Los efectos de "Jova" en el municipio de Autlán de Navarro, Jalisco, México: un caso histórico

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Resumen

Este trabajo proporciona información de los efectos del Huracán "Jova" el pasado Octubre del 2011, fenómeno clasificado como atípico en el municipio de Autlán de Navarro, Jalisco, México. Registrado en un período de tiempo de 18 horas, con 330 mm de lluvia acumulada promedio (período de retorno de 75 años); lámina que alteró la capacidad de escorrentía en los cauces fluviales, causando desbordamientos y daños severos en zonas urbana y agrícola. Éste favoreció el ciclo de lluvias anual de la región (más de 40% de lámina precipitada) y el volumen total de capacidad de las presas (más de 45%). El objetivo fue describir y analizar la distribución del huracán "Jova", su impacto e interacción en los usos del suelo como actividades primarias; se resalta la importancia de la información climatológica, útil en la toma de decisiones y en la planeación estratégica del territorio.

Palabras clave: Huracán "Jova", precipitación pluvial, volumen medio escurrido, sedimentos.

Abstract

This paper provides information on the effects of Hurricane "Jova" last October 2011, classified as atypical phenomenon in the municipality of Autlán Navarro, Jalisco, Mexico. Recorded in a period of 18 hours, with 330 mm of accumulated rainfall average (return period of 75 years); sheet that altered the ability of runoff to river channels, causing severe flooding and damage in urban and agricultural areas. This favored the annual rainfall cycle in the region (over 40% precipitated sheet) and total volume capacity of the dams (over 45%). The aim was to describe and analyze the distribution of hurricane "Jova", their impact and interaction in land use as primary activities highlights the importance of climate information useful in decision-making and strategic spatial planning.

Key words: Hurricane "Jova" rainfall, average volume drained, sediment.

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Introduction

The water cycle and its components of precipitation, runoff, evaporation, evapotranspiration, infiltration, and other associated processes are central topics in hydrology (USGS, 2006). Each of these components present spatial and temporal variations, which play a critical role in various natural processes (physical, chemical and biological) that regulate terrestrial systems; on these, human activity is intrinsically related (Dunne and Leopold, 1978; Mendoza et al., 2002; Kalbus et al., 2006). In this sense, Hoover and Hursh (1943), state that the different topographic conditions, vegetation and depth of the soil, are inherent conditions and therefore, identified within a drainage area or hydrographic basin; These, together with the climatic characteristics, are the main causes of the hydrological variations registered in these areas and with it the hydrological cycle, which can be modified based on the different land use practices that are implemented.

This response is recognized by UNESCO (2003; 2006), as local alterations that human beings produce in the hydrological cycle, which can have global implications of great impact. And before this, changes in climatic conditions, which directly affect their different economic activities, which are accentuated depending on the geographical conditions of each place (Magaña, 2004). Some of these alterations are associated with the volume of water precipitated and captured in these drainage areas or with the volume of water that drains into it; situation that Hoover and Hursh (1943) manifest, are associated by the different soil profiles and the lower or higher topographic elevation found in them. Heede (1985), states in this sense that the effect of soil management (specific in forest areas), increases the surface flow in the lower areas of the basin, thereby reducing transpiration.

In another way, it is related to the amount of water that can be absorbed by the soil. An example of this is a totally impermeable surface (asphalt), almost all the water is retained on it (runoff coefficient almost equal to 1.0) since a small part will be evaporated, and another will circulate as runoff. This effect, at the beginning of a rain event on relatively permeable land (agricultural, livestock or forestry), the initial runoff coefficient can be 0.5, if the rain continues, the land becomes saturated and the runoff coefficient is approaches 1.0.

The runoff coefficient is then known as the relationship between the amount of water precipitated on a surface and the water sheet that runs off the surface (expressed in millimeters); This varies mainly due to the type of soil, the slope of the terrain and the type of vegetation cover. It is expressed by the relation:

$$k = \frac{Pr}{E_s}$$

As:

k Runoff coefficient.

Pr Rainfall (mm).

E_s Sheet of drained water (mm).

The values obtained from this relationship, associated with anthropogenic alterations (deforestation, change in cultivation pattern, expansion of agricultural, livestock and urban frontiers), and regional physiographic composition (physical-chemical composition of the soil, drainage area, dimensions and geomorphological composition of the hydrographic and hydrological basin), would cause large floods in streams and rivers, additional contamination and deep modification of the hydrological cycle. It is then that these large-scale alterations can be conditioning factors to alter hydrological processes worldwide.

However, this runoff is of great importance not only for maintaining river systems, but also because these, for long periods of time, can modify the structural patterns of the earth's crust, or generate large floods in agricultural, livestock and urban areas. Situation that has already been manifested in the constant changes in the local landscape, increasing the erosive process of the soil, and even generating serious human and material losses.

It is then considered that the climatological factors that affect the hydrological processes on the drainage of the basin are, among others, the form, intensity and distribution of rainfall, air temperature, wind speed and relative humidity; but mainly, the formation or type of pluvial precipitation (convective, orographic and cyclonic). In this regard, López and Romero (1992) consider that the energy with which raindrops reach the soil surface (partially dissipated through the uprooting and removal of soil particles and their transport) in addition to the runoff generated, constitutes one of the most important subsystems of the soil erosion process by water. Associated with this, Taguas et al., (2007), establish that topographic controls are impact components in the modeling of the hydrological-erosive process.

This last process, comes to increase exponentially in combination with the increase in the activities carried out by the human being, mainly in the increase of the agricultural and livestock frontiers, and the consequent reduction of the forest area. Situation confirmed by De Alba et al., (2003), when considering that soil management determines the seasonal variability of its covering and therefore, the variability of its degree of protection against rain erosivity.

In this sense, Caviedes (1991) suggests that the diversity of high or low frequency, intensity, duration and distribution in the presence of hurricanes in Mexico have affected precipitation patterns and the subsequent impact on the different urban and agricultural activities. An example of this were the effects caused by Hurricane Kenna (category 5) on October 25, 2002 on the coasts of the States of Nayarit and Jalisco, with which considerable damage was recorded in rural communities and coastal areas, generating considerable losses. economic, being the most important in agricultural, livestock and fishing activities, as well as in communication routes; losses amounting to several million dollars (CRN, 2002).

The objective of this document is to make known the impacts generated by the climatological phenomenon of last October 12, 2011 (Hurricane "Jova"), considering in it the distribution and probability of occurrence of rain, the volumes of runoff generated and the degradation of soil and water resources. Through the database generated, create a sense of planning and prevention of extraordinary events and thereby reduce their impacts on productive activities (primary and secondary), through strategic planning proposals parallel to this document for the municipality of Autlán of Navarro, in the State of Jalisco-Mexico. In it, the different impacts caused in the municipality will be announced, which based on Cardona (1992) could be direct (physical damage) or indirect (social and economic).

METHODS

This work was developed based on the measurements and estimates of the effects generated during the occurrence of Hurricane "Jova" and manifests in the municipality of Autlán de Navarro, Jalisco (Figure 1); it has an area of 71,508.68 hectares, located between the geographic coordinates 19° 34' 42.240" to 19° 57' 52.488" North Latitude and 104° 07' 13.151" to 104° 30' 07.524" West Longitude. The main economic activities that stand out are agriculture and livestock, in addition to the different urban activities such as commerce.

The results generated are based on the historical records of rainfall obtained from the "Melchor Ocampo" Cañero Sugar Mill (INIFAP, 2011), as well as wedge pluviometers (Tru Chek brand) distributed in the municipality by the University Center of the South

Coast of the University of Guadalajara from 2009 the records obtained from these, the volume of water captured in the main intermittent riverbeds (Streams: El Cangrejo and El Coajinque) was estimated, as well as the sediments (in suspension and in the bed) carried by surface runoff. Finally, the average volume of precipitated water was estimated in consideration of land use (agricultural, 28%; livestock 9% and forestry 63%), the slope of the land (0 to 5%, 5 to 11% and >11%). and soil texture, through the relationship:

$$V = Ce \;\; Pm \, A$$

As:

V Precipitated average volume (m^3).

Ce Runoff coefficient (obtained from C.P., 1991).

Pm average precipitation (mm).

A Municipality Area (m^2).

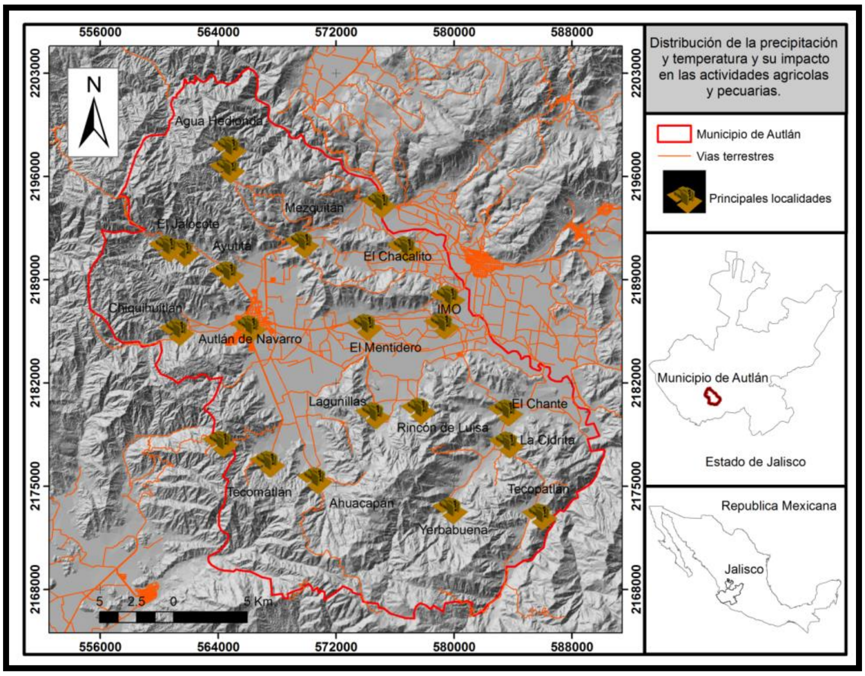

Figure 1. Location of the Mpio. Autlán de Navarro, Jal.-Méx.

In this sense, the use of Geographic Information Systems (GIS) useful in the spatial determination of the distribution of precipitation and temperature within the

Municipality of Autlán de Navarro, Jalisco, is proposed. It is worth mentioning that for the development of this method, the ArcGis V-9.3 program was used. and the information from the precipitation records mentioned above.

RESULTS

Hurricane "JOVA" made landfall on the coasts of Manzanillo and Cihuatlán (in the States of Colima and Jalisco, respectively), on Tuesday, October 12 at 8:30 p.m. under category III (Saffir-Sipsom scale), dissipating on Wednesday around 4:00 p.m. According to forecasts, this meteor was considered to pass approximately 30 kilometers from the municipalities of Autlán de Navarro and Unión de Tvla in category II (Figure 2). Based on this, the mobilization and prevention was established in consideration of the risk zoning recognized by the municipalities, through which precautions were taken, evacuating neighborhoods in risk areas.

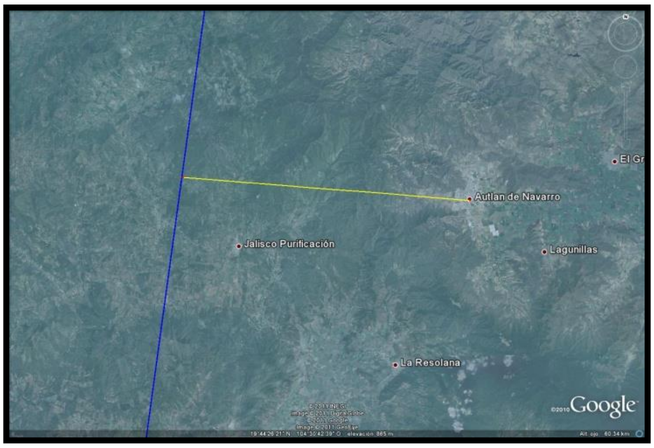

Figure 2. Estimated direction for the "Jova" meteor.

This meteor was the consequence of a low pressure system in the Pacific Ocean, recorded as being of great magnitude according to the bulletin provided by the National Meteorological Service; it presented a trajectory to the coasts of the States of Jalisco and Colima (Figure 3), mainly affecting the beaches of Barra de Navidad, Melaque, La Manzanilla and Tenacatita; and the Municipalities of Autlán de Navarro, Cihuatlán and La Huerta in the State of Jalisco.

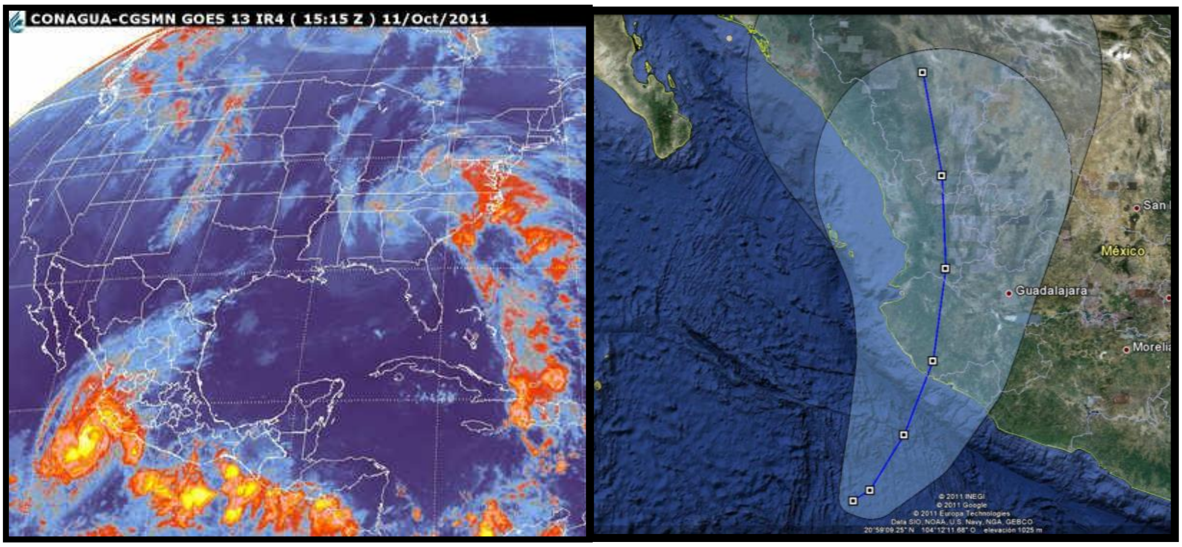

Figure 3. Image of the hurricane "Jova" in the direction of the coasts of the States of Jalisco y Colima, México (SMN-CNA, 2011).

This meteor remained in category III, with an average displacement speed of 7 Km hr-1 and sustained winds of 205 Km hr-1 (gusts of 250 Km hr-1), which generated various degradation processes in its wake. Through the use of the Geographic Information Systems tool (Google Earth) and with data from the National Hurricane Center of the States, it was established that the path of entry of the meteor to the coasts was through the Ejido de la Manzanilla (Jalisco).

For the municipality of Autlán de Navarro, the effects of this meteor were very heterogeneous, an example of this were the rainfall records, which ranged from 230 to 490 millimeters (Figure 4), with an average of 330 millimeters of rain. in 18 hours 30 minutes, time in which the meteor remained (variable with respect to the registration area).

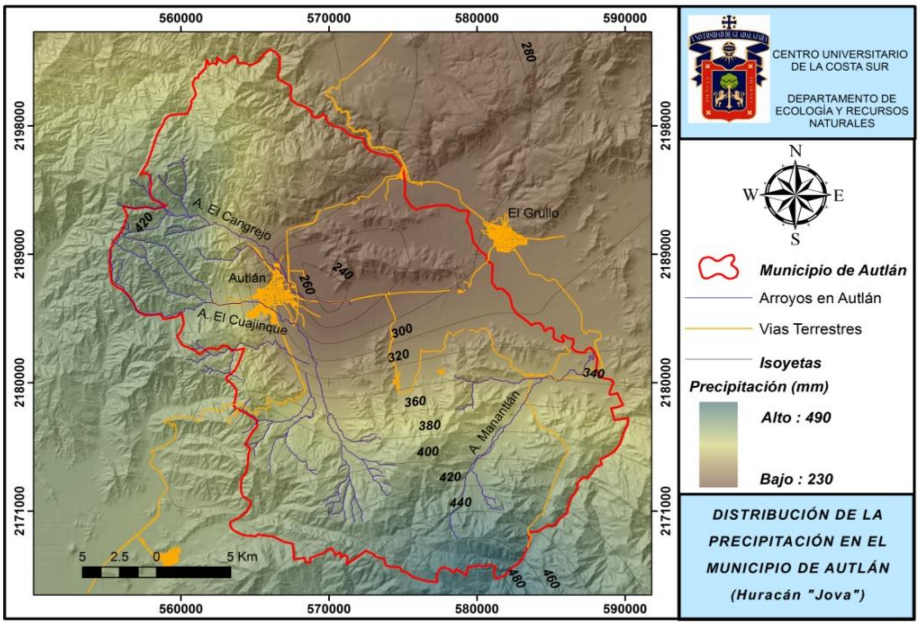

Figure 4. Isohyets of the “JOVA” meteor, Mpio. Autlán de Navarro, Jal -Méx.

From the analysis of the distribution of rainfall, it is shown that there is a heterogeneous pattern throughout the municipality, however, the month of October is framed in response to the meteor "Jova" (Figure 5); values that, when compared to the regional historical, represent a change in the pluviometric records for the Sierra de Amula Region; this response is considered to have been modified due to the intensive and extensive increase in agricultural and livestock activities, as well as the consequent reduction of the forest frontier (deforestation) manifested in the municipality (Miramontes et al., 2009), a situation that has favored climate change in the region and the great impact on the low-lying areas of the municipality of Autlán de Navarro.

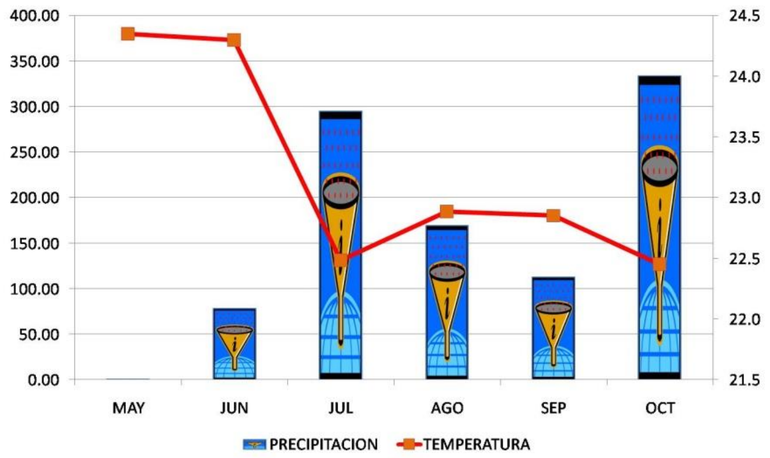

Figure 5. Rain distribution and temperature, Mpio. Autlán de Navarro, Jal -Méx.

Based on historical records, it is established that the greatest amount of rain for the last 10 years has been for the month of July, since prior to these years, September registered the maximum intensity and quantity; being the mountain areas, the areas with the highest rainfall collection (South zone corresponding to Los Mazos and Manantlán, and West zone for El Jalocote); values that are reduced in the area of the Autlán-El Grullo valley and north of the municipality. Regarding temperature, the maximum historical records reported are 37°C for the months of April, May and June, dropping to 20°C during the rainy months (July, August and September).

This phenomenon was considered as torrential with maximum intensities of 65 mm hr-1, which caused overflows in the intermittent streams that cross the "El Cangrejo and Coajinque" municipality, generating estimated maximum runoff greater than 1,800 cubic meters and 11,000 cubic meters per second. respectively (Figures 6 and 7). Based on the 50-year rainfall records for the Sierra de Amula region and this one for the month of October, the estimated return period was 75 years. Notwithstanding this, the volume precipitated during the "Jova" meteor improved the rainy season for the municipality in 2011, since prior to this, the average annual rainfall records were 475 millimeters (sheet of water precipitated by square meter), producing 49% more rain during the event, which restored the historical average for the municipality to 750 millimeters.

Figure 6. Stream overflow El Cangrejo, Mpio. Autlán de Navarro, Jal.-Méx.

Figure 7. Overflow of the El Coajinque stream and rupture of communication routes, Mpio. Autlán de Navarro, Jal.-Méx.

Being the rivers at their maximum capacity and being these overflowed in some sections of their path, some inevitably sought their recognized natural channel prior to the planning and establishment of urban growth (Figure 8), which caused flooding in residential areas and riverbanks. , generating economic losses due to damage to infrastructure and assets (hospitals, houses and bridges, as well as agricultural and livestock plots, among others); situation that led to requests for support from the state and federal government to compensate for the damage, as well as the support of the population to start the cleaning activities of the municipality.

Figure 8. Flooding in the urban area of the Municipality of Autlán de Navarro, Jal.-Méx.

The large amount of energy released by this volume of water precipitated and captured in the upper areas of the municipality, caused visible and irreversible consequences in the lower areas within it, as well as in each of the regions located in its perimeter of influence. An example of this were the estimates made of the sediment dragged (in suspension and in the bed) by the average volume precipitated during this phenomenon, which were greater than 15 million tons of soil, deposited in the lower parts of the urban area, as well as its agricultural and livestock areas (Figure 9). This response manifested by Hoover and Hursh (1943), is increased by the inadequate use of agricultural and livestock practices in the upper areas of the drainage area, thereby reducing water infiltration and storage, accelerating the registration of maximum floods in the lower parts.

Figure 9. Entrained sediment, effect of runoff, Mpio. Autlán de Navarro, Jal.-Méx.

In this sense, the losses in some cases were irreparable, being these mainly manifested in human beings. However, they were also reported in material goods, as well as in primary activities such as agriculture and livestock; For the municipality of Autlán de Navarro, the preliminary records were of 674 hectares of crops affected as well as the loss of 92 head of cattle. For its part, the OEIDRUS-Jalisco (2011), through its representative in the region, Ing. Angelica I. Miramontes C., reports claims in agricultural activities (Figure 10) with more than 13% of the area damaged, in especially in the cultivation of sugar cane (20% of the total area), in cane for seed (80%) and in corn for grain (11% of the total area); as well as in livestock activity, for which losses were reported in beef and dairy cattle (12% of the total registered), and in poultry (2%).

These impacts were, among others, the common denominators that prevailed for at least 15 days after the occurrence of the phenomenon and whose ravages were reported as the damage count was made.

Figure 10. Reported havoc on productive agricultural and livestock activities, Mpio. Autlán de Navarro, Jal.-Méx.

On the other hand, communication between the municipalities of the region was totally interrupted due to landslides in mountain areas or due to the total destruction of bridges (Figure 11), a situation that brought with it food shortages, medicine and transportation (urban and foreign) between the Municipalities of the Sierra de Amula and Costa Sur Regions in the State of Jalisco, generating the search for other means of communication such as air. An example of this was presented by the municipalities of

Casimiro Castillo and Autlán de Navarro, which found it necessary to hire a helicopter (at a cost of 300 pesos per person) to cover the needs of each particular situation.

Figure 11. Damage caused by hurricane “Jova” on communication routes.

The large amount of water generated by this meteor and captured in the municipality was estimated through the average volume (Vm) of precipitated water, a response that manifests itself depending on the region of registration; This was estimated considering the parameters of rainfall, physiography, soil texture and mainly the primary activity or dominant land use of each locality. Being this volume close to 117 million cubic meters (Table 1).

Table 1. Average volume precipitated by land use and slope, Mpio. Autlán de Navarro, Jal.-Méx.

Uso del suelo	***Pendiente***			***Vm (m^3) por uso***
	0 a 5%	**5 a 11%**	**>11%**	
Agricultura	21,687,505.65	6,365,954.27	8,765,428.74	36,818,888.66
Bosque	768,151.35	2,201,383.17	69,207,085.53	72,176,620.05
Pastizal	227,380.61	473,470.14	7,205,888.24	7,906,738.99
Vm (m^3) por pendiente	**22,683,037.61**	**9,040,807.58**	**85,178,402.51**	116,902,247.70

This result with respect to the primary activity, shows an inversely proportional behavior between the response of the average runoff volume and the use of land with respect to the slope of the land. For agricultural activity, the average volume captured is reduced by increasing the slope in a ratio of 6:2; reverse response for forests and grasslands, in these, the volume captured increased with respect to the slope in a proportion of 10:1.

Regarding the benefit obtained for the storage vessels, the estimated total volume compared to the capacity of the most important and largest dams for the Sierra de Amula region in the State of Jalisco, the Basilio Badillo dam (located in the Municipality of Ejutla), as well as Tacotán and Trigomil (located in the Municipality of Unión de Tvla), accounted for more than 80% of its total storage capacity and 78% for the first two, and 46% for the latter. The official records of storage prior to the meteor (October 7, 2011) show 79, 91 and 66% respectively of its total capacity (SAGARPA-Rural Development District V), after this phenomenon, the record of its total capacity was 100%.

Conclusion

There is no doubt that in the presence of natural phenomena, the release of the great accumulation of contained energies has triggered active processes of support and re-humanization in each of the inhabitants of the affected populations; Given this, their landscape and behaviors for themselves and the municipality have been remodeled, strengthening themselves through collective support and citizen participation. In counting the damage, the large investments destroyed and the consequent reinvestment of efforts by the community and the government to compensate, will not always be enough to recover what was lost; however, the spirit and strength expressed by the population shows that no natural phenomenon will be greater than the strength of the human being to rebuild itself.

Given the great devastation caused by the "JOVA" meteor, on October 13, 2011, in an extraordinary session of the full council of the municipality of Autlán de Navarro, it was officially declared an emergency zone, as a consequence of the damage caused;

damage that was evaluated by State Civil Protection, and from which, the State Fund for Natural Disasters (FOEDEN) and the National Disaster Fund (FONDEN) were accessed. Those that to date, have not been received.

Despite the fact that these damages are difficult to quantify, they have been solved to the extent that they have been revealed by different means, the union of municipal, state and federal efforts to support the disaster zone, as well as the System for the Integrated Development of the Family (DIF), the State Unit for Civil Protection and Firefighters (UEPCBJ), as well as the University of Guadalajara through the University Center of the South Coast.

The impacts of Hurricane Jova, were reported in different magnitude for each population and/or ejido of the municipality, this in consideration of its geographic location, as well as the physiographic conditions and the productive activity developed. This damage was reported in a similar way for the coasts of the State of Jalisco, manifesting the affectation of 40 neighborhoods and 2600 flooded houses; placing 4,200 people in different shelters and 8,000 with relatives.

The "JOVA" meteor, compared to the well-known "EL NIÑO" phenomenon, generated the same amount of continuous rain in 18 hours, unlike the latter, recorded in 15 days. Given this, it is considered that maintaining permanent and updated climatological records allows the creation of the current and historical database on the presence of meteorological phenomena in the region, and with it, their probabilistic presence; what is considered important to create a culture of prevention and coexistence of human beings in their daily productive activities with the environment.

Finally, based on the results obtained and the great impact quantified as a direct effect of the hurricane "JOVA", it is established that the calculation of the drained volume represents great importance for the management of the effective flow based on its own risk. In this sense, the magnitude of occurrence of this volume is correlated with soil management and rainfall events recorded within a catchment basin, as well as the moisture that can be contained in the soil.

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