26 July 2007

ENGLISH ONLY

UNITED NATIONS CONVENTION TO COMBAT DESERTIFICATION

CONFERENCE OF THE PARTIES
Committee on Science and Technology
Eighth session
Madrid, 4–6 September 2007

Item 6 (a) of the provisional agenda
Programme of work of the Committee on Science and Technology
Priority theme: The effects of climatic variations and human activities on land degradation: assessment, field experience gained, and integration of mitigation and adaptation practices for livelihood improvement

The effects of climatic variations and human activities on land degradation: assessment, field experience gained, and integration of mitigation and adaptation practices for livelihood improvement

Submissions from Parties and accredited organizations

1. By its decision 20/COP.7, the Conference of the Parties (COP) encouraged Parties and all accredited organizations to prepare concise reports concerning the priority theme for discussion by the Committee on Science and Technology at its eighth session – “The effects of climatic variations and human activities on land degradation: assessment, field experience gained, and integration of mitigation and adaptation practices for livelihood improvement” – and to transmit them to the secretariat no later than six months before COP 8.

2. The secretariat has received three such submissions. In accordance with the procedure for miscellaneous documents, these submissions are reproduced[*] in the language in which they were received and without formal editing.

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ICCD/COP(8)/CST/MISC.1

GE.07-63107

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PAPER NO. 1: MONGOLIA

Submission on the priority theme for the eighth session of the Committee on Science and Technology

1. Introduction

Mongolia is considered to be the driest country within the region, with an aridity index range between 0.05 and 0.65 (calculated by data obtained from all meteorological stations during the last 40 year period). Only in taiga and high mountainous regions does the index exceed 0.65. Thus, taking into account the definition of desertification, as formulated by the UN Convention on Combating desertification, the territory of Mongolia is regarded as naturally susceptible to land degradation/desertification. Nonetheless, current natural resource use pattern, which mainly presented by nomadic pastoralism highly dependent from nature and environment, considered as a factor causing severity of land degradation. Therefore, desertification is one of the most serious environmental and socio-economic problems facing the nation this century. According to some studies, 70% of grassland has more or less desertified [National report on CBD, 1998]. In desert steppe and desert regions (occupy 41.3% and 56.6% of territory, respectively) severe and highly severe land degradation occurs [Adiyasuren, 2003].

Moreover, research results on grassland condition show that the yield of grasslands has decreased by 20-30 % in the last 40 years [Bolortsetseg, 2003]. With the degradation of grasslands, yield vulnerability of herds to drought and 'zud'' (harsh winter condition, considered in Mongolia as meteorological disaster) has increased also [Natsagdorj, Sarantuya, 2003; Natsagdorj, Sarantuya, 2004]. For these reasons, desertification has become a major ecological threat for the nation, affecting human safety, national security and development.

The Mongolian Government ratified the UN Convention on Combating Desertification in 1997, and elaborated its action plan where major concern made on establishing monitoring and control system, strengthening national capacity and developing public awareness. In 2003 the national action plan has revised putting the actions into a time-frame and elaborating indicators to measure its performance. Also, in newly updated version the main concern made on monitoring, considering it as a most necessary action. Moreover, National committee works in direction to integrate mitigation and adaptation practices to sustain livelihood in regions experiencing severe land degradation and desertification.

Accordingly, from 2004 the Academy of Sciences and the Institute of Geoecology implementing research on desertification dynamics and its future trend. This considered as a third nation-wide assessment on land degradation and desertification, which mainly focus on elaborating comprehensive methodology of assessment involving remote sensing methods as well as integrate spatio-temporal hierarchical approach to monitoring activities. Also, the University of Agriculture with support of Tokio University implements a project entitled "A Pilot Study in North-East Asia for Developing Desertification Assessment and Constructing an Early Warning System".

Furthermore, to mitigate effect of land degradation and integrate adaptation practices for rural livelihood programs and projects with technical and financial support of international donor organizations have been implementing. For instance, Rural poverty alleviation by IFAD, Sustainable grassland management by UNDP and Government of Netherlands, Combat desertification through Sustainable Land Management by GEF. Also, some other international organizations such as Swiss Agency for Development and Cooperation, GEF Small grant program, WWF program office in Mongolia and others running subprograms directed to mitigate the effect of land degradation on livelihood, promoting ecological education as well as on increasing public awareness in nature conservation.

2. Causes and impacts of desertification

Mongolia located remote from the oceans and seas in the center of EuroAsia continent. It is surrounded by high mountain ranges and elevated approximately on 1.5 km above sea level. All above-mentioned determines distinct continental climate with harsh and high fluctuation condition within days, seasons and years.

Particularly, the climate of Mongolia characterizes difference within 4 seasons, temperature fluctuation is high, precipitation number is low, and the altitudinal and latitudinal difference occurred.

According to researches annual air temperature in Altai, Khangai, Khentii, Khubsugul mountainous region colder than -4 degrees, of which in river watersheds and intermountain hollows it can fall up to -6-8 degrees. In desert steppes annual temperature is +2 degrees, whereas in southern gobi region it is slightly higher or +6 degrees. The isoline equal to 0 degree goes by transitional zone between mountainous and gobi region though 46 degree latitude. In a regions with mean annual temperature less than -2 degrees permafrosts are distributed [Natsagdorj, Tsevelsuren, 2000].

The amount of precipitation in Mongolia basically low, for instance mountainous region receives 300-400 mm, in Mongol Altai and forest steppes it vary between 250-300 mm, in steppes its between 150-250 mm and in deserts, desert steppes less than 150 mm. In a spatial distribution precipitation increases to the north and west direction which can be explianed by the barrier effect of mountains surrounding a country. In a timeframe 85 percents of precipitation fall in warm period of the year or between April and September of which 50-60 percents received in July-August months [Natsagdorj, Tsevelsuren, 2000].

According to the result of drought observation conducted in last 30 years period it can be concluded that drought occurs in northern part of the country once or twice in decade, when in desert steppe zone every one year of two has a drought condition. Also, in transition zone between steppe and desert steppe drought event appears once in three years (see fig.1). As a result of a difference in spatial distribution of atmospheric percipitation a risk of drought increases to the south and east directions coinciding with geographic distribution of the percipitation.

Fig 1. Geographic distribution of the drought frequency [Natsagdorj, Tsatsaral, Dulamsuren, 2002]

The drought index has high correlation with vegetation yield (r=0.86), thus doctor B.Jambaajamts have assessed a drought event using the vegetation index. Consequently, he created a map of drought severity over the Mongolia, where in northern part (Khangai region) frequency of drought is less that 1 percents, in steppes 20-30 percents and in desert steppes 30-60 percents. Thus, according to the research on vegetation condition in longterm shows that dought frequency in mountainous and forest steppe region 1-2 yers in decade, whereas in desert steppes and deserts every second year has drought.

The above mentioned results was compared with Cogan index calculated from satellite adat obtained from NOAA over last 22 years period. As a result, doctor M.Bayasgalan concluded that drought event in desert steppe region occurs one or two years in every three year period which is coincided with results obtained from groud truth data. Thus, implication of remote sensing for drought assessment can be promoted in Mongolia [M.Bayasgalan, 2006].

The impact of wind considered as a major factor of land degradation in Mongolia. Particularly, steppe, desert steppe and desert regon characterizes with windy climate with average wind speed between 4-6 m/sec. For instance, in Altai, Khangai, Khentii, Khubsugul mountainous region the average wind speed varies between 1-2 m/sec, and in other regions 2-3 m/sec. Observation of wind speed conducted in over 250 settlements in country shows, in one forth of them mean annual wind speed is more than 4 m/sec [Natsagdorj, Gomboliidev, 1999].

Deflation or wind blow out process starts with wind speed more that 4 m/sec, therefore researches on estimation of winds' duration have observed. Results shows, that duration of winds with speed more than 4 m/sec in Eastern Mongolia and Gobi region more than 4000 hours/year, in southern part of these region it increases up to 4000-5000 hours/year, but in northern parts and in Great lake hollow it is not exceed 1000-2000 m/sec.

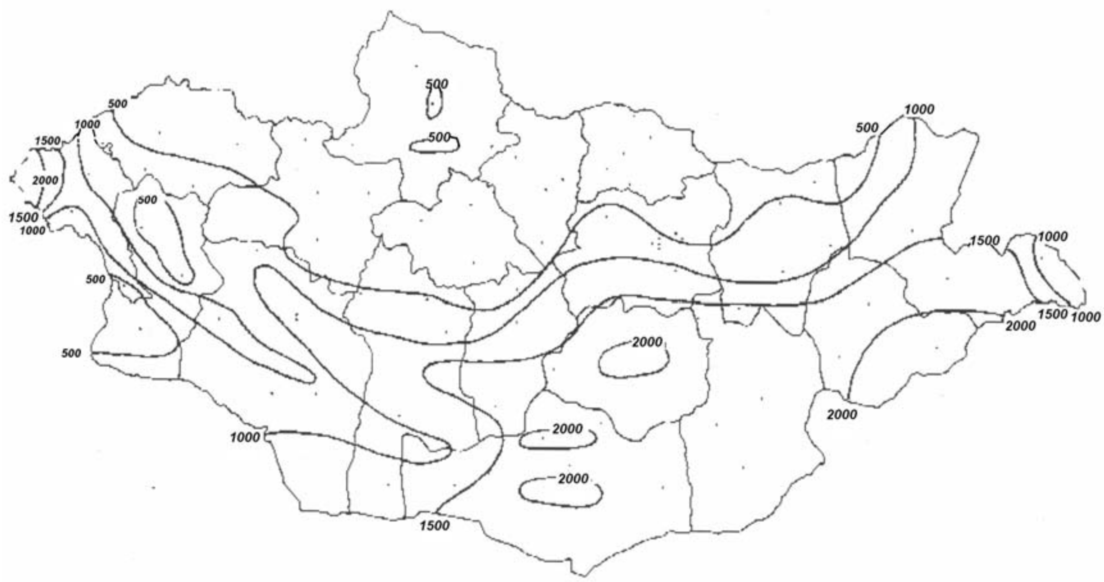


Fig. 2. Spatial distribution of wind duration with 8 m/sec (hours/year)

Moreover, duration of winds with spreed over 8 m/sec varies between 1500-2000 m/sec in Eastern Mongolia and Gobi region which determines wind erosion could be a major factor of land degradation for this region (see fig.2.). Meanwhile, in desert steppes deflation causing winds appears 17-23 percents of days in a year, but in northern parts and in Great lake hollow it apears less than 500 hour/year. Also, the field aerodynamic researches conducted in desert steppe zone shows that during the high speed winds totally 4.14 tons of topsoil transported by the wind anually [Lomborinchen et al., 1983; Mandakh et al., 2003].

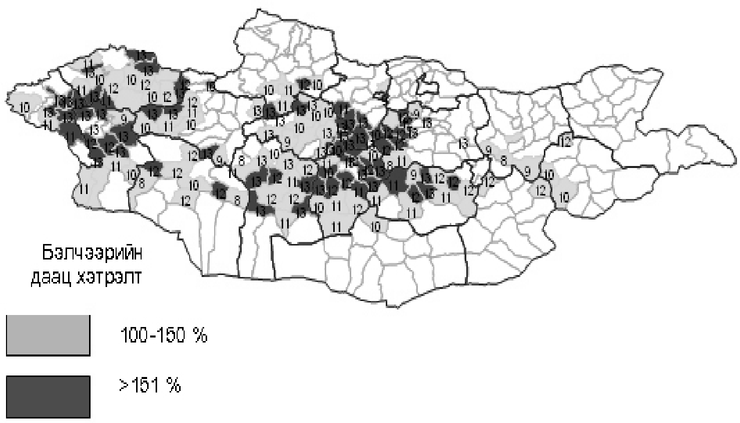
For centuries, Mongolia's herders were nomadic, roaming what is the world's biggest natural grassland in search of pastures for their animals — an approach that was environmentally sustainable. There was common access to land, and the herders lived in harmony with nature in this fragile and dry ecosystem in Central Asia.

Then, in 1921, the communist era imposed state ownership, with state-controlled collective farms (Negdel) and traditional community practices that had preserved the pasture and grazing lands were lost. The central government owned all livestock and pastureland, herders belonged to collectives, and the state determined their nomadic wanderings and provided their supplies.

Yet another change occurred in 1990, when the 69-year communist regime came to an end with democratization and decentralization. As the herds were privatized, the number of herding families almost tripled and the number of herding animals rapidly increased from 25 million in the early 1990s to 34.8 million by the year 2005. To compound the problem, the herders stopped roaming as much as they used to, with the richer ones living close to their winter and spring shelters for the entire year. The result of all these various changes has been serious overgrazing and environmental degradation.

Overgrazing is also causing rangeland ecosystem degradation in this part of the world. For example, livestock population in Inner Mongolia was 9.2 million in 1947 [Chen, S., 1996] and reached 62 million by 1998 [Orenchi S., 2000]. However, the total usable pasture decreased from 88 Mha in 1947 to 63 Mha at present [Chen S., 1996; Enkhee J., 2000]. These 63 Mha of natural grassland can feed 44.2 million sheep units, and corn leaves and other fodder can support additional 10.5 million sheep units totaling 54.7 million sheep as maximum capacity. However, at present there are over 85 million sheep units. Grazing pressure has increased for the central and western regions of Mongolia during the recent decade, especially in Arhangai, Bayan-Olgii, Uvs and Hovd aimags by 50%-100% [Tserendash S., 2000].

Historically, pasture carrying capacity have decreased year by year, especially visible change occurred in period of 1995-1998. At the national level total pasture carrying capacity according to climatic condition can be 67 million herds in relatively humid years and 55 million herds in drought occurred years [Bolortsetseg, 2002; Tserendash, 2000; Jigjidsuren, 2005]. In and average pasture carrying capacity is not exceeded in Mongolia and only 89% is used. Temporally, pasture carrying capacity was stable during the period of 1986-1994 and become increase from 1995. Research results shows that pasture carrying capacity have exceeded by 3-7 million herds in 1999, 2000 years, in other period its pressure not exceeded. Thus, accordingly to the climatic variations pasture carrying capacity changes and for now it is decreasing due to overall drought condition occurred in period of last 5 years.



Note: in numbers the number of years with pasture carrying capacity excess has reflected.

Fig 3. Pasture carrying capacity exceed rate (1986-2001)

In period of 1986-2001 pasture carrying capacity exceeded in 145 soums of which in 73 soums by 150 percents, in 18 soums by 200 percents. Moreover, studies have shown that continuous grazing in the same pastureland can be much more damaging than a rotational system of roaming herds. Dense and stationary herds of grazing livestock can stop grass from growing altogether. In addition, once the pasture and soil in this windy grassland region is severely damaged, desertification can quickly set in. Indeed, Mongolia’s own National Environmental Action Plan warns that the Gobi Desert in the country’s southern region may be advancing northward by as much as 500 meters per year. In 2005, the Institute of Geoecology conducted research on mapping process of land degradation/desertification taking into account all above mentioned factors as well as estimating human pressure on environment (see fig.4.).

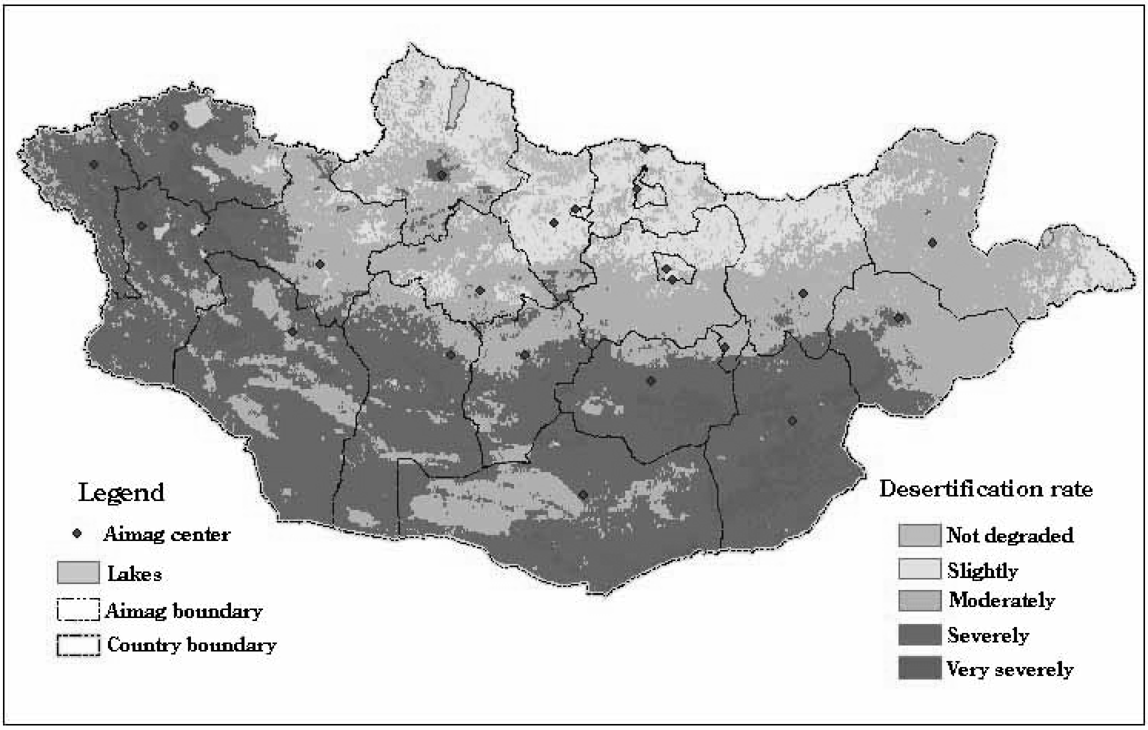


Fig. 4. Map of the state of land degradation/desertification, 2005

According to the map the land degradation/desertification process occurred on 80 percents of the territory of which irreversibly degraded desert steppe regions mainly located in western and eastern parts of Gobi. Totally, 47 percent of the territory have severely desertified, which involving the Government to take a great attention on nature resource management issues.

Table 1. The state of desertification

Desertification rate	Area, thousand sq. km	Area in percents
Not desertified, water bodies and natural forests	23.63046	1.509934
Slightly	215.4008	13.76363
Moderately	582.5499	37.22364
Heavily	633.3666	40.47071
Very heavily	110.0523	7.032094

The traditional pasture rotation system has lost during the social transformation due to some people have less than 100 herds they tend to stay in same place for over the years. Thus, land degradation issues near water wells, spring and winter places, along the major roads and surrounding aimag, soum centers have drastically increased. Such an extreme situation has been in center of discussion not only on the national but also on the international level. Therefore, developing co-management with implementation community-based environmental management approach and restore traditional way of nomad pasturing has been necessary.

Currently the process of transition to the market economy is ongoing in Mongolia. After privatization of the livestock its composition and structure has changed significantly. Thus, traditionally the ratio of sheep and goats in Mongolia has been 1 to 3. At the moment this ratio equals to one to one meaning that the number of goats has increased for the previous 10 years 2.1

times as compared to the period before the livestock privatization. Consequently, 80% growth of the livestock for the previous 10 years has been achieved by the growth of goats. The latter is connected with the increase of prices for down. The number of camels has reduced 1.8 times for that period and accounted for the number of camels in 1918. The tendency for reduction of sheep and cows is also present.

In the future situation may not be different from the present. In other words, in the composition and structure of the livestock the number of goats and sheep will prevail. Moreover, there is probably the number of livestock in the country will increase, which means the pasture carrying capacity may exceed in most places.

However, there is some positive view on a future of Mongolian grassland, which will directly relate with future Government policy implementation. In this case Mongolian government has to increase tax for livestock and introduce tax for pastureland use. Later have to finance the restoration activities in degraded pastures. Another major factor for gain positive results is to implement decentralization policy in all business spheres. Establishing nation wide market place in already defined economic zones can solve the problem of centralization and decrease pasture pressure in certain areas in a central part of Mongolia surrounding major cities.

Moreover, the development of bioengineering science especially in field of breeding high qualitative livestock can decrease pasture pressure in long term. For this Mongolian government as well as the relevant institutions and research organizations have to pay more attention on technology and knowledge transfer, which is not sufficient in rural currently.

Desertification is a process which has socio-economic feedbacks. The human interaction with nature leads to desertification. In Mongolia the human impact on desertification is not so high so, we have not included it to this report.

The main socio-economic impact of desertification is a loss of economic value of traditional pastoral production due to decrease of pasture yield. A survey shows that Mongolia's pasture lands, especially those in the central regions of the country, are under serious threat of desertification due to overgrazing.

According to the survey conducted by the Mongolian Ministry of Food and Agriculture, the average number of livestock per 100 hectare of grazing land has reached 56 from 43 in 1990. The increasing migration of herder families' to regions closer to urban areas, where they sustain their lifestyle based on animal husbandry, also accelerated the degradation of pastures.

Around 50 percent of the Mongolian population reportedly depends on income generated by animal husbandry, a sector claiming 30 percent in the nation's GDP, or 90 percent in national agricultural production. Due to the natural disasters such as drought and ‘zud’ and related with them decrease of pasture yield have increase mechanical migration of the population to the cities and towns. According to the annual statistic report over the 1200 people have to migrate from the countryside to the towns and cities. Those increasing of unemployment in the cities have reached disastrous rate, currently.

Due to the lack of alternative income generation activity most of poor going for the mining or other hard working activities. The WWF pro-poor investigation showed that the implementation of community based natural resource use management is the one way to tackle desertification and increase social status of rural.

3. Desertification research and management programmes of the Mongolian Government

The extent and pattern of desertification varies within and between counties and continents and, according to the UNEP global assessment, territories with ‘severe’ desertification occupy area minimal area. But there is still a need for more research and surveys to assess factors causing severity of process due to unknowing the root of desertification somehow have negative impact on planning and implementing countermeasures. Therefore, in current stage of development it considered to pay attention on rehabilitation of degraded land and sustainable management of land use. The rehabilitation measure should come from deep analysis of factors causing it and the planning should consider economically effective and sustainable in timescale.

Human activity often considers as a factor of desertification. Thus, first of all it is necessary to arrange activities through policy regulation and decision making. Therefore, the aim of combating desertification activities is to analyze the current development strategy, ensure sustainable development policy is developed, and law enforcement takes place.

However, the rational policy environment can ensure the capability of rural as well all stakeholders to initiate and implement activities directed to sustainability. Establishment of proper socio-economic rules of development and increasing participation of rural community in a process of development can be helpful to increase their interest and involvement as well as share with experience ad lessons learnt.

Finally, the government policy on combating desertification should consider sustainable development concept accepted worldwide, promote rational use of natural resources, ensure conservation of terrestrial ecosystems, initiate programs directed to solve ecological problems in equal to socio-economic development, and guide through integration processes [Sarantuya, 1999].

During the last decade Mongolian government paid great attention to ensure environmental sustainability, for instance policy documents have been revised taking into account issues on rational use of natural resources as a major part of nature conservancy. In relatively short time period the kit of law related with nature and environment has initiated and ratified establishing a new subsystem in a law structure. But with the socio-economic development some of laws and policies are losing their meaning to ensure sustainable development in modern time. Thus, it is necessary to analyze current laws and revise them in a way to regulate newly formed relations [Ecosystem sustainability assessment, 2005].

With increase of natural resource use the problem of law violation have increased, which shows on weakness of law enforcement in one case. Another is related with low transparency within regulation and implementation as well as weakness of laws and their content. In other word, the current law system on environment did not meet current socio-economic and environmental needs.

In a framework environmental law revision it is necessary to consider other related laws and policies which directed to regulate socio-economic relations. Moreover, it is necessary to implement law enforcement program through organizing workshops, seminars and trainings to educate and promote law knowledge in community level.

Thus, from 2003 with technical and financial support from international donor organizations varies projects, especially directed to conserve pastures, promote sustainable livelihood in rural as well as strengthen public awareness in nature conservation have implemented. Most of those project objective can be defined as implementing sustainable grassland mangement, promoting alternative income generation to sustain rural development and reduce pressure on environment, thus ensuring environmental sustainability.

Moreover, from 2005 Mongolian government ratified national program on agroforestry development entitled Green Belt. The objective of this program is to create an ecotrass by planting trees in the transitional zone of the Gobi and steppe regions in an attempt to reduce the "present intensification of loss of forest reserves, desertification, sand movement and dust and sand storms, caused by climate change and inappropriate anthropogenic activities" (MNE, 2005). The Green Wall will extend for 2,500 kilometers from the east to the west of the country, with a width of at least 600 meters, covering 90,000 ha, and will be planted with a mixture of *saxaul* and other species such as elm (*Ulmus* sp.), poplar, willow, and *tamarix*. In this context of increasing interest in, and funding for, planting initiatives, this study evaluated the success of planting sites planted in recent years.

Finally, the main policy of Mongolian Government to tackle desertification directed in two ways developing agroforestry concept as one priority, and improving pasture management.

3.1 *Programmes targeting pasture management*

Pastures are used as a common resource and the individual management is not in line with the current grazing patterns, where neighboring herders are dependent on the same water and grassland resources. Therefore, since its inception, we are paying a proper attention on community-based grassland resources, which supports the formalization and strengthening of existing informal herder groups.

Presently, the herder groups are being evolved as a non-government organizations (NGO) and/or cooperatives, which provide them the right to deal legally with third parties. At early stage of group development, there was a trend to form non-government organizations (NGO), which allowed them to get a small and medium loan or to create user contracts for pastureland between community and Soum Governor. As community starts to run a more business activity (vegetable growing, fodder production, wool and dairy production), there is a need for herding groups to become a cooperative because of common ownership due to individual contributions.

Nowadays, herders became more business oriented and initiating different activities to generate their income, such as wool and dairy processing, boot making, fodder production, dairy farming. And in every case the projects and programs targeted to sustaining the communities providing technical as well as financial support.

One of the main objectives of pasture management activities is to utilize of natural forage plants in full capacity, develop methods and technologies to prepare fodder, especially prepare new kinds of fodder out of unpalatable plants, introduce results of experiments to livestock husbandry practice and train herders.

Within the scope of increasing fodder reserves for herders, the following activities were prioritized:

- Training of herders in forage preparation methods based on locally available resources.
- Preparation of silage from unpalatable plants.
- Support of forage production of herder groups with good forage resources

Moreover, recently many crop fields are being abandoned, resulting unpalatable plants grow on abandoned fields which make it impossible to use as pasture again. Therefore, in order to rehabilitate abandoned crop fields into pasture and hay field experiments of reseeding with perennials have been undertaking. The experiment is done in abandoned crop fields mostly located in forest steppe zone. This method can be explained as following:

- In spring the soil ploughed by 22 cm in depth and processed by disc and needle harrows
- Before reseeding the soil harrowed again in order to keep moisture and to cut roots of weed.

Precipitation levels and temperatures strongly affected germination of seeds. In some places 25 mm of precipitation had positive effects on seeds' field germination. However, some plants have dried and their growth stagnated in places where there was no rain and air temperature was mostly +25+30° C for 40 days after germination. Thus, it was recommended to perform artificial watering during the germination period.

Furthermore, to reduce effect of drought in southern part usually in spring, early summer period artificial raining activities have been implementing.

3.2 Programmes researching and implementing the physical remediation of degraded lands

Experiments on prevention of pasture degradation and rehabilitation of already degraded pasture, which has such dominant unpalatable plants as *Artemisia*, are being done in three main directions. First, burning of weed, second, cutting weed in early stages of growth, and third, cutting weed before seeds are ripen. The method of rehabilitating pasture through burning and cutting unpalatable plants has not been used in Mongolia before.

Experiment on burning weed on pasture near winter camps have tested in certain parts on the country. According to research on seasonal pasture reserves" of 2004, winter pasture in some soums had not been rotated for many years and thus, has become heavily degraded with predominantly weeds (*Artemisia adamsii, Artemisia commutata, Artemisia scoparia*). Therefore, herders are experiencing deficit in winter and spring pasture and less possibilities to rotate their pasture. Naturally, livestock does not eat such weed plants when it is green, and moreover, in winter its stem becomes thick and hard making it difficult to eat. However, it is more suitable to feed livestock after *Artemisia* is cut and pound. Thus, in order to increase reserves of winter-spring pastures, an experiment to burn unpalatable plants was conducted in April before plant growing period. Burning of weed on pasture has never been practiced before. Results of burning showed that place with flat litter (bottom parts of plants) burn better than those with sparse vegetation and less litter. On areas where weed did not burn completely weed plants started to grow from end of June, while no weed grew on spots where weed was completely burned out.

Experiment on cutting weed on degraded pasture was conducted in two variations nearby the summer camp in some parts. In first half year around May 10 when plants were in shooting and branching stages herder's group cut weed on 20 ha of pasture. Weed did not grow on this field until July, which shows that cutting could be an efficient method. We consulted and agreed with herders to use cut weed for livestock fodder during winter. The double advantage here is in experimenting cleaning pasture from weed and using it for livestock fodder.

Also, the experiment on increasing hay yield methods on fencing, fertilizing and irrigating pasture, and rehabilitating abandoned crop fields into pasture have been implementing. Currently the experiment fencing of natural hay fields with good yield for sustainable utilization of hay implementing in different zones of Mongolia. As result, it is suitable to fence one side of hay fields that were protected from three sides by mountains, rocks or forests which allowed protection of wide areas cost-effectively.

The fenced abandoned crop fields sowed with perennials also tested as an alternative method for land reclamation. This creates favorable conditions for germination, protects from livestock trespassing, protects seedlings, and is directed towards producing hay in future years. Perennials are special in that already after 2-3 years it is possible to produce seeds and fodder. However, fencing of fields sowed with perennials and of improved hay fields is costly, it is significant in making the abandoned land economically viable and turning it into stable hay field that could be used for many years in future.

In a framework of Green belt program afforestation in 3 sites 5–7 have implemented and are managed with expert advice from the Institute of Geoecology (Mongolian Academy of Sciences). All these sites had fences that were adequate to exclude livestock. Also, the permanent wells have drilled, which pump groundwater from 50 to 100 m to water taps every 50 m.

In the first year after planting, the success rate of all the projects was very high, with a minimum reported survival rate of 70 percent. The survival rate is decreasing from the second year of plantation. A major reason for the high mortality rates of the saxaul seedlings is that the growth of a normal taproot may inhibited by the shape of the nursery seedling container. Consequently, the seedlings easily dry out shortly after planting. However, after the trees have established a sufficiently extended root system, they are extremely drought resistant and can survive without precipitation for more than a year. Species like Siberian elm and poplar, which are planted in the Green Wall program, need to be hardened off in their juvenile growth stages in order to adapt to the arid conditions, meaning that the amount of water supplied at least twice a week is slowly reduced. But irrigation is required for at least three years. The removal of groundwater in large quantities can be contradictory to the initial aims of the Green Wall program, thus accelerating the already observed lowering of the groundwater table in southern Mongolia. The transpiration of the trees will lead to a further lowering of groundwater. The second major cause of failure is due to grazing by livestock. As reported by other authors [e.g. Walter and Breckle, 1986] and also as indicated by the results of this study, *saxaul* grows easily from its stumps. This is probably an adaptation to browsing, as the tree is often the only source of green biomass in arid regions. However, seedlings are vulnerable and must be protected if the planting initiative is to be successful [Lessons from tree planting initiatives, 2006].

4. Lessons learnt

The land degradation issue has become more serious in Mongolia, and in order to maintain sustainable development it is necessary to establish sufficient mechanisms to respond to all negative impacts. The main factors of land degradation affects Mongolia are:

(i) Environmental degradation under the influence of Global change

(ii) Unsuitable nature resource use practice.

As it mentioned before Mongolian economy mostly dependant from agriculture, especially animal husbandry, thus to ensure environmental sustainability in a country development it is need to establish strong cooperation among the agriculture and other socio-economic activities to the environmental protection strategy. Moreover, it is necessary to gain transparency within the sectors as well as to link projects and programs implemented in different sectors to the environment. In case of Mongolia most of the activities implemented through the technical and financial collaboration with international donor organizations, therefore it can be suggested to establish an comprehensive methodological approach and indicator system to evaluate the projects progress as well as integrate the best practices for further their implication in other regions as well as sustain results gain from the various activities.

Planning and implementation practical actions on rehabilitation and combat desertification depend on current state of environment as well as on deep knowledge about factors affecting this environment. A conservation and rehabilitation activities should consider following points:

- Land use planning: directed to regionalize territory according to the specifics of production and industry sector ensuring decentralized development directed to diverse income generation;
- Methods to prevent desertification: rational use of pasture, conservation and sustainable use of forest and other biological resources, maintain water supply, establish early warning system for prevent pest insect distribution, forest and wild fire and other disasters;
- Establish network of specially protected area: to conserve biological diversity and protect species threatened by land degradation and desertification and promote sustainable management in pilot area it is recommended to establish SPAs in some hot spot area.
- Establish combating desertification management system: the system should be response for conservation and rational use f natural resources, establish suitable legal environment, train and educate rural decision makers as well as community in environmental protection issues, operating early warning system and information sharing;
- Agroforestry: train rural to plant naturally adapted tree species to prevent land degradation as well as to plant cash trees to promote alternative income generation supporting poverty alleviation strategy. Moreover, gardening in urban area, establishing windbreaks for fixing sand are proposed.
- Reduce desert encroachment: to prevent sand movement and related disaster apply appropriate methodologies in agriculture system.

- Water harvesting: regulate water flow, decrease evaporation, water harvesting through establishment of micro and macro catchments.

Lessons learnt from recent developments shows that the following strategies should be performed to implement sustainable nature resource management ensuring environmental safety:

(i) Due to overall environmental change caused by global change it is necessary to elaborate more comprehensive, climatically and environmentally sound agricultural methods. Especially it is needed to innovate soil cultivation techniques.

(ii) To sustain grasslands and decrease pressure it is need to decrease number of animal in certain area accordingly to natural pasture carrying capacity. Currently, in central parts of Mongolia, which falls to the steppe zone experiences huge pressure on grassland ecosystem. So far, the projects implemented in this region have not yet solved this issue. For now, it is needed to experiment farming practice involving herders to decrease their livestock up to its suitable condition and increase the genetically valuable livestock. Thus, ensuring sustainability not only in environment but also in socio-economy of rural. More over, it is need to conduct preliminary assessment of nomadic and settled livestock farming difference, its suitability to Mongolian pasture condition.

(iii) Establishing herders' groups, cooperation and other legal bodies should directed to increase herders participation in rural development planning. Moreover, such social structure should strengthen transparency between government strategy and community as well as develop information sharing among all level stakeholders.

(iv) Through last 5-year period Mongolian Government seeking a way to raise responsibility of herders for their pasture condition and one of this might be to establish ownership on pasture land. Thus, in light of increasing pressure on pasture and demand on forage production the projects and programs implemented in the country should link their activities to develop more suitable legal environment on grassland ownership action.

Consequently, it is need to develop the multi-disciplinary, ecologically-sound rehabilitating approach. Experience with tackling desertification projects, such as Green wall, in Mongolia should be increased through targeted research on long- term study plots, and the collation of data from comparable sites outside Mongolia. To design such programs, it will be necessary to determine the major causes of land degradation as well as the social and ecological baseline for the region. This should be studied in the context of the impacts of different types of land use, which are part of the ecosystem dynamic.

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PAPER NO. 2: BULGARIA

The effects of climatic variations and human activities on land degradation: assessment, field experience gained, and integration of mitigation and adaptation practices for livelihood improvement

Introduction

Particular attention has been paid during the recent years to the need for a stable land policy, aimed to preserve natural resources. This has been dictated by the significant role of land and soils in the current global environmental and socio-economic conditions changing in response to industrial development and climate change.

Soils are among nature's most important resources and are the basis for existence for humans, animals and plants. In natural or managed ecosystems soil performs definite functions, namely: sustains plant and their productivity; regulates and partitions water flow; stores water and acts as a buffer of the environment through immobilizing and destroying toxic substances. Soil sustains gene reserve and is a habitat for many organisms. It is a physical medium of socioeconomic structures, source of raw materials and protects geogenic and cultural heritage of human.

The development of sustainable farming systems that satisfy the current and the future needs of humanity by long-term preservation of soil functions require knowledge of the limitation and the potential for the use of soil resources. Soil degradation is a damage and/or deterioration of the soil which has adverse effect on one or more of its functions. The causes could be natural and/or human induced.

1. Degradation of agricultural soils

The combination between specific natural and agricultural conditions in Bulgaria creates the prerequisites for high risk of occurrence of soil degradation in agricultural lands.
The submitted data provide information about the status, the development and the forecasts about the distribution of agricultural land degradation in Bulgaria, highlighting the main threats identified as priority - soil erosion, soil contamination, reduction of organic substances in soils, loss of biodiversity, salinization, acidification, compaction. The characterization of these threats involved summarizing of data from annual reports on soil and land conditions, statistical year-books, reports of the European Soils Bureau and publications in specialized scientific publications such as monographs, magazines and proceedings.

1.1. Soil erosion

Soil erosion is a phenomenon, associated with a series of natural and/or anthropogenic processes of detachment and transfer of soil particles by wind, rain and irrigation waters. Erosion causes reduction of the depth of the root layer, reduced amount of nutrients and available moisture in the soil; exhaustion of the filtering and buffering capacity of the soils; decrease of the organic matter in the soils; loss of biodiversity; degradation of the soil structure and soil crust formation; distribution and accumulation of pollutants in water flows and in the sediment accumulation zones. The natural and economic conditions in Bulgaria create conditions that favour a wider distribution of water, wind and irrigation erosion of soils.

<u>*Water erosion*</u>

Models forecasting the factors and intensity of area water erosion that have been validated and adapted to the conditions in Bulgaria were used as the basis for a mathematical model for evaluation of the risk of area water erosion according to which the potential for area water erosion of soil exceeds 100 t/ha y for 10.4% of the country's territory (Figure 1), 19.5% of the soils are at risk at a rate of 40 to 100 t/ha y, 31.7% – between 10 and 40 t/ha y, and only 25.9% of the soils are at risk for less than 20 t/ha y.

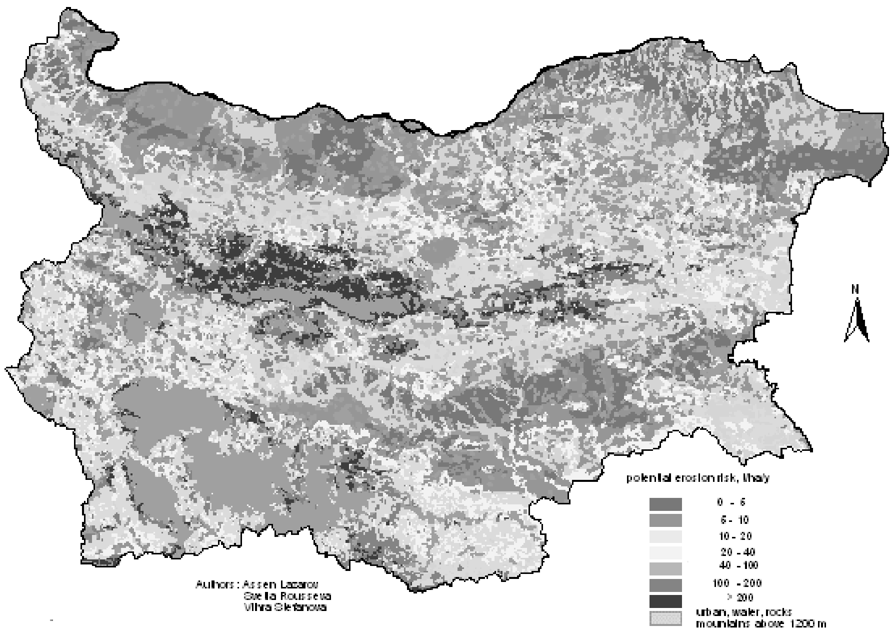

Figure 1. *Distribution of the territory of Bulgaria according to potential water erosion risk classes*

Percentage distribution according to the degree of water erosion risk of the area of different types of land use considering field crop rotations with 50:50 % proportion of row to cover crop shows that about 1/3 of the agricultural land, including 65.3% of the area of perennials, 34.9 % of the area of rangeland and 23.3 % of the cropland are with a risk of erosion exceeding 3 t/ha y. The average annual rate of water erosion of soil varies depending on the type of land use from 2.69 t/ha y for the rangeland and 4.76 t/ha y for the cropland, to 12.65 t/ha y for the perennials.

The highest risk for area water erosion of agricultural soil exists in the lands of the areas of Burgas, Razgrad and Russe, with an average forecast intensity of 12 to 15 t/ha y, followed by Dobrich, Silistra, Kardzhali, Gabrovo, Lovech and Sofia (10 – 12 t/ha y), Sliven, Haskovo, Targovishte, Veliko Tarnovo and Varna (7 – 10 t/ha y) and Blagoevgrad, Pazardzhik, Smolyan, Pleven and Yambol (5 – 7 t/ha y). Figure 2 presents the distribution of Bulgaria's territory by degrees of 'real' risk of area water erosion.

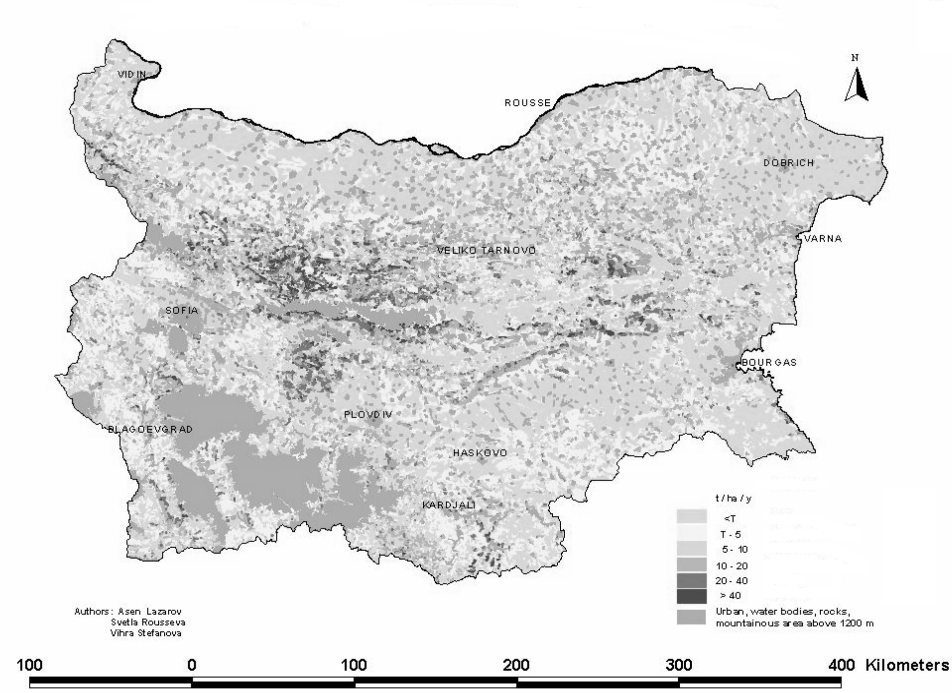

Figure 2. *Distribution of the territory of Bulgaria according to the classes of actual soil erosion risk by water*

According to national statistics, the area of lands used for agriculture has decreased after 1989, being superseded by abandoned land. The significant reduction in the arable land area has caused substantial reduction of the average annual soil loss and of the total annual soil loss in agricultural lands, as compared to 1980. However, the increasing area of abandoned lands has accelerated processes such as linear erosion on these lands and on the surrounding territories.

Wind erosion

Wind erosion of soil is manifest on plains and deforested areas. The areas with higher risk of wind erosion are those with low degree of forest cover and soils that are highly prone to deflation. According to the mathematical model developed for assessment of the risk of deflation, cropland with an area of 1,348,750 ha are at risk of deflation of more than 0,5 t/ha y. The risk is moderate for 19.7% of the cropland areas, moderate to high for 1.4%, high for 11.7% and very high for 2.7% (Figure 3).

The highest relative risk of wind erosion exists for the cropland in the areas of Dobrich and Pleven (60-75% of the areas), followed by Russe, Silistra, Razgrad, Yambol, Vratsa (50-60% of the areas) and Vidin, Montana, Varna, Targovishte, Shumen, Veliko Tarnovo (40-50% of the areas). The cropland in the Dobrich area are at risk of deflation with intensity of 11 t/ha, and 5 to 10 t/ha in Sofia and Burgas, as well as 3 to 5 t/ha in Varna, Yambol and Sliven.

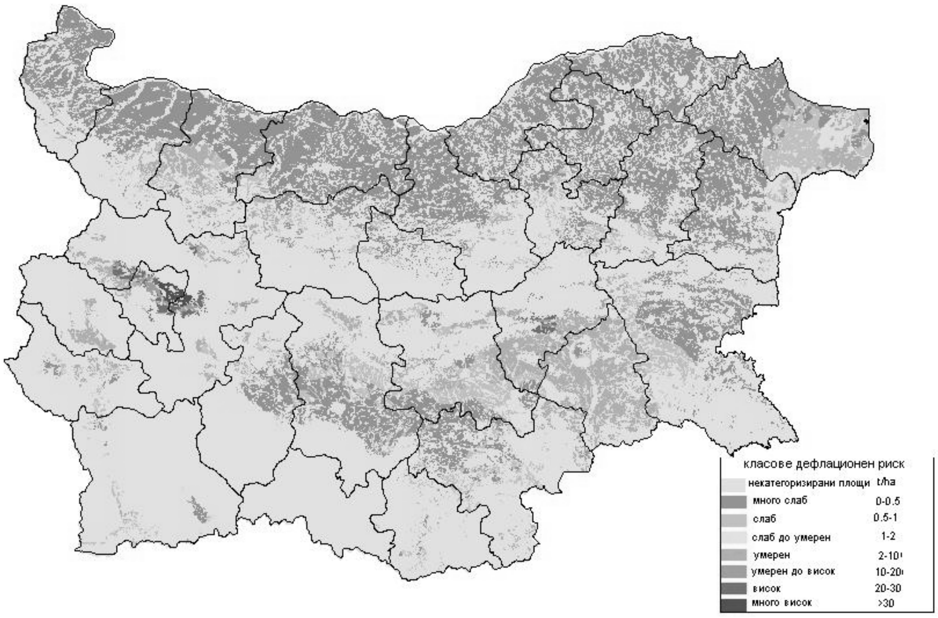

Figure 3. *Distribution of the territory of Bulgaria according to the classes of soil erosion risk by wind s in*

<u>*Irrigation erosion*</u>

The risk of irrigation erosion is negligibly small as far as it affects irrigated lands with inclination of more than 3°, most of which have been abandoned since 1990. The irrigated areas in Bulgaria until 1990 had been approximately 25% of the arable lands. In-depth studies have shown that the risk of irrigation erosion is highest in the case of gravity irrigation along furrows varying between 2.5 and 8.6 t/ha per one application of water and that the application of sprinkler irrigation might reduce soil losses to a significant degree.

The natural conditions, the management of lands and the inefficient enforcement of the law suggest a high degree of risk for water and wind erosion of agricultural soils. These processes depend on the annual erosive capacity of precipitation and wind, and by the management of lands. If the current management of farmlands is retained and in light of the increasing trend for the annual erosive capacity of precipitation and wind, the processes of farmland erosion can be expected to accelerate. There is a need to develop and implement specialized programs for protection of farmlands from erosion that include soil protection and corrective measures consistent with the specifics of the soil, climate and topography.

<u>*1.2. Soil contamination*</u>

Soil contamination is a process of accumulation of harmful natural and/or anthropogenic substances whose behavior and concentrations cause damage to soil functions regardless of whether they exceed the current limit values. Soil pollution causes deterioration of soil functions and pollution of surface and ground waters. The presence of pollutants in concentrations higher than certain levels may have negative consequences along the entire food chain, in all types of ecosystems, and in other natural resources. The pollution may originate from local (point) sources or from diffuse sources.

Usually *local pollution* is associated with operating mines and industries while farming practices have the highest contribution to the main non-point sources. *Diffuse pollution* of soils has been very slightly pronounced during the recent years due to post-1990 the economic and agricultural restructuring, the heavily decreased use of plant protection chemicals and mineral fertilizers, the ban on use of leaded petrol and increased environmental monitoring of the operating industries.

Past pollution of agricultural lands with *heavy metals and metalloids* affects an area of 44 900 ha, 61.3% of which are close to industrial facilities. No statistically significant areas of farmland have been registered as polluted with heavy metals and metalloids after 1994/1996. The statistical processing of 2004 data shows that the values measured in 97% of the cases are below the Permissible Contamination Level (PCL). The nitrogen and phosphorous content data derived from statistical processing of the results for 2004 show that the availability of nitrogen is average (an average value from 408 monitoring points at 1, 87 g/kg and a median of 1, 60 g/kg) and that the availability of phosphorous is low (average of 0, 08 g/kg and a median of 0, 07 g/kg).

The economic and farming changes and the increased environmental control on operational industrial processes have lead to a substantial reduction of heavy metals and arsenic in the soils used for agriculture. The soils in monitoring points exhibit average availability of nitrogen and low availability of phosphorus. The agricultural activities have not caused new loading of the soils due to the decreased use of fertilizers and plant protection chemicals, and also to the programs for environmentally sound agriculture and ecologic farming, which should be expanded.

1.3. Decline of organic matter in the soils

The organic matter in soils, assessed via the content of humus and organic carbon in the soils, is a complex system of humus substances, proteins, amino-acids, hydrocarbons, fat acids, waxes, resins, lignin and other components. The reserve of organic carbon in soils in Bulgaria has been evaluated on the basis of data from measurements of the content of organic carbon and the volume density across layers deep 0-25 and 0-50 cm, and across the entire soil depth. The total content of organic carbon for Bulgaria was calculated at approximately 1.3 Gt. The reduction of the soil organic matter in arable lands, as compared to no-cultivated lands (long term abandoned lands), is between 10 and 40% for most soils, but may reach higher values. Decline in soil organic matter in arable lands is caused mainly by removal of the surface soil layer by water and wind erosion, oxidation of the soil organic carbon due to high aeration at intensive cultivation, lack and accelerated transformation of plant residues, and degradation of soil structure at soil compactions. Water erosion of soil controls the organic carbon reserve and its distribution on the soil landscape thus influencing the carbon circle, the carbon dioxide content in the atmospheric air, and the global warming. By destroying the soil aggregates by raindrops water erosion disturbs the physical content of organic carbon in the soil particle aeration process and releases the weakest-bound fractions of organic carbon.

Despite the absence of systematic observations, there are data indicating a permanent tendency towards decline in soil organic matter in cultivated lands. Development and application of specialized programs is necessary to maintain and increase soil fertility focusing on good agricultural practices for maintaining the soil organic matter, integrated with the measures for soil erosion and soil compaction control, etc.

1.4. Loss of biodiversity

The loss of biodiversity is associated with (i) the other soil degradation processes; (ii) landscape modifications resulting in loss of the natural habitat of a number of biological species; (iii) illegal arson of stables, which destroys the entomofauna and flora and disturbs the soil microbial equilibrium and thus resulting in a considerable loss of soil fertility. The ploughing up of field borders in the 50-s had destroyed the natural habitats of a range of species and had discontinued the corridors connecting farmlands to forests. Stubble burning is a substantial part of the total human caused impact on agroecosystems. Massive fires in hundreds of thousands of hectares can be seen in Bulgaria after every year's harvest. The areas on which stubble is burned amount to 600,000 ha, and the post-harvest stubble averages out at 4 t/ ha.

Stubble burning destroys some of the beneficial soil microflora as well as beneficial animals, and their enemies and the pests are destroyed only partially in the process. Stubble burning destroys game animals, beneficial insects that include soil microorganisms that contribute in humus formation and are an important soil fertility factor, as well as earth-worms and others of exceptional significance for the ecological balance. The use of post-harvest residues as fertilizer may reduce the nitrogen fertilizer expenses without reducing the yields of subsequent crops.

There are no systematic observations on the loss of biodiversity in farmlands. Limiting the intensity of soil and land degradation processes, the landscape changes leading to loss of natural habitats and the burning of stubble can reduce the loss of biodiversity.

Crop residues can be used in farming by plowing up, composting, mulching etc., and as animal bedding, crop beds, fodder, briquettes, direct incineration in special ovens, and as raw materials for various industrial productions.

1.5. Salinization and alkalization

Soil salinization is a process of increasing content of water-soluble salts and alkalization - increasing of exchangeable sodium and/or magnesium in soils in quantities that degrade the properties and, therefore, the productivity of the soils. Approximately 35,500 ha of arable land have been registered in Bulgaria as affected by salinization processes, with 252 ha being salt affected with normal soda and chlorides. These processes affect mainly the areas of Burgas, Varna, Veliko Tarnovo, Pleven, Plovdiv, Sliven, Stara Zagora and Yambol. Factors that control occurrence, extent and level of soil salinity are natural (climate, relief, hydro-geologic and geogenic conditions), as well as anthropogenic (urbogenic, technogenic, inappropriate irrigation).

The data from salinization process monitoring in the long-term soil salinity monitoring network in Bulgaria show significant variation of the basic characteristics (pH, water soluble salts content, exchangeable Na, exchangeable Mg etc.). A big part of the salt affected soils in Bulgaria is spread in association with soils of high fertility. The extension of the salinity is potentially possible, because salinization is closely linked to water movement through the soil profile and the degree of salinization depends on the climatic, hydrologic and economic conditions.

Successful solving of salinity problems requires enormous finance support as it can be achieved after eliminating the anthropogenic factors only on the base of complex amelioration activities including soil drainage, chemical soil melioration (through amendments as gypsum or phosphor-gypsum), soil deep loosening, soil leaching, appropriate cultivation practices. “Gentle” management practices combining soil water management, planting salt tolerant and deep rooted forage crops, soil surface gypsum application and appropriate cultivation practices are more sustainable in case of moderate to low salinization**.**

1.6. Acidification

Soil acidification is a natural process which intensity depends on genetic origin and also on human factors and is characterized by reduced soil pH, appearance of exchangeable acidity and development of aluminum and/or manganese phytotoxicity, reduction of bases in the soils, molybdenum deficiency, suppressed microbiological activity and acidic destruction of clay minerals. About 1 500 000 ha of the cultivated land, approximately 11% of cultivated areas, are with acid reaction. About 500 000 ha of the acidified agricultural lands are with acidity toxic for most of the crops.

One of the major causes for anthropogenic acidification of Bulgarian soils is the long-term mineral fertilization with acidifying nitrogen fertilizers, particularly when applied individually without concomitant phosphorous and potassium fertilization. Acidification of Bulgarian soils under the influence of acid rainfalls has a limited significance. Acidification of soils caused by acid industrial wastes is limited to confine territories close to point source pollution. Seasonal soil surface waterlogging in some regions sets conditions for additional soil acidification.

Data from observation on acidification process in the network of long-term monitoring of acidified agricultural soils in Bulgaria’s arable lands show a permanent tendency toward neutralization of the exchangeable acidity, reduction of the values of easily exchangeable aluminium and hydrogen, and retention of the saturation degree of the permanent sorption positions in soil Cation Exchange Capacity (CEC) to of saturation rates of arable lands, where no intensive erosion occurs and no intensive fertilization using hydrolytically acidic mineral fertilizers is applied. Permanent tendency has been established to neutralization of the exchangeable acidity in the anthropogenically acidified soils due to reduced application of hydrolytically acid mineral fertilizers.

1.7. Temporary surface soil waterlogging

About 10% of the agricultural lands in Bulgaria are affected by temporary surface soil waterlogging - in this about 350 000 ha are represented by Planosols and about 100 000 ha by Vertisols. This degradation process is typical for soils covering flat and depressive relief's form. These soils are characterized with high texture differentiation of the soil profile (Planosols) or with high clay content in the whole profile (Vertisols). Besides the genetically vulnerability to surface waterlogging due to the heavy texture, causing the extremely low filtration coefficient (0,06-0,10 m/24h and lower), reason for the unfavorable state of these soils are also the specific climatic conditions (positive soil water balance during the main part of the year) and anthropogenic impact (land consolidation, infrastructure works in embankment, inappropriate farming practices).

The extremely low filtration capacity by some of the Vertisols is due to the higher content of exchangeable Na and/or Mg at the CEC. Surface waterlogging is observed predominantly in spring but often in autumn-winter period as well. It causes a number of unfavorable for farming effects such as postponing and complicating the ploughing and the other field works, postponing or compromising germination, sprouting and growing of crops and harvest lowering.

1.8. Soil compaction

Soil compaction is a process of deformation and of increase of soil bulk density accompanied with decrease of the soil aeration porosity and water permeability, increase of soil penetration resistance, deterioration of the soil structure and modification in soil profile. The process of soil compaction is connected with cultivation and unsuitable tillage operations, grazing and intensive livestock moving. Cultivated soils are affected by topsoil (20-25 cm depth) as well as subsoil (below the plough layer) compaction. In contrast to the plough layer, which is being loosened every year, compaction in the subsoil is accumulated and associated with formation of a compact layer below the topsoil named “plough pan”. Especially inappropriate in this connection are cultivation operations at high soil moisture.

Soil compaction is associated with respective decreases of the soil aggregate stability ranging from 40 to 80 % and the available soil moisture ranging from 1 to 29 %. Aggregate stability of most than 60 % of Bulgarian soils at virgin conditions can be categorized as good and only of 3 % of them – as weak. The anthropogenic load causes deterioration of the soil aggregate stability, which is dominating weak for the cultivated soils. Intensive spring and summer rainfalls followed by long dry periods are the most common cause of *crusting* of the structurally degraded Bulgarian soils. The surface crust affects the soil properties directly and indirectly. The direct effects are associated with inhibition of the plant germination, root and plant growth. The indirect effects include decrease of the soil water permeability, which increases both the soil erosion risk and the soil penetration resistance. Soil crusting is a widely recognized agronomic problem in the region of the gray forest soils (Distric Planosols), covering 12 % of the arable lands of the country.

Despite the absence of systematic observations, there are data indicating a permanent tendency to a structure degradation of Bulgarian agricultural soils.
Development and application of specialized programs is necessary to maintain and improve soil structure stability focusing on use of agricultural machines with a reduced ground pressure, good agricultural practices for maintaining and restoration of soil structure, integrated with the measures for controlling soil erosion and decline of soil organic matter as well as application of machines and devices for soil processing with reduced pressure.

Recommendations and trends toward restraining and overcoming land degradation processes in agriculture

Limitation and overcoming of the degradation processes in farmlands is possible by implementation of good farming practices including a set of measures for soil protection and runoff reduction efficiency for integrated soil and water conservation specific with respect to the soil, climate, topographic and landscape conditions aiming at:

- ensuring a protective cover of the soil surface by vegetation or plant residues during the periods of high rainfall and wind erosivity;
- increasing the soil infiltration capacity;

- maintaining and restoring the soil structure;
- maintaining and increasing of the soil organic matter reserves;
- using machines and technologies for soil tillage with minimal ground pressure;
- using the plant residues from crop rotation for briquettes, incineration in special ovens, use as raw materials for various industrial processes, etc., instead of on-site burning;
- eliminating the conditions for a secondary salinization (irrigation using highly mineralized groundwater, natural or human caused deterioration of the drainage of intensively irrigated terrains, unsuitable land use structure, which is not consistent with the particular soil and hydro-ameliorative conditions);
- removing the conditions for anthropogenic soil acidification;
- removing the conditions for soil loading with heavy metals and metalloids (plant protection chemicals, irrigation water, sewage slugs, etc.);
- decreasing the concentrations of HMM in highly polluted soils through application of appropriate technologies remediation including bio/phyto remediation.

2. Degradation of forest land soils

Forest land soil degradation, deterioration in quality and, therefore, productivity, are caused mainly by:

- erosion processes;
- contamination by heavy metals;
- soil acidification;
- changes in soil properties due to forest fires.

Other degradation processes such as compaction, loss of structure, salinization, waterlogging etc., were also found but they have no particular importance for the overall condition of forest soils.

The productivity potential of forest soils depends on their properties and on the regional climate. Furthermore, the anthropogenic impact may cause or intensify the soil degradation process. This can be the result of:

- inadequate forest soil cultivation, erosion and absence of erosion control activities, nutrients leaching, and soil contamination;
- removal of the natural vegetation – transformation of forestlands and pastures into arable lands in areas with high erosion potential.
- excessive use of wood for heating, building materials and use of vegetation for fodder;
- overgrazing – destruction of vegetation and soil compaction;
- urbanization, including construction of forest roads, industrial activities, automobile pollution, etc.

2.1. Soil erosion in forest areas

The former unregulated business activities in Bulgaria causing destruction of forests by fire, felling and grazing have caused soil erosion on a significant part of the country’s territory. The slope relief of approximately half of our country exceeds 18 – 20% and this is the main cause for the development of erosion. One third of the country’s territory being mountainous as well the other natural conditions (climate, soils, soil forming rocks) are precondition for intensive erosion, flash floods and flooding. Flash floods have caused significant damage during the most recent years.

By late 2004 the total area of forestlands was 4,063,555 ha, of which 3,648,005 ha were under forest vegetation. Of those 510,824 ha were reconstruction forests and 108,549 ha were areas without vegetation but subject to forestation. The rarefied crops and natural vegetation of density up to 0.3 occupy 108,216 ha of the vegetated areas. The total area categorized by the degree of erosion (5 levels) was, by the end of 2004, approximately 291,838 ha. The largest areas affected by erosion exist in the Regional Forestry Boards of Blagoevgrad, Kardzhali, Kyustendil, Sofia and Smolyan (Figure 4).

The total area categorized as affected by erosion (1^{st} to 5^{th} erosion level) within these SFs amounts to approximately 246,700 ha. The distribution of SFs by percentage of area affected by erosion within this area is as follows:

from 5 to15 %	23,2 %,
from 15,1 to 25 %	46,7 %
above 25%	30, 1 %.

The soil on 291,838 ha of forestland is affected by erosion in different degrees. The highest numbers of eroded areas are those in the Blagoevgrad, Kardzhali, Kyustendil, Sofia and Smolyan RFBs. The highest percentage of area affected by erosion exists in the Kyustendil, Blagoevgrad, Kardzhali and Smolyan RFBs.

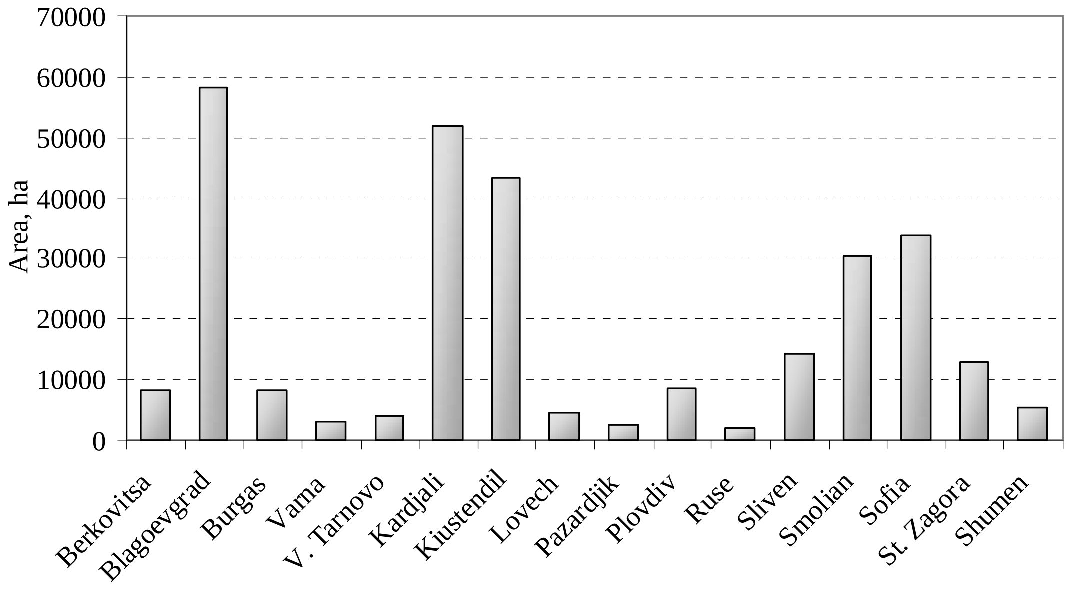

Figure 4. *Area of erosion affected forestlands in various degrees, according to Regional Forestry Boards*

2.2 .Soil acidification

To the investigation of forest soil acidification contributes a large scaled research carried out in the country in the period 1986 – 2003. In the beginning of observation (period A) soils with acidic reaction cover 35, 6 % of forest territories followed by the strong acidic soils (28.7%) and the light acidic soils (24.8 %). In the end of the period (period B) it is observed increasing of the portion of acid and light acid soils accordingly to 48.4% and 39.0%. The portion of the strong acid soils decreases significantly to 7.6%. During the second research period light alkaline soils covered about 2% of investigation areas (Figure 5).

2.3. Pollution of soils by heavy metals

The problems related to soil pollution are the direct result from the development of industries and community needs. The main sources of pollution are industries, accumulation of excessive quantities of industrial waste and the large number of harmful substances that they contain. The statistical parameters characterizing the heavy metals content in the forest soils for the areas in which *values higher than the PCL have been measured* show increase of the average values of the heavy metals concentrations measured during the most recent years as compared to the initial data (Period A) (Table 1). The high levels of standard deviation (SD) for Cu, Pb and Zn are due to the large differences of the minimal and maximal concentrations of these elements measured in soils from various parts of the country. The data show that the most cases with values higher than the PCL have been established at the start of monitoring (Period A). The cases of values higher than the PCL may be arranged in a descending order as follows: Cd, Pb, Zn, and Cu. These cases have decreased during the most recent years of monitoring.

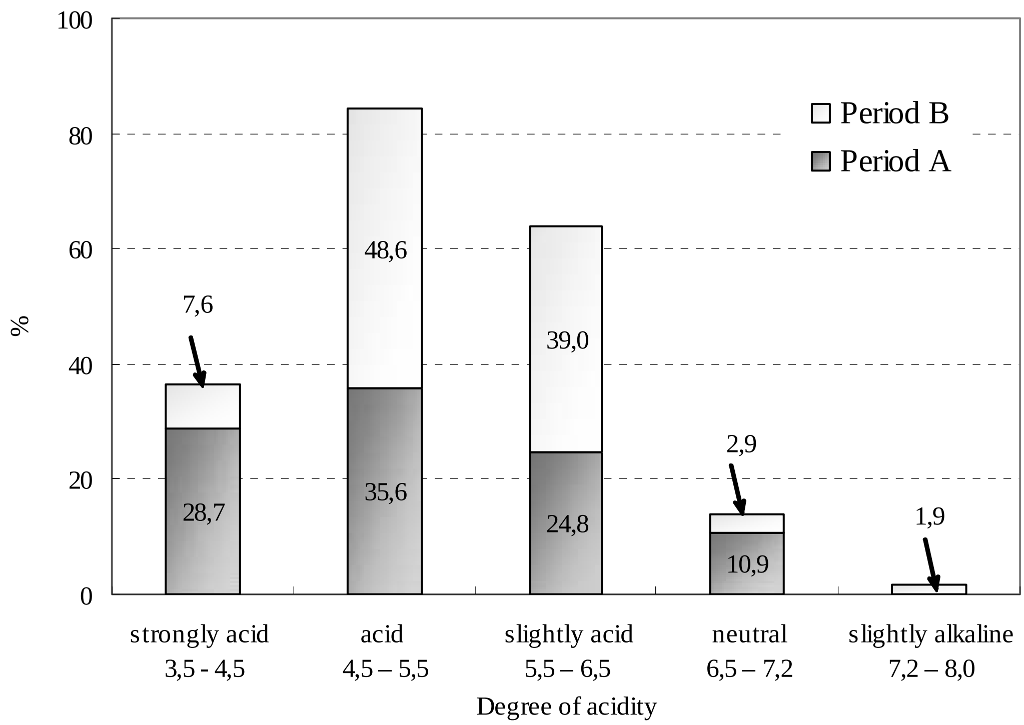

Figure 5. *Distribution of soils by degree of acidity at the beginning (Period A) and during the most recent years (Period B) of monitoring studies (% of the total quantity of studied sites)*

***Table 1.** Statistical parameter of the heavy metals content in the forest soils at the start of monitoring (Period A) and in the end of monitoring (Period B) mg/kg*

Statistical parameter	Cu		Zn		Pb		Cd	
	A	B	A	B	A	B	A	B
Number observations	136	136	136	136	136	136	126	51
Average value	89.0	110.0	95.2	135.9	67.1	76.9	1.99	2.06
Standard deviation	123.28	69.00	49.05	109.94	33.10	56.71	0.81	0.68
Minimal value	33	52	45.0	53.9	32.0	44.0	1.0	1.5
Maximal value	475	248	261.0	380.0	213.0	256.0	5.0	3.0
Median	48	73	81	91	28	60	1.8	1.8
Number of exceeding permissible concentration value (PCV) (% per total observation)	7.4	5.9	25.0	6.6	29.0	9.6	81.7	15.7

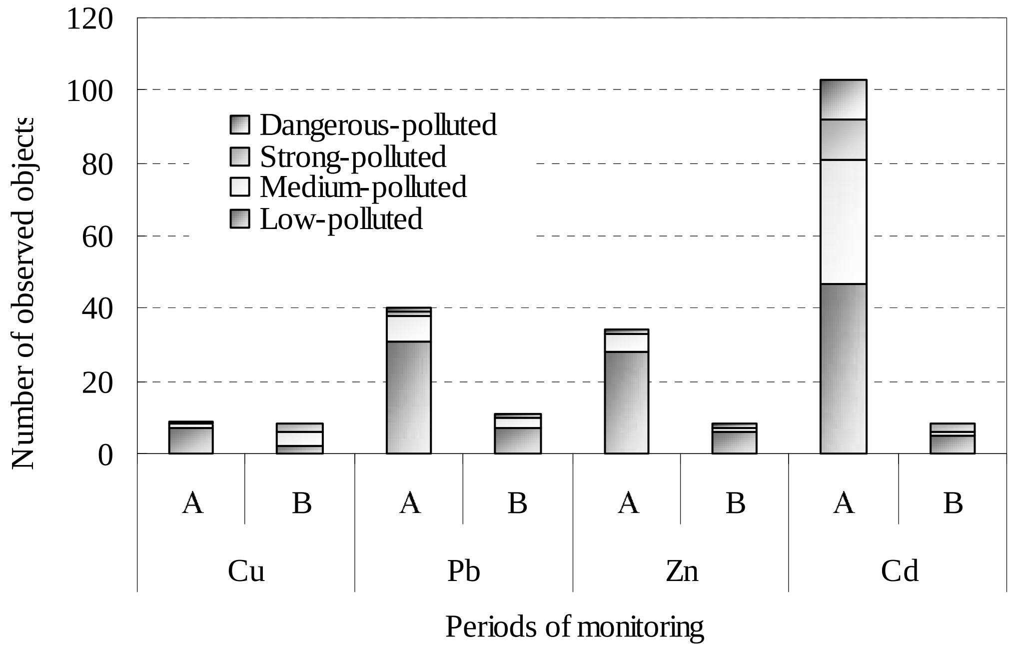

***Figure 6.** Degree of heavy metals pollution1[1] of forest soils (number of occurrences)*

The data from this figure show a significant reduction in the number of occurrences of soil pollution during the final monitoring period as compared to the initial monitoring period. The

[1] Relation between the measured concentrations of heavy metals in soils to PCV

preservation of these trends means that the condition of forest soils and lands will be improved (Figure 6).

2.4. Change of soil properties as a result of fire

Fires that cause complete destruction of forest vegetation or damage in various degrees have caused loss of organic matter, damage of the structure and subsequent erosion. The degradation of soil is the result of partial or complete destruction of tree vegetation, the forest litter, and the grass vegetation. This changes the percentage of mechanical fractions of macro-aggregate composition and soil texture. A trend toward increasing skeleton content of the soils is observed. The number of fires and Bulgaria, and worldwide, has increased drastically during the recent 10-12 years. In most cases the damage is loss of timber. The overall actual loss from forest fire, however, are difficult to evaluate because timber destruction is accompanied by partial destruction of the humus layer of the soil, extinction of rare and protected plant species, and even human lives are lost.

The dynamics of fires presented as number of occurrences and affected areas during the post 1991 period are presented in Table 2. The highest number of fires with the largest area affected has occurred in the years 2000 and 2001. The number of occurrences and the areas affected during the period 1992 – 1994 are also substantial.

Table 2. *Number of forest fires and affected areas after 1991.*

Year	Number	Affected areas, ha
1991	73	511
1992	602	5243
1993	1196	18164
1994	667	18100
1995	114	550
1996	246	2150
1997	200	595
1998	578	6967
1999	320	8291
2000	1710	57406
2001	825	20150
2002	402	6514
2003	452	5000
2004	279	1151
2005 (till June)	210	1386

According to the percentage of areas destroyed by fire between 1991 and 2000, the RFBs have been classified by the degree of risk of fire in the following sequence:

- High degree of risk of fire (3.1 to 5%) – Berkovitsa, Lovech and Kyustendil;
- Very high degree of risk of fire (more than 5.1%) – Kardzhali, Stara Zagora and Sliven

These RFBs include 72% of the areas with fires occurring during the 10-year period. These two levels of risk are characteristic of approximately 37% of the country's total area.

According to *degree of risk of fire* (by areas affected by fire and their position at the national level) the RFBs arrange in the following descending order: Kardzhali, Sofia, Berkovitsa, Sliven, Burgas, Lovech, Stara Zagora, and Pazardzhik and according to *the need for extinguishing of fires* as follows: Sliven, Kardzhali, Stara Zagora, Burgas, Berkovitsa and Sofia.

Recommendations and directions for restraining and overcoming of forest soil degradation processes

The main activities and recommendations to restrain forestland erosion are as follows:

- Mapping of the areas by degree of erosion. Creation of a database of erosion status of forest soils and of ongoing erosion processes; creation of an erosion map of Bulgaria. The areas affected by soil erosion must be identified using a modern method based on the use of remote methods and GIS;
- Identification of areas and water catchments affected by erosion, and determination of erosion control measures in various subsections and sections;
- Carrying out of uniform design of erosion-control measures in the forestlands and farmlands, by preparing integrated projects at the catchments level.
- Carrying out of forestry and technical activities, including preventive measures and introduction of new methods and processes aimed to restore affected areas and protect the soils from erosion;
- Carrying out of monitoring in the areas most affected by the ongoing erosion processes.

The arising trend for reduction and also for increasing of forest soil acidity means that it would be uneconomical to take special measures to limit soil acidification in the forest plantations. The following recommendations and guidelines are advisable:

- Continued monitoring;
- Monitoring the dynamics of pH changes in the affected regions;
- Carrying out of integrated studies in these regions that include:

a) analysis of the origin and quantity of aerosol emissions;

b) occurrence in depth across the soil profile;

c) occurrence across the layers of forest litter;

d) water and physical parameters of soils;

e) other factors affecting the acidity of soils.

- Carrying out of systematic forestry measures in young plantations aimed to ensure their proper growing, appropriate morphological structure, and good health status.

The application of certain forestry measures that might contribute toward the reduction of acidification is recommended:

1. Concerning the establishment of forest crops:

- selection of tree species for forestation on soils widely ranging in acidity;
- selection of suitable meteorological conditions for forestation and suitable soil preparation.

2. In the forest crops – a systematic carrying out of selection cutting.

The following is recommended with regard to heavy metals contamination:

✓ The following is required in order to ascertain the areas of distribution of heavy metals:

a) continuation of monitoring

b) thickening (drawing close) the sampling network points in 8 x 8 km grids and, where possible, 4 x 4 in certain regions

c) identification of the dominant factors that determine contamination

- ✓ The main activity aimed to limit soil pollution comprise:

d) application of contemporary emission reduction methods and processes;

e) selection of tree species that resist pollution;

f) carrying out of timely forestry measures in the forest plantations.

The changes in acidity established in the soil and forest litter, and the content of heavy metals in the soil are certainly affecting the potential productivity of soils. These processes are accompanied by various degrees of leaching of nutrients, destruction of soil particles, and alteration of the physical and mechanical properties. All this is closely related to the biological productivity and biodiversity of forest ecosystems.

The main activities and orientations toward restriction of the degradation of soil by forest fires are as follows:

- ✓ Promotion of the regulatory and territorial frameworks of the forest territories in order to:
  a) prevent the occurrence of forest fires there;
  b) reduction of the degree of fire hazard of the plantations;
  c) prompt discovery of any fires, restriction of their spreading and successful extinguishing;
- ✓ Establishing the degree of fire risk by RFBs and SFs;
- ✓ Selection of suitable technical and forestry measures depending on the degree of risk of fire in a region (barriers and forest crop obstacles, mineralized strips, fire protection belts, sanitary protection belts, construction of roads for fire extinguishing tank trucks, and setting up of observation points)
- ✓ Removal of waste from felling;
- ✓ Placing of signboards - *with fire-safety content* and *indicating the areas allowed for lighting of fires*

3. Land degradation due to industrial, mining, urban and other activities outside the farming and forestry sectors

As compared to the total area of the country, 11,100,683 ha, there are 578,631 ha of land whose soils have been degradated by human activities among industry, mining, civil engineering etc (Table 3).

***Table 3.** Distribution of degraded soils in Bulgaria (according to data from BANSIC, 2001) in different regions*

Code	Description	Total area, ha	**1**	**2**	**3**	**4**	**5**	**6**
14	Swamp lands, bogs	27 576	3616	3132	5950	2812	5947	6120
69	Construction projects, buildings, public construction projects	1 899			399	881	99	520
70	Other terrains whose topography was changed by extractive activities	19 828	1290	2285	1549	4032	8496	2177
71	Other terrains whose topography was changed by various depots	22 353	1091	2332	1636	2000	13204	2088
75	Terrain with compact covering and trees	10 631	402	1786	1305	5961	901	276
76	Terrain with compact covering, without trees	49 553	14061	4963	5450	11827	5612	7640
77	Terrain with linear shaped covering, with trees	57 641	2402	2859	10635	17800	12209	11736
78	Terrain with linear shaped covering, without trees	204 558	20067	37937	32557	35896	56096	22006
80	Low buildings, closed, covered	82 956	13072	12480	14219	13979	20990	8216
81	High buildings, closed, covered	12 499	721	2924	3947	1861	1966	1081
82	Greenhouses, shelters and high sheds	2 220		719	386	213	900	
83	Structures without walls, with roofs only	2 570	206	490	947	193	634	100
84	Temporary buildings	3 330	94	1161	585	732	561	198
85	Other industrial and civil facilities	10 756	494	1654	1953	1778	1687	3190
86	Abandoned constructions	9 330	1608	1188	1399	1350	2380	1406
87	Urban areas	59 353	4047	27237	3483	11696	7891	4999
88	Industrial areas	1 578	298	660	425	100	95	
	Total	**578 631**	**63469**	**103807**	**86825**	**113111**	**139668**	**71753**

Note: a) **1** – Northwestern region; **2** – Northern – central; **3**- Northeastern; **4** – Southwestern; **5** – Southern – central; **6** – Southeastern.

b) All areas are in ha.

<u>*Diffuse pollution of soils*</u>

The main sources of soil contamination are ore and coal mining, chemical and metallurgic industries, transport, and other activities. As result of their activity is the contamination of a part of the lands in Bulgaria along with additional soil acidification and alkalization.

There are 44,900 ha of farmland polluted by industrial activities including heavy metals and metalloids, of which 8,160 ha are contaminated five times above the PCL. 1,000 ha are contaminated with natural radioactive elements from uranium mining. There are almost 130 ha polluted by petroleum products and approximately 250 ha of farmland are salt affected due to industrial activities.

Approximately 70 to 80% of the total emissions of SO_2 is caused by power production from TPPs. Pollution is multiplied also by human caused increase of background radioactivity in these regions as a result of the content of such radioactive elements in the coal. The most significant share of soil contamination is that of the cement industry concentrated in the towns of Dimitrovgrad, Pleven, Zlatna Panega, Beli Izvor, Devnya and Batanovtsi. The deposition of dust particles containing carbonaceous minerals leads to soil pH changes (alkalization), soil silting (colmatation) and reduced soil fertility.

The increased construction activity has lead to change of the designation of land from farming to urban. Construction works have caused excessive territorial compaction. The territorial scope of contamination is characterized by: the strongest rates are observed in the central town parts and in the areas near industrial facilities and along river flows that receives wastewater. The scope of contamination is larger in closed valleys or as a result of specific natural and weather phenomena (Sofia- Pernik; Varna-Devnya; breeze caused circulation in Burgas; inversions /industrial smog/ etc). The predominant pollutants are hydrocarbons, lead, cadmium etc.

Local soil contaminations

The local soil contaminations caused by point sources are usually associated with operating mining facilities, chemical and metallurgic industries, emergencies and accidents and disposal and storage of waste (whether household, industrial, mining, or pesticide stores) etc. These are two groups – depositions from the past and old industrial sites. The objects of impact are lands and soils (Fig.7-9). There are approximately 1818[2] potentially polluted sites and from informational point of view most of them are at a stage of preliminary study. An insignificant part of those has been through the complete cycle of study (privatized sites / sites currently being privatized, mining sites).

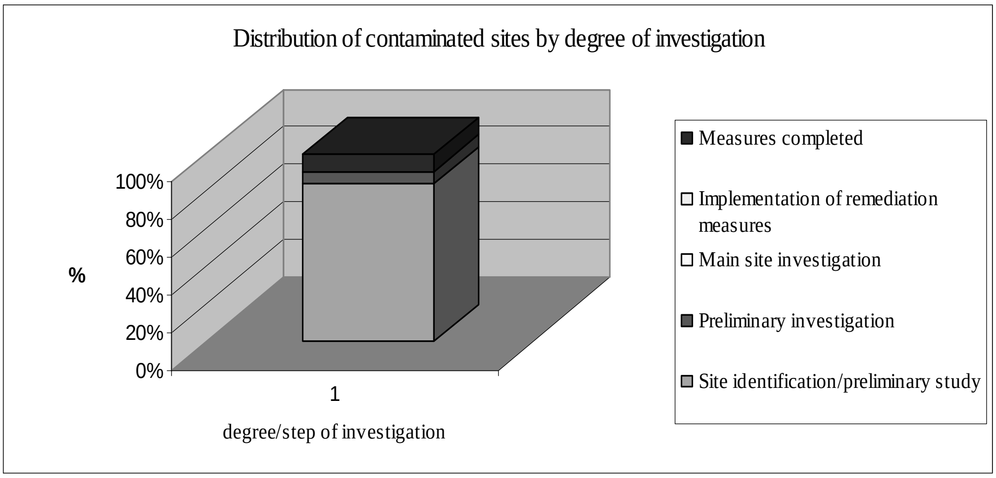

Figure 7. *Distribution of contaminated sites by degree of investigation*

[2] The difference in numbers from previous years is caused by the use of more accurate techniques and the requirements for reporting to the Executive Environmental Agency.

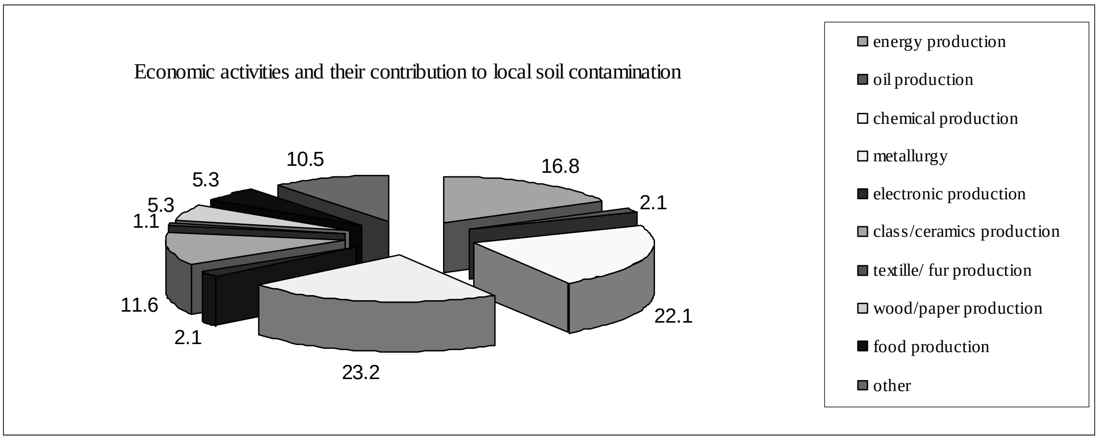

Figure 8. *Economic activities and their contribution to local soil contamination (%)*

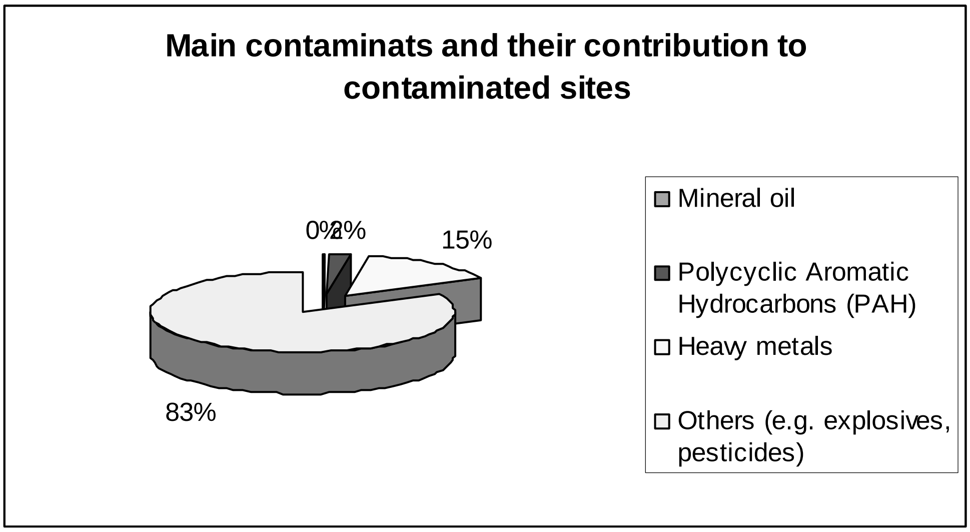

Figure 9. *Main contaminants and their contribution to contaminated sites*

Polluted site management is a long and gradual process requiring substantial funding. The remediation of polluted sites is assumed to be the final stage of the so-called studies – preliminary and detailed/basic. The responsibility for remediation is borne by the owner/operator of the respective facilities while the state is responsible for the preliminary studies and registration of polluted sites as required for their management.

Industrial activities (for sites subject to IPPC)

Consistent with Annex 1 of Directive 96/61/EC on Integrated Pollution Prevention and Control and Annex 4 of the new Environment Protection Act, a list of industries falling within the scope of this Annex has been drawn up, and includes various numbers of industries from various sectors, as follows:

- Energy – 36;
- Mineral oils and gas refineries – 4;
- Metal production and processing - 43
- Processing of non-metalliferous mineral raw materials – 58;
- Chemical industry 27;
- Other activities – 54.

Transport and infrastructure

Building activities in cities (entire town infrastructure of the residential and industrial areas) and their expansion causes changes in soil cover - soil profile and soil characteristics.
The main soil degradation processes in urban areas are brought down to:

- compaction and sealing;
- contamination with heavy metals and other toxic substances;
- salinization.

Compaction of the surface layers and the construction of dense surfacing (paving stones, asphalt, concrete) lead to insufficiency of oxygen and deteriorated water drainage which delays the growth of the root system, as well as the normal gas exchange in soils and poses risks to the vegetation.
Transport is one of the main sources of soil contamination in urban areas. The pollutants fall onto the soil surface indirectly, by atmospheric deposition and precipitation, or directly through the local use of specific chemical substances. The contamination is both regional and local, the latter occurring on more limited areas but having a more pronounced and accumulating effect as far as the main pollutants - heavy metals and water soluble salts - are concerned. Contamination is strongest in soils located next to boulevards with intensive traffic, and next to highways. According to the criteria for degrees of soil contamination adopted in the Republic of Bulgaria, these soils are moderately to strongly /dangerously polluted with lead, moderately polluted with cadmium and lightly polluted with copper and zinc.

Soil salinization in towns is the result of the use of various chemical substances sprayed on the street and pavements to protect against ice formation (during the winter) and to suppress dust (during the summer).

Recommendations and trends toward restraining and overcoming of degradation processes

The severe diversity of pollutants, their impact on the environment and on the type of land use require application of various approaches aimed to limit and overcome the processes of degradation.
Good practices require:

- ✓ evaluation of the environmental and human-health risks;
- ✓ restriction or modification of the sources in order to prevent the spreading of pollutants;
- ✓ use of physical barriers;
- ✓ change of land use (if necessary);
- ✓ monitoring;
- ✓ collection and presentation of the necessary information about the locations and sources of degradation (by absence of sufficient data);
- ✓ completion on a regular basis of the existing registries of landfills for the mining and processing industries, and for hazardous and non-hazardous production waste.

The storage of materials from the mining and processing industries, and the maintenance of the landfills (for industrial and solid household waste), which pose high potential risks (radioactivity), require appropriate measures for:

- ✓ construction of protection covers;
- ✓ prevention of denudation and deflation processes;
- ✓ collection of polluted/runoff water;
- ✓ carrying out of monitoring;

- ✓ biological reclamation.

The main objective is to provide complete (overall) reclamation of the affected areas in order to ensure suitable use consistent with the degree of soil degradation or restoration of the lands for other purposes in accordance with the principle of restoration within reasonable limits.

PAPER NO. 3: SAHARA AND SAHEL OBSERVATORY

Adaptation and the fight against desertification

Introduction

This paper is meant to be a contribution to the UNCCD COP8 CST work. It is derived from a previous note prepared by OSS for a CRIC5 side-event with GTZ's support[1].

As mentioned in COP7 decision 20 (to be checked), climate change is one of the most crucial issues linked to desertification. This short paper has been conceived to help prepare the following COP8 CST sessions:

"The effects of climatic variations and human activities on land degradation: assessment field experience and integration of mitigation and adaptation practices for livelihood improvement."

The issues of the fight against desertification and climate change are increasingly crucial for Africa, where these two phenomena combine to obstruct the development efforts of countries and concomitantly the living resources of their populations. The OSS member countries are among those most vulnerable to climate variability and changes and those most affected by desertification and drought.

Indeed, for the UNFCCC, there are two types of response to climate change: measures which reduce emissions of greenhouse gases (GHGs) and adaptation measures.

Starting from current knowledge of the issue, this study aims to define adaptation strategies, to determine the way they relate to the fight against desertification and to recommend actions to increase synergy between UNFCC and UNCCD.

The first section of this document deals with the relationships between desertification and climate change in Africa, based on actual consequences of these phenomena and recent evolutions as described in the scientific literature referred to. It highlights the links between vulnerability, desertification and climate change and variability.

The second section considers the notion of adaptation and the way this notion calls for scientific and institutional improvement.

In conclusion a few thematic recommendations are proposed to improve the implementation of Multilateral Environmental Agreements considering the common points and objectives that adaptation and the fight against desertification share.

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[1] Deutsche Gesellschaft für Technische Zusammenarbeit – the technical arm of the German development agency

I- Climate change, variability and desertification

I.1- Climate variability, a common factor of desertification and climate change?

Climate change refers to significant long-term modification (or variation) of the climate, due mainly to human activities. The most widely used indicator at the present time, for characterizing climate change, is the increase in concentrations of greenhouse gases related to human activity[2]. These emissions are the main cause of the increase in mean global temperature, from 0.3° to 0.6 °C over the last 100 years (IPCC[3], 2001). The last report of the IPCC is even more alarming as it states that the mean increase in temperature over the last 100 years has grown from 0.6 °C in 2001 to 0.74 °C in 2007.

While climate change is mainly caused by the concentration of greenhouse gases, to which African countries only contribute in a very slight way, it has the effect of amplifying extreme phenomena, such as, in particular, droughts in dry areas, thus leading to a global increase of climate variability. This evolution will intensify as long as the emissions are not brought under control.

The desertification phenomenon degrades land and soil in dry areas, according to various factors, among which a combination of climate variations and human activity. This definition indicates that if all other factors remain constant, climate change will increase and continue to increase the risks of desertification in dry areas.

I.2- The impact of climate change in dry areas in Africa

The dry areas[4] vulnerable to desertification risks are characterized by a 'natural', acute climate variability. In these regions, the term 'climate variability' refers more specifically to fluctuating rainfall. Climate change reduces rainfall which accelerates the degradation of vegetation cover and hence erosion thus accelerating desertification mechanisms. In turn, changes in vegetation cover and the degradation of soils affect the climate to the extent that an exposed soil increases evapo-transpiration and reduces rainfall**:**

- The degradation of vegetable cover leads to an increase in albedo (the reflection of solar radiation) which stops rainfall from falling (Charney's hypothesis).
- Other analyses have shown that vegetation (in particular that of dense forests) captures water vapour better than bare soil and plays a role in monsoon circulation. Thus, re-evaporation from tropical vegetation allows for the reconstitution of humid air masses which lead to rainfall further to the North.

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[2] The use of fossil fuels, industrial production and changes in land use have caused an increase of about 30 % of CO_2 concentrations since the 18th century, doubling of the concentration of methane since the pre-industrial era as well as an increase in concentrations of nitric oxide (NO), sulphur dioxide (SO_2) and ozone (O_3).

[3] Inter-governmental Panel on Climate Change (IPCC).

[4] In this text, the term 'dry areas' covers arid, semi-arid and dry sub-humid areas affected by desertification

These mechanisms are still poorly understood and debated by scientists. An observation of rainfall minima and maxima over a few decades indicates that remarkable trends may indeed be manifestations of climate change.

We support this rationale for the case of the Sahel strip to the south of the Sahara by stressing the consequences for rainfall agriculture and livestock breeding, the two main types of subsistence farming of rural populations in this region.

In this zone, rainfall has been observed according at different time scales.

- As an inter-annual variation since the 1970s:
    - The series of observations on amounts of rain water recorded each year show abundance peaks and scarcity dips which are more marked than during the previous periods; during these extreme events, drought9 or floods, crops burn or rot on their stems;
    - The overall duration of the rainy season tends to shorten; several studies have indeed emphasised the shortening of the wet period over the last two generations. These evolutions mean that only one harvest of any given agricultural product can be made per season. Moreover, the stop-gap period in between harvests, which is the most critical period from a point of view of food security, is consequently longer.

- During a given season, the temporal distribution of rain leads to irregular growth. Good harvests can only be obtained if there is regular rainfall throughout the season. However, observations made by rainfall stations indicate an increased frequency of drought pockets during the winter season. These drought pockets limit the growth of crops and sometimes lead to young plants shriveling on the stem.

In arid African regions, extreme events such as droughts[5] and floods appear to have become more intense and more irregular for the last three decades. The reduction in the overall duration of the rainy season and the increase of drought pockets are explicit indicators of climate change and increased risks for local populations.

For regions to the North of the Sahara desert, the issue of the impact of climate change is posed in different terms. In climate terms, obviously, the region, as for the Sahel, is characterized by low rainfall which varies between countries and years. Over the last few years, serious drought episodes have required the implementation of emergency plans which are very costly for governments and populations alike.

However, the rural development of these regions is characterized by an increasing disconnection of farming activities, agriculture and livestock breeding from rainfall. Irrigated agriculture of the oasis type, which is traditionally the predominant form, is evolving towards the exploitation of trans-national underground aquifers. Livestock are increasingly being fed on industrial sub-products from agriculture. This evolution is the sign that populations are less dependent on rainfall constraints.

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[5] Drought is an irregular phenomenon which refers to rainfall which falls below the normal mean and which causes a water deficit in the soil, water courses and groundwater, thus endangering crops and leading to scarcity of water for household use and also to famine.

Thus, the problems in this region have, in general, more to do with the management of water resources and will no doubt increase with climate change.

The main risks include:

- an increase in the need for irrigation water raising the risk of conflicts between farmers over water rights;
- an increase in the need for fertilizers raising the risks of polluting the groundwater; no recycling of used water;
- the lack of water following the exhaustion or pollution of groundwater; a mounting pressure on aquifers and the risks of trans-national conflicts over water rights.

Other negative consequences in this part of Africa could be the impact of climate change on the marine and coastal environments due to a rise in the sea level. The main North-African cities and ports along the Mediterranean shoreline are particularly vulnerable.

I.3- Climate change and desertification are both defined by an increased vulnerability

The main difference between climate change and desertification in dry areas in Africa is the time scale on which they occur. That is because climate change takes place over much longer periods than desertification.

Desertification is a recent concept dating from 1949, on which most studies have been undertaken since the 1970s. However the work done on desertification also provides information on climate change even if this information is limited both geographically and in time.

At this stage, it would no doubt be overly bold and simplistic to assume that desertification is a manifestation of climate change. However, it is clear that climate change has already contributed to the intensification of desertification processes and that it will reinforce them in the future, if emissions of greenhouse gases (GHGs) are not brought under control.

Whether causing extreme events or inadequate rainfall, climate change goes beyond posing risks to the environment. The economy of rural African populations is mainly based on harnessing natural resources, in particular water, land and their products and services. Climate change will only increase their vulnerability, given that they are already suffering from desertification. In fact, many dry areas are located in the least developed countries (LDCs); countries which already have a low level of general development and which are now suffering from a combination of fragile ecosystems and rural production systems with very little technological input. This situation indicates that the populations in these regions are living in a state of major vulnerability. Vulnerability depends on three elements: the extent to which a system is exposed to risks[6], the sensitivity of the system and its capacity to adjust.

[6] The risk of natural disasters, for instance can be measured by the frequency of the events and their intensity, but also by their self-correlation with other types of risks, for instance with famine, epidemics, etc..

If we look at Africa in terms of these three elements, and the ways in which they combine, we can see that climate change increases the risk or exposure of natural and social systems while at the same time decreasing the capacities of a system to adjust:

- among the social and economic indicators which express the capacity to adjust, we find the official indicators (GDP/capita, HPI and HDI[7]). These indicators are at their lowest in sub-Saharan Africa and have often dropped even further since 1985. These evolutions indicate increasing difficulties if not the impossibility for households to overcome increased climate risk;
- from the point of view of natural criteria, the observations we have merely referred to here, namely increasing lack of vegetation cover and simplification of ecosystems in arid areas, massive deforestation and loss of biodiversity in humid areas, the reduction or abandoning of regenerating practices such as leaving land fallow and transhumance, the farming of marginal land and concentration of livestock in smaller areas, are all widely covered in the agro-ecological literature; in short, we may well speak of the weakening of natural environments.

In Africa, the general trend towards rising climate risk and diminishing natural and social environments capacities is an indication of increasing ecological and social vulnerability.

II- Is Adaptation an Adequate Response to the Increasing Vulnerability of Africa and Drylands?

II.1 – Main definitions of adaptation

In the field of social science, vulnerability can be quantified and expressed by the ratio between the degree of likelihood of a risk occurring and the capabilities[8] developed by households.

$V = R/C$ (V: vulnerability; R: risks; C: capabilities)

In terms of this approach, it is possible to counter vulnerability by introducing measures to increase capabilities or decrease risks. Identifying these measures requires defining the main adaptation tactics which allow societies and ecosystems to withstand climate change.

Indeed, the concept of adaptation refers to any adjustment in natural or human systems in order to deal with the actual or predicted effects of climate change. In practice, adaptation means all of the abilities and practices developed and implemented by societies to survive over time, in particular during times of crisis. Adaptation methods vary from one society and context to another but they also depend on a population’s resources and the level of development of the country in question.

The UNEP and Intergovernmental Panel on Climate Change (IPCC) distinguish between two forms of adaptation for the purpose of reducing vulnerability to climate variability and change. Anticipatory adaptation is implemented before the initial impact occurs. It requires a risk

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[7] GDP: Gross Domestic Product, HPI: Human Poverty Index, HDI: Human Development Indicator

[8] Sen (1992) defines the concept of capability as being all of the capacities of individuals to meet their needs (eat enough, be in good health, be happy, have self esteem, take part in the life of the community, etc.). It covers not only their capacities, their personal characteristics and social opportunities but also their potential and their different resources (financial, physical, human, social).

knowledge system and information systems, particularly efficient environmental[9] information systems. Reactive adaptation, however, is designed and implemented in response to initial impacts. This could take the shape, for example, of a major change in cropping practices[10].

Considered over the very short term, reactive adaptation may, furthermore, aggravate desertification when, to deal with periods of drought and famine, populations start consuming the immature subjects in their environment: wood, plants, animals thus endangering the reproduction of species.

II.2 – Adaptation, traditional knowledge and natural resource management

In regions which are naturally subject to significant climate variability, populations have developed specific adaptation techniques over the centuries. In the Sahel, since the major droughts of the 1970s and in a context of the liberalisation of economies, we have observed the emergence of new forms of adaptation and the sometimes late recognition of the relevance of older techniques:

- diversification of economic sectors, to deal with the unpredictability of harvests. For example: livestock breeding, trading, fishing, temporary migrations, etc.;
- modification of management practices for agro-sylvo-pastoral systems: the development of a combination of farming and livestock breeding;
- the development of varieties which are more drought-resistant, shortening of the growth cycle, the use of early-maturing varieties and flood recession agriculture for catch basins, the development of irrigated farming through control of water, market gardening, greenhouse gardening, intensified agriculture are some of the adaptation strategies which have been observed in the agricultural sector;
- forest management, by the promotion of less wasteful cooking stoves, use of butane gas and participatory management of villagers on forest perimeters;
- management of domestic and agricultural water: new local practices for controlling and storing rainwater (large domestic water tanks, storage reservoirs, dams, stone bunds slowing down surface runoff, traditional wells, drilled wells, etc.);
- the management of marine and coastal ecosystems: practices for the conservation and transformation of fish and valorisation of sea water (used for cooking food, desalinisation) to overcome the lack of fresh water;
- pastoralism and mobility of herds as well as the choice of sedentary species (for example, goats who can live on a wider variety of vegetation than other livestock);
- social capital: traditional solidarity is based on the use of religious and traditional ethical mechanisms for dealing with poverty;
- migrations: these enable risks to be managed by extending the spatial area with respect to resources and sources of income within families. Previously seasonal or temporary, they are becoming permanent.

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[9] The term environment is here taken to mean all of the biophysical and climatic characteristics of society, a fairly inclusive definition suggested by UNESCO.

[10] The change in the Sahel to irrigation farming, through the use of fossil water resources, would be a possible form of reactive adaptation. This technological innovation would moreover require many precautions for precise and fair management of this finite resource

The above list also shows that adaptation is essentially a social phenomenon (involving solidarity and migration mechanisms): it continues to be implemented by populations depending on the means available to them and depending on the events. There is a dearth of long-term agricultural and livestock breeding policies which would enable these practices to be integrated, in a sustainable way, in national development strategies.

II. 3- Adaptation and the fight against desertification: a few thoughts

There is a clear similarity between the fight against desertification and adaptation as both imply the reducing of vulnerability.

Knowledge gap

As far as we know, there is no detailed synthesis of adaptation practices which would be used differently depending on the context, nor of their relevance and potential with respect to recent economic and climatic evolutions (globalisation).

Furthermore, while research on vulnerability has been undertaken in the scientific disciplines of ecology and social science, little work has been done which relates to the two types of vulnerability, social and ecological[11]. Cross-matching them with traditional and new adaptation modes has not been attempted.

Such works could allow a better identification of the synergies between adaptation and the fight against desertification, not only conceptually but also in terms of development actions.

Institutional gap

After more than ten years of implementing the two conventions, few are the UNFCCC and UNCCD joint programmes which brings about synergies from actions undertaken as part of the national action programmes recommended by both conventions. However, the types of rural actions indicated in national communications for adaptation often appear to be similar to those proposed in the PAN/LCDs.

Although the drafting and implementation of PAN/LCDs and NAPAs are two parallel processes based on the same concept of vulnerability, they do not feed into each other. These programmes however, offer opportunities for joint implementation. Might it not be possible to identify common actions to be undertaken in national development strategies?

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[11] We should note that the NEPAD has just recommended the introduction of a vulnerability index combining ecological and socio-economic dimensions.

Conclusion and Recommendations

The study revealed that there are several possibilities to ensure that efforts undertaken for adaptation and the fight against desertification converge.

Better identification of adaptation mechanisms and better evaluation of vulnerability.

The sectors which are the most sensitive to climate variability and change in Africa are also those which are the most sensitive to desertification:

- water resources;
- human health[12];
- ecosystems in arid and semi-arid areas;
- food security;
- coastal zones.

The risks are not only climatic and ecological; conflicts over water rights, poverty and migrations may also increase, with increasingly perceptible consequences, on a global scale.

The importance of knowledge management and environmental information

Information is vital for adaptation and climate and environment monitoring is indispensable for forecasting risks. However, the results of the most advanced research must be made accessible and understandable both to national structures in charge of managing and preventing crises and also to final users (populations, civil society, NGOs). This work on translating and distributing information and scientific knowledge requires specific pedagogical skills. Exchanges of experience for instance between the North and the South of the Sahara should also be promoted in this framework.

In order to ensure better management of available information, it is essential to develop a base of regional knowledge of the crucial stakes involved in degradation of natural resources (water, soils, climate). Such a base will only be viable if it is regularly fed on a national level, via all of the initiatives undertaken in favour of the environment and socio-economic development. It would require setting up or reinforcing national systems for observing and evaluating natural resources. This can be done through a user-friendly model for gathering data and for making and managing databases. It would also be useful to specify how monitoring of desertification feeds into climate monitoring. Thus, setting up or reinforcing national information systems for environmental issues would make it possible to improve implementation of the Multilateral Agreements on Environment.

The need for regional development and more dialogue

Regional cooperation is important to the extent that many African countries share natural resources (river basins, aquifers, protected reserves, etc.), belong to common institutions and are subject to the same environmental concerns, including degradation of land and climate variability and change. It is important to emphasize the reinforcing of regional networks which may be made possible through African organisations on a sub-regional, regional or even

[12] Comité permanent inter-état de lutte contre la secheresse au Sahel.

international level. Such a regional platform should also involve sub-regional authorities (CILSS[13], UMA[14], IGAD[15], CENSAD[16]), specialised sub-regional technical organisations (Centre Régional Agrhymet, INSAH[17], OSS, CRTEAN[18], AOCRS[19], ACMAD[20]…), working together with bilateral cooperation organisations (USAID, ACDI[21], DFID[22], DDC[23], GTZ…), multilateral organisations with databases on Africa (the FAO, UNEP, World Bank, GEM, Global Mechanism…), as well as environmental NGOs (WRI[24], UICN[25], WWF…).

Adaptation should thus offer an opportunity to reinforce existing instruments and encourage the introduction of efficient procedures for the collection and processing of data which indicates clearly where the information comes from. This should not take the form of a new programme or plan which would duplicate those which have already been developed by the countries affected, and which implementation would run into the same obstacles encountered by previous programmes.

Devising strategies to adapt to climate variability and changes should rather be a process which reinforces, supports, stimulates, and emphasizes the different environmental governance principles defined by the concerned countries and by the actions envisaged as part of the fight against desertification, or the conservation of biodiversity; actions which have not yet been effectively implemented.

On the international level, it will be a good idea to redefine the framework for reinforcing relations between UNCCD and UNFCCC, in particular through decisions to be taken on adaptation.

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[13] Comité permanent inter-état de lutte contre la secheresse au Sahel
[14] Union du Maghreb Arabe
[15] Inter-governmental authority for development
[16] The Community of Sahel-Saharan States
[17] Institut du Sahel
[18] Centre Régional de Télédetection des Etats de l’Afrique du Nord
[19] African Organization of Cartography and Remote Sensing
[20] African Centre of Meteorological Application for Development
[21] Agence canadienne de développement international
[22] Department for International Development (UK)
[23] Direction du développement et de la coopération
[24] World Resources Institute
[25] Union Internationale pour la Conservation de la Nature