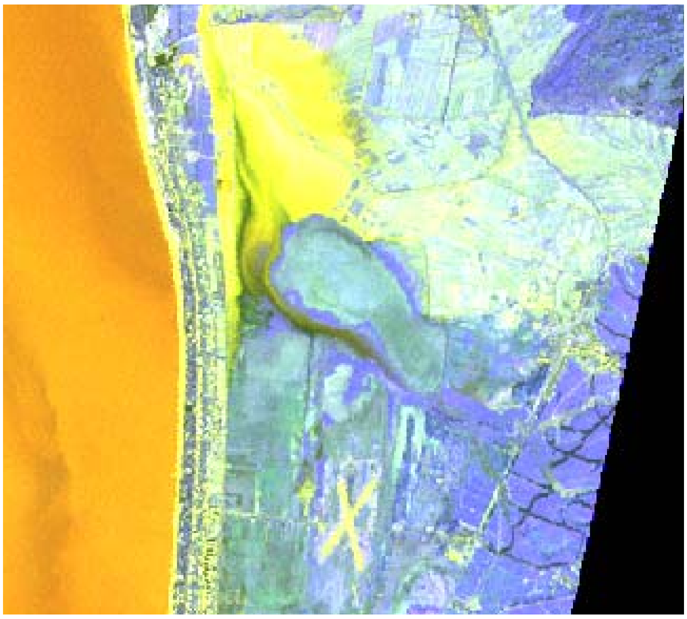

Figure 14: Satellite image of the Ispani 2 bog and its surroundings, showing the frequently flooded areas in yellow colour.

Conclusions

The peatland Ispani 2 is globally unique as the type locality of the 'percolation bog' and one of the only two percolation bogs known in the world. Furthermore, the bog is special because of its abundance of rare and relict species and the rapid rate of peat accumulation.

Recent scientific studies have revealed that during the 20th century the bog has substantially suffered from deforestation, reclamation, and exploitation of the surrounding lands. The established agricultural lands have negatively impacted the hydrology of the bog and have furthermore let to the input of dust and nutrients, hydrological damage, eutrophication, and a change in vegetation cover. From a nature conservation point particularly the decrease of the rare and sensitive *Sphagnum austinii* has to be mentioned.

Since 1990, the lowered intensity and abandonment of the surrounding agricultural land and a substantial improvement of the management in the framework of the Kobuleti Nature and Managed Reserve has enabled the bog to recover from the damage.

The further economic development of Georgia, Adjara and the region around Kobuleti should take the globally important natural and cultural heritage of Ispani 2 into account. Both the history of the mire itself as well as experiences from bog reserves worldwide show that the establishment of a buffer zone with appropriate location and size is necessary to minimise damaging effects from the outside and to ensure the conservation of the Ispani 2 bog on the long term.

The instalment of such buffer zone should not be seen as a restriction to economic activities, but as a challenge to developing new land use concepts. The prospects of combining nature conservation (buffer zone, nature development), sustainable land use (incl. afforestation, Carbon trade, *Sphagnum* farming, and grazing) and (eco)tourism (forest restoration, open air museum) in a multi-functional buffer zone around Ispani 2 are very promising and also economically attractive. Such integrated land use planning and management will diminish the inevitable conflicts between incompatible types of land use and will bring benefits to all stakeholders in a synergistic way. Parallel to similar projects in Western Europe, it would be elegant to establish such bufferzone as a compensation measure for the construction of the highway east of Ispani 2. The pilot character of such project will create a very positive image that will radiate far beyond the boundaries of Adjara and Georgia.

We hope that jointly with the Adjaran government we can further develop and implement these ideas.

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Route of the IMCG field trip through Georgia and Armenia, details here: www.imcg.net/09/imcg09dp.pdf