Surface Hydrology and Soil Conservation in Volcanic Islands; Strategies Against Climate Change

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Surface Hydrology and Soil Conservation in Volcanic Islands; Strategies Against Climate Change

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Abstract

The present study describes the hydrologic characteristics of volcanic islands erosion and identifies problems that occur in them. In order to manage and mitigate climate change is necessary watershed management of the islands, including the management of natural hazards through its analysis, flood estimation and stability of slopes and embankments because the torrential rain regime, and finally erosion control and soil conservation, one of the main problems of oceanic islands that directly and indirectly affect its hydrological cycle.

Keywords: hydrology / oceanic islands / climate change / water erosion

INTRODUCTION

The islands are isolated systems, this has meant to evolve as different environmental units with respect to the continental land in several aspects (Santamarta, 2013); on one hand plant diversity -including endemism- that in most of the islands is present, this effect is greater the more distant to continent, all resulting from a combination of evolution and geographical isolation. The other aspect to consider is the origin of volcanic islands, produced by a volcanic eruption located on the seabed. The islands have a short life cycle compared with the continental land and from the beginning, go through the following stages: (i) seamount formation, (ii) growth, (iii) collapse building due to large gravitational landslides and erosion processes, and finally (iv) sinking under the sea.

They also share common environmental, economic and social characteristics such as: (i) unique forest ecosystems and highly sensitive species to small perturbations in habitats, (ii) botanical singularity, (iii) high presence of the primary sector, (iv) dependence on tourism as an industry, (v) high energy dependence but can integrate renewable energies, (vi) high population density -an illustrative example is Hawaii that has the highest population density in the United States. Even edafologic levels between the volcanic soils in the islands are more similarities than differences.

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HYDROLOGY OF VOLCANIC ISLANDS

Watersheds in the islands show a morphology bounded by ravines, when there have been conditions of precipitation and significant erosion over time (Fig. 2), these are very pronounced in the highlands of the islands -greater concentration of precipitation in the rift zone-, also they are smaller than in continental areas, the terrain is steeper, especially in young islands, when the ravines are close to the coast lines and become more stretched and widths. It is necessary to take certain precautions while technical projects are drafted, specially related to the estimation of surface runoff, because the formulas used to continental terrains tend to overestimate the runoff amount, according to some studies carried out (Santamarta, 2013).

Except very specific archipelagos, such as Hawaii, volcanic islands tend to not have continuous rivers, but small streams especially after heavy rainfall episodes can occur. This means that only a small percentage of the surface water resources are used (mainly in agriculture). In some cases, these waters are mixed with groundwater of lower quality -with high content Sales- to improve the final characteristics of the waters. It may seem that the volcanic islands with heavy precipitation rates such as the island of Terceira in the Azores with 1,300 mm on average per year or Jeju Island in South Korea with a rainfall of 1,975 mm per year may have rivers throughout the year, which does not occur due to the permeability of the volcanic terrains in the islands (Jong-Ho et al., 2005).

The surface exploitation is based on use of water that flows through the ravines when they are perennial -occasionally-, or temporary when there is significant rain amount. Conventional water dams are used to collect the water in the ravine itself if geological conditions are possible; in other cases, indirect methods as channels in ravine (known as "tomaderos" in local terminology) are used. After that, surface water is led to other dams or water basins waterproofed artificially. It is desirable that the water collected come with fewer sediments in order to not decrease the ability of storage both dams and basins.

Numerous water harvesting systems are described in which forestry engineering, historical tradition and specific strategies in semiarid land are combined, often of Arab origin, in order to increase the availability of water resources in crops.

STRATEGIES FOR SOIL CONSERVATION AND WATER HARVESTING

Erosion occurs when conditions are favorable for detachment and transport of soil particles. Both sheet erosion and rill erosion are caused by the impact of falling raindrops, the shear surface runoff and concentrated flow channels, and the combination of both processes. Factors such as climate, soil erodibility, tilt and length slope and vegetation cover conditions determine the magnitude of the erosion rate.

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Figure 1. Rill erosion on the island of La Gomera

To reduce erosion many practices have developed, not all of them universally applicable; however, wherever the erosion phenomenon occurs, there are three basic principles for effective control, not only of water erosion, but also wind erosion:

- Increase the resistance of the soil to erosive forces
- Reduce the erosive force of flow
- Reduce the impact of falling raindrops on the ground

Soil resistance to erosive forces is increased by improving the structure and stability of the soil, through measures such as addition of organic matter or other chemicals (lime, gypsum or fertilizer), and certain farming (topographic contours, terraces).Maintaining a permanent cover to protect the soil surface mainly reduces the impact of falling raindrops on the soil. The reduction of the erosive force of the flow is achieved by reducing the runoff amount and flow rate. The resistance to flow velocity can be increased by several practical applications, such as building of barriers or terraces. It is also possible to use hydraulic retention structures, piping and control of water and storage (Santamarta, 2011):

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Figure 2. Construction of a sediment retention dam

One of the biggest problems facing soils in the volcanic islands are forest fires. The effect of fire alters the physical and hydrological properties.

DISCUSSION AND CONCLUSIONS

The origin, geology and the formation of volcanic islands significantly determine the development, use and both positive and negative effects of water resources in the island environment.

Water and natural resources must be managed in a special way and jointly, taking into account the peculiarities of the volcanic island systems and its water resources; this means that sometimes the strategies and methodologies used in continental land need not be valid for limited and heterogeneous spaces as the islands.

Part of the solution to the shortage of water resources and erosion control is in sustainable forestry in addition to the construction and maintenance of aquifer protection areas corresponding to natural spaces.

Finally the following actions are necessary: i) surface water sources uses and control of associated natural hazards, (ii) reduction of surface runoff are necessary and therefore erosion rates, (iii) planning and management of natural areas for mitigating the effects of torrential rains, (iv) improving the processes of infiltration and groundwater recharge by increasing and

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treatments of the vegetation cover, and (v) soil conservation by water infrastructure and mitigating of its effects by immediate post fire hydraulic performances (Santamarta, 2013b).

REFERENCES

Jong-Ho, W., Ji-Wook, K.; Gi-Won, K.; Jin-Yong, L. 2005. Evaluation of hydrogeological characteristics in Jeju Island, Korea. *Geosiences Journal*, 9, 33-46.

Santamarta J.C. (2013a). *Hidrología y recursos hídricos en islas y terrenos volcánicos. Métodos, Técnicas y experiencias en las islas Canarias*. Tenerife: Colegio de Ingenieros de Montes.

Santamarta J.C. (2013b). *Ingeniería Forestal y Ambiental en Medios Insulares.* Tenerife: Colegio de Ingenieros de Montes.

Santamarta J.C. (2014). Hidrología de las islas volcánicas; singularidades y contribución de la ingeniería forestal. *Revista Montes*, 116, 26-31.

Santamarta, J.C. (2011). Estudio y evaluación de las hidrotecnias e infraestructuras hidráulicas, para la prevención de la desertificación , en el Archipiélago Canario. *Cuadernos de la Sociedad Española de Ciencias Forestales*, 32, 109-115.