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FORESTS AND WATER VULNERABILITY UNDER CLIMATE CHANGE IMPACT IN THE PUTNA RIVER BASIN -VRANCEA

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Abstract

Located in a temperate – continental area the Romania's mainland is influenced in the last period by the worldwide climate changes: extreme weather conditions (high temperatures and prolonged dryness, rainfall accompanied by storm) what have as effects: increasing the risk of desertification, floods, forest fires, erosion, landslides, flash floods, snow squall etc. As precipitation effects have resulted leakage liquid and solid, in particular on slopes without forests, which led to the submission of material eroded in river beds. Concentrating leaks have resulted in an increase in flows of the volume and speed both water on slopes as well as the network of sinks and intensify torrential erosion processes. Floods have been accompanied by intense processes of erosion of the banks causing subsidences or land slides. The other vessel types were excessive transport have clogged hydrological collecting network and as a result, have diminished the ability of transit of liquid flows, increasing frequency and flood, with negative implications for water quality and social and economic activity. The paper, address an integrated approaches cause-effect by analysing river Putna's basin following aspects: analysis of risks and their main causes of, any effects on the ecosystems, vulnerability of water resources, measures to reduce their impact on water resources.

Key words: *climate change, ecosystem, forest, water.*

INTRODUCTION

The current Climate Changes in Romania have imposed a close monitoring of environmental factors and assessments of the causes leading to their appearance.
Romania has faced in the past decades with extreme weather events, which generated great calamities. Floods increasingly common since 1970, caused extensive damages, including the loss of lifes. They were accompanied by torrential phenomena evident watercourses, erosion and landslides, with devastating effects on communities, transportation routes, land and agricultural crops (Panaitescu and Onutu, 2013, Panaitescu and Bucuroiu, 2014). Also, at short intervals, in the plain areas an excessive record dry years of drought, the agricultural crops represent only 10-30% of the corresponding normal years.
The need to evaluate the current status of environmental factors and analysis climate changes influences on the latter can only be achieved by addressing system in an integrated manner cause-effect (Panaitescu at al., 2008). So within this framework of this study, has been taken in view of a European legislation and its implementation at the national level. European legislation direct and related governing quality of surface water is supplied by the main Directive as follows: 60/2000/EC, 2008/105/EC, 2000/60/EC.
National legislation which contribute to the implementation of the Directives is given by: HG (EC) No 964/2000, the law 310/2004, the law on protection of the environment (EC) No 137/1995, amendments to the law on environment No 294/2003. From the point of view of legal rules which are involved in the management of emergency situations in the case of floods and drought normative acts are oriented in two directions: for prevention and intervention in the case of urgent situations. Of these we mention: HG 1489 of 9 September 2004, HG 1490 of 9 September 2004, government decree 21/2004, government decree 15/2004, A88/2001.
River Putna basin represents an area of interest from the point of view of ecosystem changes due to climate change. The Vrancea County is

congruency of factors which may cause human casualties and damage to the human communities, in particular where the manifestation of one hazard produces congruent effects, thus amplifing their effects. Only hidrographic water network inside of Vrancea county measured 1756 km water courses, of total surface area of the catchment area of the river Putna is 274200 ha (approx. 70% of the county surface area). Difference in altitude is one of the most semnificative parametres - max. altitude is 1777 m (vf. Lacauti, the mountain Goru), and spill in Siret, altitude is 12 m. Of the features may basin may be mentioned:

- litology substrate highly varied, fragmented and diverse in composition;
- continental climate with truer excesivitate
- annual average temperature: between 6 - 8 degrees C, up to 10 degrees at the bottom of the basin;
- precipitation: average 600 l/m^2 (between 300 and 1000 l/m^2) of which, rainfall frequencies (40-80 l/m^2/24hours), indicates raised aggressivity; maximum quantity of precipitation in 24 hours was 199.5 l/m^2 and 220 l/m^2 in 2005.

The drainage of the water produces erosion, as a result of which land eroded lose capacity retention and storage of water at the rate of 20 - 90% (Clinciu, 2006; Untaru et al., 2006). Such lands represent segments of the most powerful altered environment: they promote and enhance environmental disturbances, being the main outbreaks of other vessel types were supply during floods, adversely affecting considerably biological diversity and habitats

In Romania, water erosion affects about 47% of the agricultural area of the country, over 6 million acres (and only 2.3% of forest area) and landslides over 700 000 ha (and only 1.5% of the forests - approx. 100.000 ha). Out of these, about 2-3 million hectares are excessively strong degraded, unsuitable for agriculture (Giurgiu, 2010).

Among the factors having a significant impact on forests and waters are mentioned:

- landslides and ruptures of banks are strictly local phenomena, even so they have increased by 10 times in the past decade as a result of torrential rainfall. Affected lands represent segments of the most powerful altered environment: they promotes and enhances environmental disturbances, are the main outbreaks of other vessel types were supply during floods, they affect powerful biological diversity and habitats;
-reducing consistency of forests, either because drying in areas exposed to drought, either because injuries due to wind, storm, snow - in areas of hill and mountain, in particular to resinous. Although reduced weight of the total surface area, forests affected have become unfit from the point of view of operational efficiency. Reducing consistency, lead to proportional reduction in the retention capacity and in this way to increase in the volume of leakage and superficial processes are resumed by erosion.

MATERIALS AND METHODS

The recent Climate Changes lead to increase the risk of injury to forests and degradation of the environment through concerted action of dangerous factors, leading to the necessity of monitoring of forest ecosystems and quantifying environmental impact on the environment, with the view to substantiation methods of sustainable forest management to reduce negative effects of these changes.

Climate change influences studied in the paper, have been determined through the evaluation of status of forests, vulnerability of water resources in the area being studied and flood risk analysis and slides (Table 1).

Evolution of the health of the forests is evaluated since 1990 in the national network of national monitoring surveys of the forest vegetation. Followed characteristics, setting mode, collection and processing of data are consistent with the methodology used by the ICP Forests of UN / ECE and the EU, and data recording is performed annually.

Continuous monitoring of air pollution effects on forests and soil acidification are tracked in the forest monitoring.

Further information on injuries forest ecosystems are provided by the administrative structures of forest department.

Landslides and floods are natural hazards in close liaison with torrential floods, that is with water leakage on hillsides not protected by forest vegetation shield (Constandache et al., 2012).

Table 1. Studied climate changes influences, recorded phenomena and main causes

Climate changes influences	Recorded phenomena	Main Causes
Floods	- accelerate flood frequency and intensity, as a result of rapid leak water from precipitation and soil erosion, with negative implications on the goals were intercepted (towns, roads, etc.); - drop in potential hydro power plant and resources of drinking water; - instability agricultural production, by disturbance of hydro balance and emphasize this phenomenon of drought; - reducing economic and tourist potential of affected areas.	-abundant precipitation or long duration precipitation unsecured or undersized dams, obstacles in the waterbed or blocking irregular water courses -wide variety of climatic conditions, strain reliefs, undercoat lithological and vegetation, give rise to an configurable high potential to natural risks
Natural risks	Storms, floods, drought, freezing and destructive phenomena of geological origin: landslides and earthquakes.	Dangerous meteorological phenomena

Putna river basin's water resources vulnerability estimation was done with water quality indices.The quality indicators that may help to estimate the vulnerability of surface waters from Putna river area were chosen WQI (the Water Quality Index) (equation 1, Table 1) (Adriano et al. 2006, Panaitescu et al., 2014).

$$\mathrm{WQI} = \left(\sum_{i=1}^{n} q_i w_i\right)^2 \tag{1}$$

where: WQI is the Water Quality Index
i– the quality parameter
q_i– the registered value
w_i – the rank of implication of the parameter in the computation formula.

RESULTS AND DISCUSSIONS

1. Forests status evolution

In Putna basin, in addition to the anthropic factor, in the outbreak of torrential phenomena, an important role has the climate factor as a result of climate changes caused by global warming.

Most of the forests are located in mountainous and hilly areas with steep slopes, substrate lithology predominantly sedimentary nature, which increases the vulnerability of land to erosion, landslide, etc. clogging. It is estimated that more than 75 - 80% of the forest area is vulnerable to various forms and intensity of degradation. Maximum leakage may reach 80-90% of the annual average leakage in the mountains and this value may exceed 1.5-4.0 times in the hills, during the heavy rains, when

floods occur. By erosion of upper' horizons soil, water circulation on slopes is amended essential, reducing speed and capacity of the water infiltration into the soil and, by default, the availability of water which runs out on slopes. It also reduces resistance and soil and to the impact of the rain drops. On hillsides libelled soils remain at low level of humidity, similar to those of the steppe.

2. Water resources vulnerability

Water is one of the most important natural resources that come from the mountains, mostly wooded. Considering that drains water from precipitation and erosion occurs on any sloping ground, it can be inferred that, depending on the surface characteristics that fall precipitation and rainfall characteristics, hydrological balance is very different.

With climate change, the frequency and intensity of heavy rains have increased. These phenomena are accompanied by torrential evident watercourses, erosion and landslides, with devastating effects on communities, transportation routes, land and agricultural crops. Phenomena rains and land degradation, exerts negative effects on a much wider area than that they occur, as a result of disruption of the hydrological regime of watercourses, resulting in periods of excess rainfall, flooding in downstream areas clogging with silt reservoirs, ascension beds of watercourses etc.

Flash floods are floods which occur very rapidly in watersheds with relatively small area, being typically caused by high intensity rainfall.
Putna River has a high torrentiality indicated by:
- 275 torrential basins, 764 km degraded bed of the torrent representing about 60% of hydrographic network, located in the mountains and high hills;
- over 1/3 of the agricultural lands in the hilly region affected by erosion, gullying or sliding;
- the report between the maximum discharge (1323 cm/sec) and middle discharge (15.4 $cm.sec^{-1}$);
- annual average flow of sediments transported (16.4 $t.ha^{-1}.year^{-1}$).

Specific conditions of degraded lands imposed the performance of special works to strengthen the ravines, torrential river beds and planning / consolidation of the slopes for planting and use of specific procedures for afforestation (Constandache et al., 2010). Hydro technical works (Table 2) are decisive on their turn, for stabilising (fixation) of core levels for silt retention, creating reservoirs for flood mitigation, for providing the necessary balance for installing vegetation.
Hydro technical works are located on the most neuralgic segments of hydrographical network, on the basins that whites "alluvial sources" marked by excessive erosion and subsidence and landslides sides and consist of cross work (rails, sills and dams) and longitudinal (groynes, defences the sides, whites regularization channels).
Pluviograph records made by ICAS notes that the decisive factor in producing shower leakage is represented, in particular the size and intensity of the rains. The most aggressive proved to be rains greater than 40 mm in 24 hours, especially when they fell on the ground saturated with water from previous rainfall.

Table 2. Clasification of transversal hydrotechnical works

Useful height (measured on the upstream - Y_e)	The construction material the running	After discharge silt mode through the body work	After sizing assumptions and methods
- barages, Y_e>1,5 m; - aprons, 0 m <Y_e<1,5 m; - traverse, $Y_e \approx$ 0 m.	- Wood; - Dry stone masonry (wrapped in wire mesh or not); - Stone masonry mortar cement; - Plain concrete; - Reinforced concrete; - Earth; - Mixed;	- monolithic; - filter.	- free admission of streaching efforts on the parameter upstream ($\sigma_B = 0$); -on admission of streaching efforts on the parameter upstream ($\sigma_B < 0$).

Critical season lays between May 1 and August 15, during which over 75 % of the heavy rains fell, often accompanied by thunderstorms and hail (Untaru et al., 2006). In the last few years, critical periods are different to a temperature rise in the area concerned with approximately 1.15°C went to the variation in quantity of precipitation with - 4.2%, which shows alternate periods will take vengeance with those abundant in precipitation has stopped.
Such water quality varied greatly deteriorates substantially over continuously.
Water quality index registered in Putna basin area indicate a moderate water quality (Table 3).

3. Flood and landslides risks analysis

Global climate change have as result in an increase in frequency and intensity of torrential floods and boosting their negative effects. Relief has a dominant role in the outbreak and development of processes of erosion and mass movement of land. Erosion intensity is directly proportional to the slope of land, the energy relief, relief or fragmentation density hydrographic network. In mountain area density varies between 1.7 and 2.9 km/km^2, and in the Subcharpatians between 1.4 and 3.0 km/km^2 - above 1 km/km^2 = configurable stronger in erosion.
The lithological substrate consisting of soft rocks has a high predispozition to erosion and semi-hard rock alternations causes high predisposition to sliding, while substrate composed of hard rocks show a lower predisposition.
The obtained results led to the finding that rain under 30 mm, with a weight of 50 ... 55 % of

the total amount of rainfall that caused leaks, generates more than 15% of the amount of erosion, and the highest of 30 mm, 85 % of the eroded material. Average turbidity (loading suspended silt) of drained water was 84 g/l in the case of very strongly and excessively eroded lands, without trees, 7...13 g/l for degraded forest, while in mature beech forest this indicator was 2.6 g/l.

Table 3. Water quality index registered in Putna river basin

River/Tributary	WQI, %	Status
Putna	67	moderate
Naruja	58	moderate
Zabala	55	moderate
Milcov	62	moderate

Accordingly, the average specific erosion was 57.5 $t.ha^{-1}.year^{-1}$ for fields with active erosion practically treeless, and only 0.41 $t.ha^{-1}.year^{-1}$ in pine forest cultures, aged between 15 and 20 years (Untaru et al., 2008). However, it must specify that if excessively eroded land with slopes greater than 30 degrees, totally devoid of vegetation, the average specific erosion determined by measures of observation reached values of 300 $t.ha^{-1}.year^{-1}$ approximately.

For an efficient management of all categories of risks, the responsible authorities should have an integrated vision and innovative one. Dealing with each risk, in the current context, is one of the simplistic method without dramatic changes in practice. Modern vision should include an algorithm of work which in principle has to comply with following steps:

- to establish specific hazards;
- to determine specific vulnerabilities of each hazard;
- to determine specific risks of the established area and draw up The Community Risks Scheme;
- to establish a hierarchy of risks, in relation with the levels of values (levels of break down), the parameters and the effects on the communities: loss of life; the value of damages on property; any effects on utilities, works of defence; critical infrastructure;
- to establish combined effects (composed) risk scenarios: earthquake + flood + chemical accident + number of fires + cut-off of electricity, gas, water, sewage. These scenarios and their effects should be studied and implemented in specialized software in order to generate the following step – Plans so next step to be;
- generation of the intervention plans - plans that may be generated on the basis of the value of the parameters to which they are studying scenarios, depending on the existing response capabilities and needs, plans which may be used in the case of the outbreak of any type of disaster (ex: plans with the expanding capabilities of hospitalization, transport, wounded, triage);
- publication of plans;
- education of citizens and economic operators;
- practicing plans through exercises and correcting them.

CONCLUSIONS

Climate changes influence on the fauna of pelvis area Putna-Vrancea monitored in the work can be reversible and difficult to control.

Forest ecosystems properly maintained play an important role in retention, water filtration and regulation of surface watercourses, reducing the soil erosion and transport of sediments, all of which result in maintaining water quality and ensure a permanent water flow.

The size, structure and health of forest ecosystems are vital for ensuring water resources and water purification. The interaction between population growth, urbanization and development of water requirements, between the flood control/flood and operating mode/change of utility, requires restoration of degraded land and planning of hydrographic basins in a manner that provides ecosystem services becoming more sustainable. Moreover, these engineering activities closely related to forestry, have been and are accepted worldwide as an effective tool to maximize ecological services and ensure clean and stable water resources.

Low percentages of forest areas in the lowlands is correlated with frequent and prolonged dryness, as well as deforestationsof the hillsor massive cuts of forest in certain mountain is correlated with torrential, degradation of land and landslides phenomena.

On the basis of the data submitted and taking into account the fact, that losses caused in the case of floods 2005 of river Putna, amounted to over 30 mil EUR (of which about 7.35 mil EUR in forestry fund) measures should be taken for the protection and rehabilitation of the ecosystem such as:

-defense strategy adaptation to floods and land slides from the current challenges of climate change, including the harmonization with modern operating systems environmental management;

- passing on the first plan of activities involving the prevention, minimise risk of producing flood or landslides and to minimise the negative impact of them. Will be worked out in full construction of the hydrographic basins, extensive afforestation programs and to promote good agricultural practice in the context of sustainable use of these resources, Improving legislative and institutional framework;

- promotion of training activities, awareness-raising and education of the authorities and the population, on line effects of floods, landslides, including the measures which may be taken at a local level to mitigate socio-economic consequences of their.

A good risk management is a result of intersectoral, interdisciplinary activities which may include: inclusion of research in the framework of the evaluation process of the risk, integrated water management, regional planning and urban development, nature protection, agricultural and forestry development, as well as protection of the transport infrastructure, masonry preservation and protection of tourist areas, community and individual protection, each sector being responsible for in carrying out specific activities.

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