

DAMAGES ASSOCIATED TO 1995–2006 FLOODS AND FLASH-FLOODS IN THE EAST OF THE APUSENI MOUNTAINS

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ABSTRACT. During 1995–2006, the Eastern Apuseni Mountains was affected by floods which generate damages almost every year, observing an increase of their frequency towards the end of the mentioned period, when, in only two years (2004–2005), there were manifested nine episodes of such phenomena. The damages analysis was achieved by direct questioning, based on the observation data and reports of the County Inspectorates for Emergency Situations and other competent authorities during the period 1995–2006. Counting the direct damages generated by the floods in the region during the above mentioned period, the total summed 75.624 million US dollars. Among the main socio-economic objectives, traffic infrastructure proved to be by far the most susceptible to the unfavorable action of the floods (72.1% of the damages overall).

KEYWORDS: floods, damages, the Apuseni Mountains

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Introduction

The floods are widely extended and frequent natural hazards, overlapping floodplains and alluvial fans, locations exposed to a significant anthropic stress. The forecasted increase of floods frequency and intensity, as well as the ongoing urbanization process combined with the growth of assets and goods values are responsible fac-

tors for flood damage increase. Under these circumstances, it is expected that such events affect more people and generate more economic losses than any other natural risk phenomena (Bălteanu and Rădiţa 2001; Romanescu 2003; Wisner et al. 2004).

In Romania, during the last period, high intensity floods have occurred almost every year,

resulting in loss of human lives and significant material damages. Between 1991 and 2000, such phenomena have caused the death of 235 persons and have generated about 80% of the damage induced by natural hazards. The most dramatic situation was in year 2005, when 76 persons died and the damages summed up more than 1.8 billion US dollars (about 3% of the GDP) (source of flood damage data: MEWM, 2006).

The studied territory, respectively the Eastern part of the Apuseni Mountains (subunit of Western Carpathians), is located in the Western part of Central Romania and it is composed of the mountain drainage basins of the Arieş (L=114 km, A=2,043 km²) and Someşul Mic Rivers (L=73 km, A=860 km²) (Figs. 1, 2).

The mountains have low altitudes, ranging between 357 m a.s.l. and 1 849 m a.s.l. They cover a large variety of rocks (igneous, sedimentary and metamorphic rocks), which is reflected in the high drainage density and multitude of land forms.

The climate is continental temperate, showing a strong influence of the westerlies. The mean annual temperature in the region is ~6.5°C, while mean annual precipitations range between 1 400 mm in the extreme Western side exposed to the westerlies and 550 mm in the Eastern part affected by foehn-effects. The largest part of the region is covered by forests (57.1%), while the arable landuse covers only 1.4%.

The localities network within the studied area includes a number of 35 administrative-territorial units (32 communes and 3 towns), comprising 421 localities, resulting an average density of 14.5 localities/100 km². The population belonging to the mountainous basins of the Someşul Mic and Arieş Rivers was 78,612 inhabitants at the 2002 census, thus resulting a demographic density of 27.1 inhabitants/ km². The highest density is specific to the "Ţara Moşilor" depression area - 43.6 inhabitants/km² (based on data from the National Census of the Population and Housing, 2002).

Being a mountain region with high drainage density, relatively small basins with steep slopes, thin soils and rocks with low permeability, floods in this region belong especially to the flash-flood type.

Methods

The term "flood damage" refers to all types of harm caused by flooding. It encompasses a wide range of harmful effects on humans, their health and their belongings, on public infrastructure, cultural heritage, ecological systems, industrial production and the competitive strength of the affected economy (Messner *et al.* 2004).

The analysis of the social and economic damages was based on the observation and quantitative data, respectively on a vast and thorough documentation, including a series of reports of various institutions (Ministry of Environment and Water Management, The "Romanian Waters" National Administration, the County and Ministerial Committee for Emergency Situations, Cluj and Alba Prefect's House) on the damages caused by floods at national or local level (no. 8-18 in references section). Regarding the analysis of the ecological impact, personally observations data and channel cross-sections at Câmpeni Station were used.

For flood damage assessment, social, economic and ecologic valuables were taken into consideration. The assessments are mainly focused on the evaluation of direct, tangible damage, especially to buildings, economic assets, loss of standing crops and livestock in agriculture, loss of human life, immediate health impacts, and loss of ecological goods. Damages on assets (buildings, infrastructure) were specified in monetary terms (tangible damages), while others which are far more difficult to assess like casualties, health effects or loss of ecological goods were identified in units (intangible damages). The damage value was established in US dollars, using the leu-dollar exchange rates in the floods occurrence periods. Other evaluation methods like the assessment of indirect losses were not carried out due to the difficulties and problematic nature required for such examinations.

Damages generated by floods

During 1995-2006, the Eastern Apuseni Mountains was affected by floods which generate damages almost every year, noticing an increase of their frequency towards the end of the mentioned

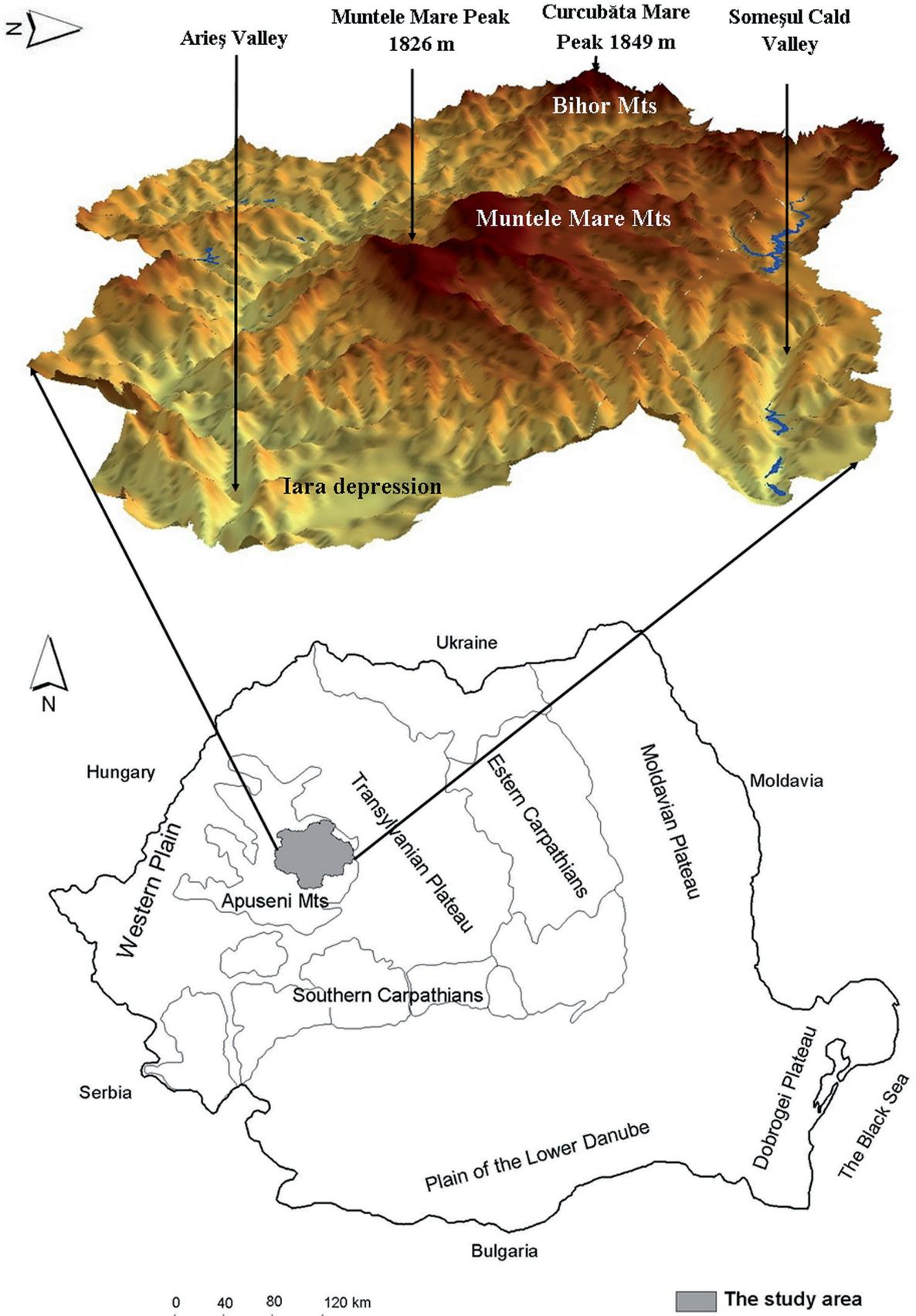


Fig. 1. Location of the study area.

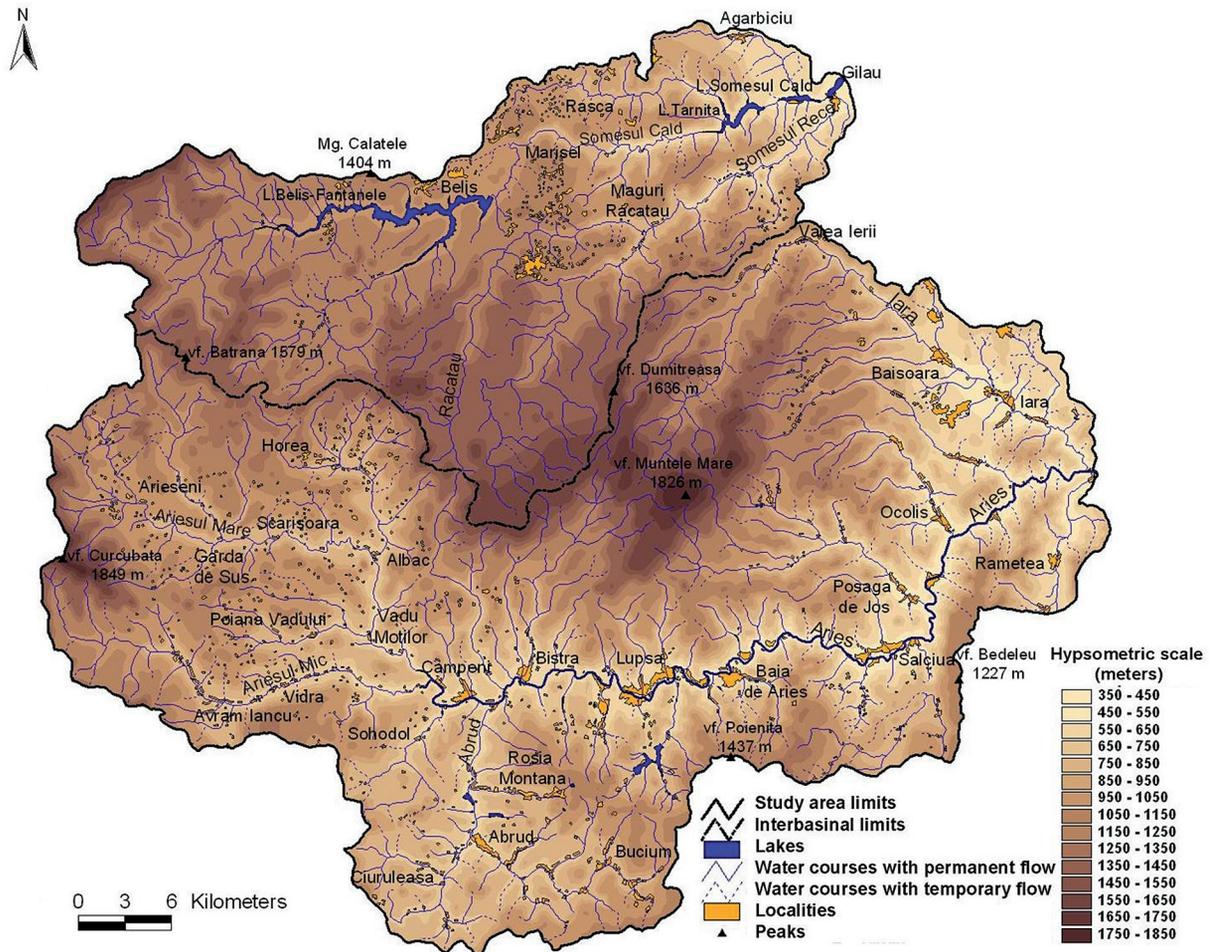


Fig. 2. General map of the study area.

period, when, during only two years (2004–2005), nine episodes with such phenomena took place. Counting the direct, tangible damages generated by the floods in the region during the above mentioned period, the total summed up 75.624 million US dollars. More than half of the damages were associated to the floods in 1995 (40.764 million US dollars (Fig. 3.). Also, during 2000 and 2005 the material losses have exceeded 10 million US dollars, respectively 5 million US dollars. The most significant damages during the analyzed interval were recorded in the Arieş River basin – 63.845 million US dollars (source of flood damage data: Alba CCES, 1995–2006, Cluj CCES, 1995–2006, RWNA, 1996, Alba County Prefect’s House, 1996). During the period 1995–2005, the damages represented 1.07% of the cumulated value of the entire country (72 million US dollars as compared to 5 618 million US dollars), whereas the population of the territory represented only

0.36% of the Romania population (0.0786 million out of 21.7 million inhabitants). The highest percentage value was recorded in 2000, when 8.8% of the national material losses were registered in the region.

Social impacts

Mortality associated with a flood will depend on the flood characteristics, e.g. flood type, but the way people respond/react to floods is a critical factor (Messner *et al.* 2004). In Romania, although the number of deaths caused by floods is not as high as in other parts of the world, flooding is the most common natural disaster, and deaths are not uncommon.

As a result of the authorities’ questionnaires in the 35 local administrative-territorial units of the studied area, the conclusion was that during

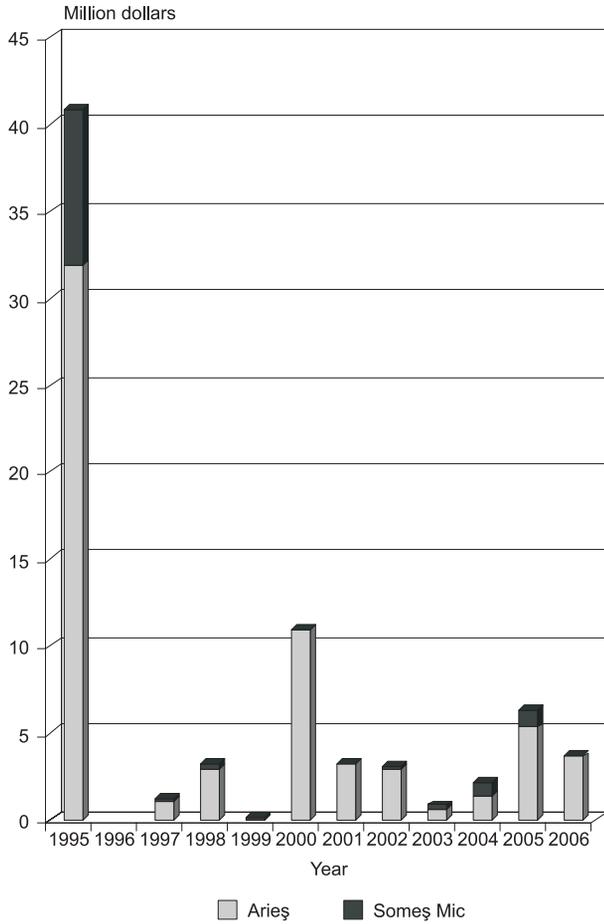


Fig. 3. The damages distribution during 1995–2006 in the mountainous basins of the Arieș and Someșul Mic rivers.

the last 90 years there were 22 deaths as a direct effect of floods and/or inundation.

Regarding the social effects, there can also be mentioned the evacuation actions, the effects of educational activities interruption (e.g. the educational process) or damage of socio-cultural assets (museums, medical and educational institutions/buildings, households etc.).

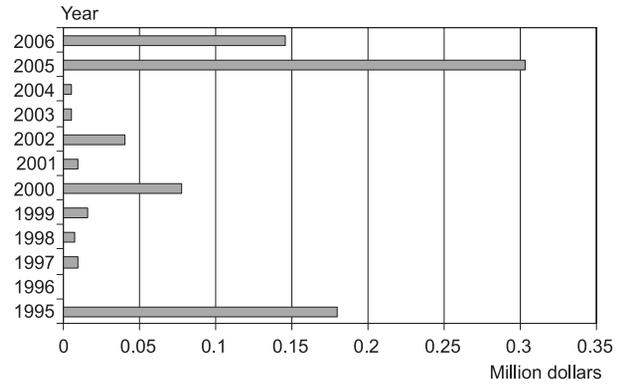


Fig. 4. Evolution of the damages at the level of residential properties in the period 1995–2006.

The total value of the damages caused to the residential buildings exceeded 0.8 million US dollars, during the last 12 years (source of flood damage data: Alba CCES, 1995–2006, Cluj CCES, 1995–2006, RWNA, 1996, Alba County Prefect’s House, 1996) (Fig. 4). At the first overlook, if this is referred to the overall damages caused in the previously mentioned period of time, (1.1% of overall damages), it would be tempting to reduce its significance, due to its low percentage. However, one should not forget that most of the families living in the flood prone areas in the East of the Apuseni Mountains are uninsured, with low incomes and without consistent bank deposits. In these circumstances, any amount of money matters. In the exposed situation, these families loose both material assets, some of them essential for the daily living (house, animals), as well as the necessary time for the repair works. Under these circumstances, these families experience material losses (some of them essential for the daily living like houses and animals), and waste a lot of time for the repair works. In 1995, the flood affected



Fig. 5. Buildings carried away by the Arieșul Mare River in the Mihoiești Reservoir (27–12–1995, video capture).

the largest number of households (1 798 houses and household annexes) and the damages totaled the value of 0.18 million US dollars (Fig. 5).

In the year 2000 severe damages of houses (0.078 million US dollars) were also recorded, especially in the Arieș Basin, upstream of the confluence with the Bistra river.

A much higher value of the damages resulted from the flash-floods occurred in the smaller basins during the period 2005–2006 (0.45 million US dollars), even if these have affected less extensive areas. This situation is due to the fact that the value of properties has considerably increased during the last period (10 times in the 2000–2006). Also, the specific value of the material damages has increased, influenced on the other hand, by the higher flood power.

Economic damages

The analysis of the economic damages was performed by direct questioning, based on the observation data and reports of the County Committees for Emergency Situations, Ministry of Environment and Water Management, The “Romanian Waters” National Administration and Cluj and Alba Prefect’s House, during the period 1995–2006 (ANON).

Among the main economic objectives, traffic infrastructure has proved by far the most vulnerable to the destructive action of floods and flash-floods (72.1% of the overall damages, 54.5 million US dollars, 1,040 km affected) (Fig. 6). The responsible factors are, on one hand the local topography which forces the network of national, county, commune and forestry roads to accompany the watercourses in their immediate neighborhood, and on the other hand the high frequency of flash-floods, with high velocity waters. Also, one should not forget the high specific cost of the road infrastructure works, especially in a fragmented region such as the studied one.

Economically, significant damages were also recorded in the urban public infrastructure (streets, water supply, sewages and water treatment plants, networks and heating stations, telephonic networks, line and gas main systems), flood defense, industrial objectives and less in the agricultural sector (approximately 0.5 million

US dollars). This situation can be explained by the specific characteristics of agriculture in such a mountainous region (animal breeding based on pastures). Besides, in Europe, at regional level, the percentage of damages associated to the agricultural sector rarely exceeds 5% of all economic costs.

The ecological effects

The high intensity of floods in the mountain areas, combined with the specific local economical activities (logging, non-ferrous metal resources exploitation), reduce the positive ecological function of such events.

The high stream power, as well as the significant load discharge, especially during flash-floods, can generate severe damages to the fluvial ecosystem, particularly in such a region, as the study one, with steep stream gradient and many channels contractions. Among these, one should notice channel degradation, alteration of physical, chemical and biological properties of water, land cover change, negative effects on the vegetation, fauna, and soil properties.

In most of the analyzed channel cross-sections there can be observed the prevalence of the deep erosion during the intense floods, in the circumstances of the young valleys predominance, with high values of the stream gradient (Fig. 7). Also, there was highlighted the alluviation of channel of the most important rivers (*i.e.* Arieș river) at the junction with torrential streams.

In specific conditions, the flash-floods determine a high piscine mortality, as a result of water action, of the physical load and of the major decrease of the dissolved oxygen, due to a high turbidity or mobilization of hazardous substances in the water. The suspended load discharge (Q_s , kg s^{-1}) during floods can exceed 2,000 times the annual average value (e.g. Arieș River – Câmpeni hydrometrical station, March 1981 – $Q_{s_{\max}} = 4,500 \text{ kg s}^{-1}$ compared to $Q_s = 2.13 \text{ kg s}^{-1}$). The salmonids are the most affected (trout – *Salmo trutta fario* and grayling – *Thymallus thymallus*), because they are very sensitive to a decrease of the dissolved oxygen concentration in water.

Several bird species nesting near water courses such as the ouzel (*Cinclus cinclus*), the kingfish-

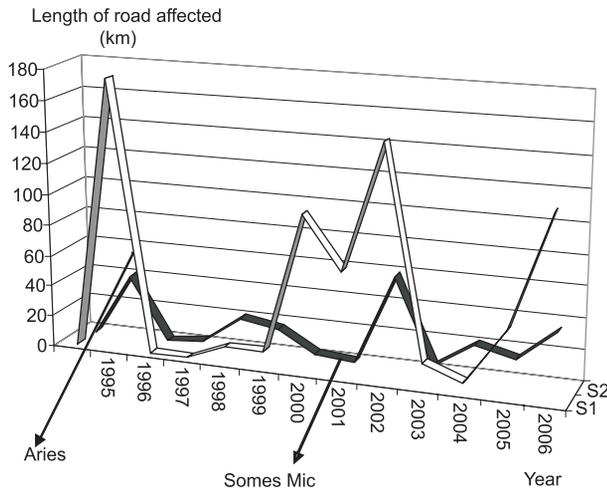


Fig. 6. Length of the roads affected by floods and inundations in the mountainous basins of the Arieș and Someșul Mic Rivers (1995–2006).

er (*Alcedo atthis*), the robin (*Erithacus rubecula*), the wren (*Troglodytes troglodytes*) and several species of wagtails (*Motacilla* sp.) can be affected when the water level rises, especially if the nesting period overlaps the interval of the highest floods frequency.

The timbering is also affected by floods and flash-floods, even if, generally, the damages caused by these natural phenomena are insignificant compared to the volume of illegal regional woodcutting (Fig. 8).

As most of high fertility soils are located in the floodplains, they are also affected by the floods, being subjected to compaction and alluviation processes, and under certain circumstances even heavy metals pollution.

Conclusions

In the studied period (1995–2006), the Eastern part of the Apuseni Mountain has experienced many flood events that have generated important damages (75.624 million US dollars) and even human lives losses (22 deaths). In monetary terms, the road network has proved to be the most vulnerable to the destructive action of floods (more than 70% of the total damage).

The high level of damages is influenced by the specific geographic characteristics of the region, where floods have a higher power and most part of the important localities and economic facilities (roads, industrial units etc.) are concentrated in

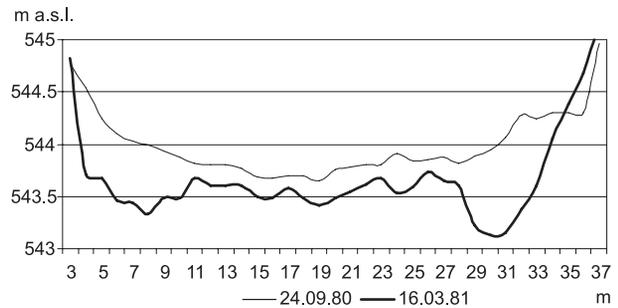


Fig. 7. Changes of the Arieș channel cross-sections at Câmpeni station after the 1981 flood (distance from the bench mark is measured from the left bank) (source: Câmpeni Hidrological Station).

the few existing flat areas which are periodically affected by floods. On the other hand, the high number of people killed in such events can be related to the unexpected character of flash-floods that are prevalent in this region.

Floods are the most frequent natural hazards in the Eastern part of the Apuseni Mountains. In mountain areas such as the studied one, an increase of the anthropic stress in the flood-prone areas is expected. Under these conditions, one should foresee that such events will affect many



Fig. 8. Rootless trees as a result of the violent action of water on the small water courses (locality Baia de Arieș).

inhabitants and cause more economic losses than any other natural risk phenomena in the future. However, there is hope that the negative effects associated to floods will diminish after the year 2015, when, according to the commitments taken towards the Commission of the European Communities, the Flood Risk Management Plans should be completed.

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