Environmental Change and Sustainable Development in the Romanian Carpathians

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ルーマニアのカルパチア山地において，近年の環境変化は気候変化で説明されてきたが，人間活動の影響も大きいとみなされる．カルパチア山地の約1,000 m～2,500 mの地域では，1960年代から2000年に気温は上昇傾向にあり，降水量は減少傾向にある．同一期間にルーマニア南部は乾燥化し，ルーマニアの平原やモルダビアでは，灌漑用水が不足した．カルパチア山地では高木限界が上昇した．また，氷河の圏谷の急斜面では雪崩が多発し，冬スポーツの施設が破壊された．岩屑流は30 mm/24 hの強雨のとき多発し，災害を大にしている．降水量は減っているが，豪雨が増えている．また，突然の融雪が山地地域の大洪水を発生させている．これらは，森林破壊が各地で起きていることに起因する．特に地すべりや泥流，ガリーはカルパチア山地の南東で多発している．ルーマニアの農務省は山頂や丘陵頂部における家畜の過放牧や薪炭，鉱山開発による荒廃に対しての持続的発展のために，エコツーリズムを打ち出している．カルパチアはWWF“Global 200”に選ばれ，動植物の保護にも努力しようとしている．

キーワード：気候変化，岩屑流，環境変化，自然災害，持続的発展
Key words: climatic change, debris flow, environmental change, natural hazard, sustainable development

I Introduction

Global climate changes have a direct influence upon the mountainous environment and thus they come to influence the human activities from this space and its surroundings. The impact of climate changes on the mountain area of Central and Eastern Europe has to be assessed within the context of a transition economy, considering the fact that the states from this part of Europe undergo a difficult period, passing from a centralized system to a free market economy. In view of it, there is a complex connection between two dynamic systems, the natural and the human one, both being influenced by the fast-going changes registered within a short period of time.

A number of studies approached the climate change issue in Romania, such as “The Country Study”, coordinated by the National Institute of Meteorology and Hydrology (Cuculeanu ed., 1997), other studies dealing with temperature (Busuioc, 1996), and precipitation (Busuioc, 1996；Dragota, Balteanu, 2001). They underline major regional differences and are based on climatologic data, some of them being over 100 years time series. Some other investigations refer to the impact of climate change on the forest ecosystems (Giurgiu, 1995；Dumitriu, 2001), the rivers' drainage regime (Serban, 1987；Diaconu, 1999), agricultural crops (Cuculeanu et al., 1999) and natural hazards (Balteanu et al., 1987；Balteanu, 1987). An overall view of Romanian research papers on global environmental change shows the particular interest for studying the vulnerability of human activities in the mountain space (Balteanu et al., 2001).

II Environmental Trends

Romania is situated in the Southern part of Central Europe, making the contact with Eastern Europe and the Balkan Peninsula. Its territory of 238,391 km^2 is intersected by the 45°N Parallel and the 45°E Meridian. Three elements deligniate this territory: The Carpathian Mountains, which extend across the broadest sector of the country, the lower course of the Danube (1,040 km) and the western coast of the Black Sea, the ancient Pontus Euxinus. The relief stretches between heights of 2,544 m (the Moldavian Peak, Fagaraş Mts) and the Black Sea shore displaying three altimetric steps: mountains of 800-2,500 m (28%)；hills of 200-800 m (42%) and the plains (30%), which lie in the south and west, outside the two former steps (Fig. 1).

The climate is continental-temperate with oceanic influences in the western and central parts, continental and Mediterranean ones in the east and the south, respectively. Zonal bio-pedo-climatic formations, corresponding to the plains and the lower tablelands, are represented by sylvosteppe and the belt of oak forests. The boundary line between the nemoral foliated forests of Central Europe and the characteristic steppe of Eastern Europe passes through Romanian territory. The presence of the Carpathian Chain shapes the soil, the vegetation and the fauna belts.

The Carpathian Mountains (2,544 m max. alt.), the Transylvanian Intramountainous Depression and the hilly region of the Subcarpathians cover over 60% of the country's surface area. They are differentiated into three belts: alpine and sub-alpine, at over 1,700-

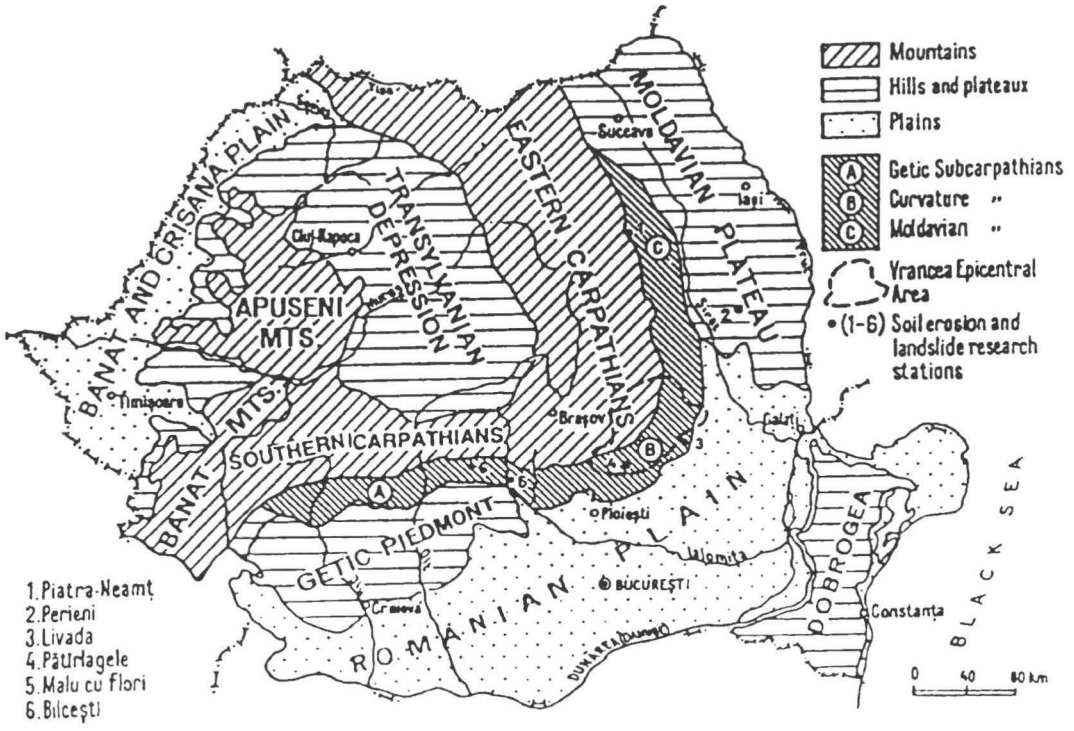

Fig.1 Geomorphic units of Romania

1,800 m; boreal coniferous forests, down to 1,200-1,400 m and nemoral oak-and-beech forests, down to 300-400 m. The Subcarpathian and depressionary sector with altitudes of 300-800m, are marked by severe human pressure on the environment.

III Climate Change Impacts

In order to assess the regional impact of climate changes, various General Circulation Models (GCMs), such as GISS (Godard Institute for Space Studies); GFDL R-30 (Geophysical Fluid Dynamics Laboratory, referred to as GFD 3); UK 89 (United Kingdom Meteorological Office, referred to as UK 89); CCCM (Canadian Climate Center Model, referred to as CCCM), (Cuculeanu ed., 1987) have been analysed. Monthly multi-annual temperature and precipitation means in scenarios of doubling the CO_2 concentrations were analysed. The CCCM model was found to be one of the best for the Romanian territory, in simulating climate evolution trends, predicting a temperature rise by 2.8-4.9℃ degrees and a change of the precipitation regime, to the effect of a quantitative increase in the winter season and a decrease in the warm one. The selected models have been used to develop the climate change scenarios for the Romanian territory in order to study the main impacts on agricultural crops, forests and water resources.

The data registered at 5 meteorological stations situated in the Southern and Western Carpathians at various altitudes (1,090-2,504 m), within the 1961-2000 and 1979-2000 interval show the following:

- a slight increasing trend in the annual mean temperatures (marked by the linear regression line) and a decrease in precipitations at each station;
- the annual mean temperatures have negative values at 2,504 m alt., (Omu Peak Station), with a slight rising trend (Fig. 2), while a clear increase tendency is registered at Stana de Vale station, in the Western Carpathians, during the 1979-2000 interval;
- the annual amount of precipitations mark an obvious decrease (Fig. 3), especially on the southern slope of the Southern Carpathians (near Sinaia) and in the alpine belt (Omu Peak Station). The analyses of the annual distribution of precipitation reveal a tendency to concentration over short time intervals and an increase of their torrential character.

IV Environmental Change and Natural Hazards

The environmental components perceive the

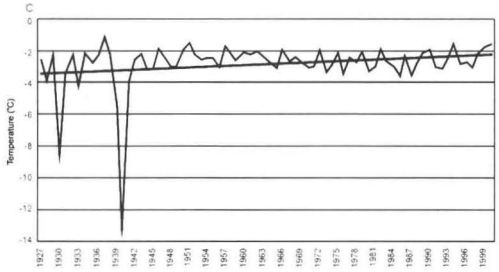

Fig. 2 Omu Peak Meteorological Station (Southern Carpathians) Increasing tendency of mean annual temperature. (Sararu, 2002)

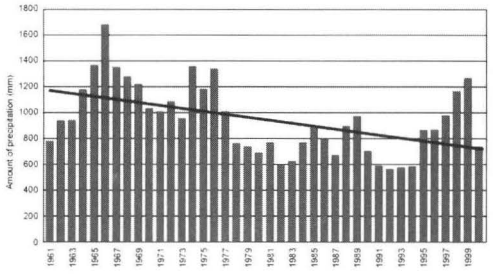

Fig. 3 Tarcu Meteorological Station (Southern Carpathians) Annual amounts of precipitation show a decreasing tendency, (Sararu, 2002)

global warming trend in a different manner. In the mountainous area such changes are reflected in the relationships between the bio-climatic belts and in the extreme climatic and hydrologic events pattern. The Carpathians, in their turn, exert a strong influence upon the surrounding areas from the eastern and south-eastern parts, where the water supply depend on rivers from the mountain region.

The Carpathians act like water castle for the surrounding regions, since almost 70% of the Romanian's water resources are formed within this space. The climate changes associated with lasting droughts and aridization processes, in the southern part of the country, impose an efficient use of these resources for irrigations and water supply of the settlements. In the southern parts of the Romanian Plain and Moldavian Platform risk of desertification is recorded.

Under conditions of global climate change and enhanced human pressure on the environment, the Carpathians play an ever greater roll in preserving the links between vegetation and fauna characteristic of the Balkan Peninsula, in the south, and of the tundra and taiga, in the north. A temperature increase will result in the modification of the altitudinal belts and the tendency of an upward shift of the timberline. The extension of the forest system is associated with the fossilization of the solifluction lobes.

Rockfalls, debris flows and toppling failures frequently occur on the steep slopes developed on crystalline rocks, sandstones and conglomerates and are a major risk to forest roads and villages. In the alpine belt avalanches are frequent on the steep slopes of glacial cirques causing temporary blockage of roads and damaging winter-sports amenities (Balteanu, 1997). The frequency of debris flows is higher in the period with heavy rainfalls of over 30 mm in 24 hours. An increase of the return period of such rainfalls could contribute to the extension of such hazards.

Correlating with the deepening tendency of valleys, the increase of water circulation can contribute to a higher instability of colluvial slopes-e. g. the extension of landslide-affected areas (Photo 1) (Balteanu, 2000).

Major consequences on the mountain space are reflected in the decrease of precipitations and modification of their regime, with torrential rains becoming more frequent. It follows that deep river erosion processes would intensify and the instability of slopes would grow. Flush floods in small catchments are associated with a significant short time growth in the amount of coarse alluvia, having a direct impact on human settlements and communication networks. Such a flood happened on 11 th July 1999 in the Raul Mare River Basin, in the Retezat Mountains, and resulted in 13 casualties, 21 wounded and tens of kilometers of damaged roads. It was triggered by 235.1 mm of rain fallen during the 8-11 th July interval. The floods that occurred on the eastern slope of the Bucegi Mountains in two small river basins caused damages in Busteni town, assessed at 70 mill. lei, and several hours of traffic stuck along the most intensely circulated corridor of Romania, the Prahova Valley.

Sudden snowmelt associated with unusually rich springtime generates strong floods in the peripheral regions of the mountain areas. In January and March 2000 such rises in the rivers level led to the failure of

Photo 1 Gully processes in the alpine belt of the Bucegi Mts.

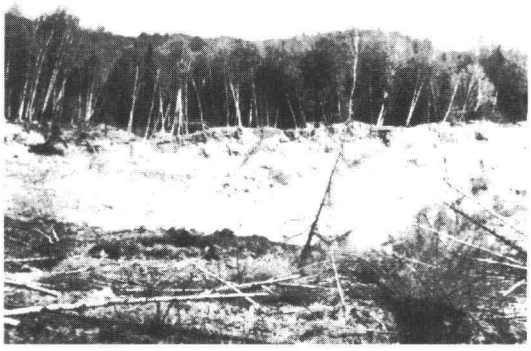

Photo 2 Deep seated landslides reactivated in the Eastern Carpahians

Photo 3 Mudflow in the Buzau Catchment, Eastern Carpathian

the two tailing dams in the Maramures County, causing pollution with cyanides and heavy metals of rivers in the Somes-Tisa Basin. Such events have major cross-border implications and studies on the hydrologic regime of rivers are needed, in the new conditions generated by global climate changes. The floods, which occurred along the Prahova Valley in July 2002, broke some oil pipes, severely polluting the downstream area along tens of kilometers.

The combined effects of sudden snowmelt, rich precipitations and heavy summer rains fallen during short periods of time create favourable conditions for landslides and mud flow reactivation, through large areas of the Western Carpathians, on the Cretaceous and Paleogene flysch, and of the Subcarpathians, on Neogene molasses (Photo 2, 3). Such processes occurred during 1993-1998 and 2000-2002 intervals. After the 1990 s, massive deforestation enhanced these processes. Small deforested river basins provide great quantities of suspended load, transported by the river network, generating some of the biggest denudation rates in Europe. In the Subcarpathians the denudation rates reach 80 t / ha / year in crop fields and vineyards ; 60 t/ha/year on meadows and hayfields and 40 t/ha/year in orchards (Motoc, 1983). As for the suspended load transport, the highest values are found in the hilly regions, affected by landslides, mud flows and gully processes in the south-eastern part of the Carpathians, notably in the Slanicul Buzaului Basin (43 t/ha/year) and in the Calnaului Basin (56.5 t/ha/year).

V Sustainable development trends

The Carpathians are mountains of medium altitudes, fragmented by numerous valleys and depressions, fact that conferred them favourable conditions for intense human activities. Their depressions and valley corridors are densely populated, being important and intense Transcarpathian traffic routes. In the Western Carpathians there is a great number of settlements spread out on mountain ridges and plateaus, up to a maximum altitude of 1,600 m. Higher densities of settlements are found at 500-1,100 m altitude.

The economic activities are mainly wood processing and mining, as well as animal breeding and agriculture, practiced especially in the depressions. The main activity in the Southern Carpathians is transhumant shepherding (Photo 4), considering the fact that these mountains hold the most extensive meadows in Europe, in the alpine and sub-alpine belts.

Human impact on the Romanian Carpathians has induced some specific types of landscapes, which react differently to the environmental changes. They are as follow :

- wooded landscapes characteristic for the mountain area : one may even speak of a "civilisation of the wood" ;
- pastoral landscapes: pastures and hayfields are areas of temporary settlement (rooms, sheepfolds, shelters etc.) in which typically montane crafts, connected with the cottage industry and the small industry are performed
- agro-pastoral landscapes : Maramures, Giurgeu and Ciuc depressions (Eastern Carpathians) or Hateg Depression (Southern Carpathians) ;
- agricultural landscapes: dominate the low depressionary areas or river terraces ;
- industrial landscapes with industries related to mining activity and wood processing, typically for some depressions and valley corridors (Mures, Bistrita valleys).

Beginning with the '50 s, the communist regime led to a rural exodus, a phenomenon with profoundly negative social and economic effects. Although collectivization in the mountain was not so extensive (yet significant in the depressions), it weakened both the peasant's link with his land and the family ties. This transformation of the peasantry's traditional

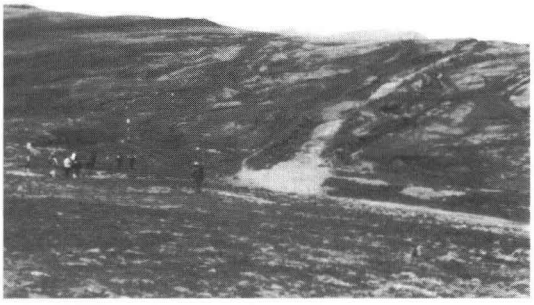

Photo 4 Alpine pastures degraded by touristic activities and overgrazing, Southern Carpathians

life-style has led to depopulation and demographic ageing of mountain villages, and of all villages, for that matter.

Heading towards a free market economy means dealing with a series of problems regarding the implementation of sustainable development measures in the Carpathian mountain space. The necessity for supporting sustainable development comes against a background of a lasting economic crisis, huge lack of funds and great environmental problems inherited from the communist system. These problems are referring to some spaces with a critical environment due to the mining industry, chemical and metallurgic industrial pollution and the population's attitude towards the environment.

Presently, authorised bodies are trying to integrate the current environmental problems, specific to mountain areas, into economic development plans. In this respect, the Ministry of Agriculture has set up a department dealing with mountain agriculture and sectors for the training of farmers at Vatra Dornei and Sibiu. A series of measures have been taken for the development of rural tourism and eco-tourism, the improvement of the forest ecology and the management of hydrographic basins, as well as the organisation of national parks. These activities are financed by different international programmes, such as, SAPARD, ISPA and LIFE. Rural tourism development is based on the ethnographical traditions such as wood sculpture, glass-icons as well as on animal breeding. Simultaneously, traditional festivals are getting more and more support. In what regards the mountain agriculture development, especially in deperssionary areas, family associations and agricultural societies are encouraged, in order to assure a balanced exploitation of land resources.

Within another context, the Romanian Carpathians preserve unique landscapes, little affected by human activities, large forest areas, a rich fauna of big mammals, which become almost extinct in other mountain chains, ethnographic traditions, a real potential for rural tourism and also human settlements with traditional activities. All of them are suitable conditions for a future sustainable development in the mountain area, within the context of environmental global change.

The Romanian Carpathians preserve the most extended primeval and quasi-primeval forests in Europe, covering a total area of 400,000 ha (Giurgiu, 2001). Their conservation is of major importance for maintaining biodiversity in the mountain space. Besides these areas, there are large perimeters ofdegraded forests that need urgent recovery and protection measures. Uncontrolled deforestation, poaching, illegal tree cuttings have caused great losses to the national forest fond. Giving back the forest lands to their former owners and the uncertainties of an evasive legislation have kept and supplied illegal deforestations and forest' overexploitation. Under these conditions, the current researches are focused more and more on forest management based on the structure and functionality of the natural forest ecosystems. In order to comply with the European legislation, a condition for our adherence to the EU structures, and with climate changes, it is estimated that in 60% of the forests the preservation of the ecological function should become a priority (Giurgiu, 2001).

Sustainable development in the mountain space requires the organisation of a national system of protected areas (national parks, natural parks, natural and biosphere reserves). The efforts made to align the management of these protected areas to the international regulations, mainly to the Community Aquis, ask for the ecological reconstruction of degraded territories, the further identification and protection of areas with highly valuable landscapes and of those important for the conservation of biodiversity. The Carpathians were selected and listed in the WWF "Global 200", being considered one of the most important ecoregions in the world in regard of the preservation of habitats and biodiversity. Starting with 1999, the Romanian Carpathians are part of the "The Carpathian Ecoregion Initiative" International Programme, whose major objective is integrated conservation of the natural and cultural heritage and cross-border sustainable development of this mountainous space.

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本論文は2002年10月24日に法政大学でバルテアヌ博士（Dr. Balteanu）が行った講演の一部であり，日本語要旨は漆原和子が書いた．この講演は，2002年度法政大学大学院の費用により実行した．