ENVIRONMENT, WATER AND TERRITORY: DIAGNOSIS AND METHODOLOGICAL ANALYSIS OF WATER RESOURCES MANAGEMENT IN A WATERSHED OF HIGHLANDS OF JALISCO MEXICO

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Abstract

For the management of natural resources, one option is integrated partial management of small watersheds; specifically the local management of water bodies as amalgam both bio-physical, socio-cultural elements, such as falling within the watershed itself. In the present work advances in the diagnosis and methodology of the research project on the quality and availability of water resources in the watershed of "Jihuite" and its interrelation with the growth of the city of Tepatitlán, Jalisco exposed, because of the change on land use, population growth and agricultural and industrial development of the region in the last 25 years. The watershed of the Jihuite is located 6 km from the city of Tepatitlán, belongs to the sub-basin of the Rio Verde, the Santiago basin and the hydrologic region Lerma-Santiago-Pacific, with an area of approximately 60 km². By the methodological approach of Cultural Ecology and various quantitative and qualitative stages, such as parametric data collection on quality and degree of availability, statistical techniques (principal component analysis) and the use of participatory geographic information systems, as well as interviews, surveys and field trips local uses and handling of water bodies were addressed, by the different users of the watershed, identifying strengths and weaknesses of the current program for local water management, in order to promote local management alternatives that offer greater certainty and sustainability of the resource.

Keywords: Water management, El Jihuite watershed, Highlands of Jalisco

Introduction

With the passing of time, humanity in its procurement of food and shelter, has changed and impacted the surrounding environment, in recent years these effects have been critical to the extent that some of these changes in terrestrial nature are difficult reverse like; environmental pollution, global climate change and significant decrease in the productivity of ecosystems. Man uses large amounts of water for their daily personal activities, but much more to produce food, paper, clothing and other products it consumes. The water footprint (WF) of a country is defined as the total volume of water used to produce the goods and services consumed by its inhabitants,, the concept of WF was introduced to provide information on water use by different sectors, the production of some food demand more water than others, while some industrialized products, such as paper, may require the use of large amount of water for their production, the amount of water used in the production of each product is referred virtual water content, Globally 86% of the WF is related to the consumption of agricultural products, 10% with consumption of industrial goods and less than 5% with household uses, the main factors that determine a country WF are: a) average water consumption per capita, related to gross national income, b) consumption habits of its inhabitants, c) climate, particularly evaporative demand and d) agricultural practices. In the period 1997-2001, more WF countries were the United States, Greece and Malaysia (Figure 1), up from 2,300 m^3/person/year; in contrast, Afghanistan and Somalia have a water footprint per capita less than 700 m^3 /person/year. In the same period, Mexico had a WF per capita of 1,441 m^3/person/year (Chapagain et al., 2004).

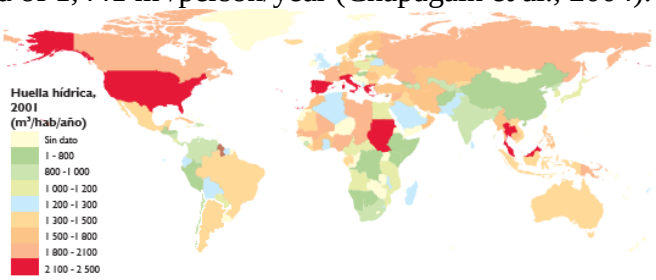

Fig. 1: Water footprint in the world.

Water is an essential for the overall development of human populations need, however is no longer an abundant and available resource quantity and quality. In Mexico the increased demand for water for agricultural use (88%), followed by the municipal (5%), industrial (7%) and without considering energy generation; on the one hand, this has led to

overexploitation, and secondly, pollution of our water resources (CNA, 2008). Therefore, local governments and users face an enormous challenge to design and implement new models of integrated river basin management to ensure the quality and supply of water to their communities and future generations (UNDP, 2006), which is included citizen participation in designing policies and agreements that promote sustainable water management, as the case of "the new water culture". During the last 20 years of the twentieth century, with the dependence on water extracted from deep wells, some with more than three hundred meters, the population of these regions has changed their practices, so that runoff water from rivers and streams passed to be on the surface drains. At the beginning of XXI century is consolidated in the region competition for water with large cities, but also with industry, agriculture and livestock (Barkin, 2005).

The territory of Highlands of Jalisco is divided into two regions: Highlands-North and Highlands-South; the first with a total area of 8882.23 km² (11.08% of the area of the state), the depth of the deep wells for the extraction of water in this region is about 200 meters on average, except for the municipalities of Ojuelos and San Diego de Alejandria where the depths are 300 and 400 meters, and Highlands-South with an area of 6677.36 km² (8.33% of the surface of the state), both regions are located in the hydrologic region 12 "Lerma-Santiago". The Highlands-South region presents an aquifer defined in Acatic-Tepatitlán-Arandas area with an approximate area of 6,000 km², same as for its geo-hydrological characteristics is widely exploited, especially the municipalities of Tepatitlán and Arandas, varying depths wells in the area between 200 and 500 meters. The sources of water pollution in these regions are directly related to the socio-economic activities taking place in each area, in general livestock farms (pork, poultry and livestock), seasonal agriculture and processing industry dominated growing (meats, dairy, tequila, etc ...), referring the cattle inventory in Mexico (Jalisco and Highlands of Jalisco) the following amounts (Table 1) are reported:

Table 1: Livestock Inventory. Based on data from INEGI 2012

	México	**Jalisco**	**Highlands of Jalisco**
Bovine milk	2 340,903	311,779	189,184
Bovine meat	29 420,059	2 661,779	105,700
Pork	15 230,631	2 595,303	1 396,738
Laying hens	184 711,880	83 901,202	73 556,730
Poultry meat	311 961,857	33 711,220	13 235,625

Reflecting the importance of the Highlands area, both in domestic livestock production, as in the generation of organic waste and wastewater, as evidenced by the high degree of eutrophication of water bodies that serve as regional livestock troughs and dam reservoirs, used as drinking water for

towns like Tepatitlán (Ramirez et al., 1997). As Secretary of the environment and social development of the state of Jalisco (SEMADES, 2006), says that all municipalities of the Highlands of Jalisco have problems of pollution of surface water, pouring untreated wastewater to the river network and farm wastes. The farming systems have also been identified as sources of nonpoint pollution to surface water bodies (Flores et al., 2009). More dramatic is the situation in which these contaminated the water resources Highland region is planned for use in cities like Guadalajara in Jalisco and Leon in Guanajuato. In Highlands-South and Highlands-North regions problems of overexploitation of aquifers (CNA, 2006), accentuated by the extraction of deep groundwater with high fluorine content (Hurtado & Gardea, 2005), with the consequent negative effect on health report population and declining water for human consumption (Figure 2). The impact of climate change on natural resources, particularly water, in the last four years, has already shown devastating effects, such as modifying the distribution of rainfall, which in 2003 caused flooding in Tepatitlán, in 2006 the loss a wide area under crops in the region and in general in the state of Jalisco the main factors that relate to the two types of pollution are: 1) the excess of nutrients contained in the food consumed and excreta; 2) the output of nutrients and suspended solids via surface runoff; 3) soil physicochemical processes associated with phosphorus and nitrogen nutrients; 4) the management of manures; 5) The erosion in grazing areas; 6) the residual long-term effect of continuous application of manure; 7) the intensity of grazing or overgrazing; and 8) the proximity of grazing animals to water currents and dramatic perspective of water in the Hihglands region of Jalisco, makes it imperative to implement actions for the conservation of natural resources.

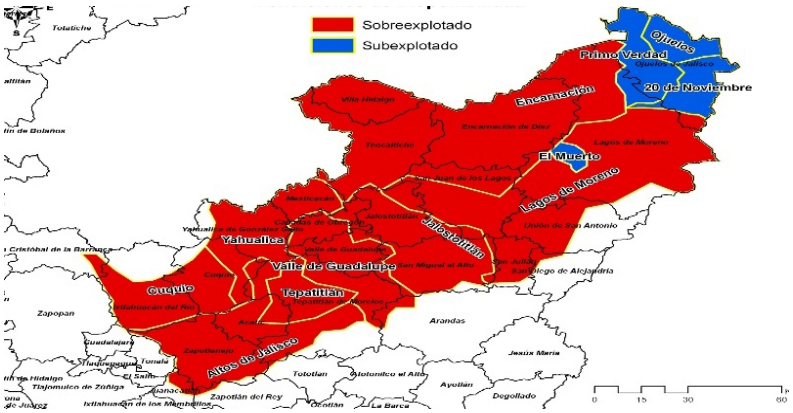

Fig. 2: Location of aquifers in Highlands of Jalisco. Source: CEAJALISCO, 2014

Study area: Tepatitlán is located on the old colonial way with the aim of controlling the silver that was transported from Zacatecas to Mexico City, east of Guadalajara. In 1940 he finished the paving of the road, which

prompted the regional productive extraction, particularly milk, ensuring military control of the area. It was here that the federal government suffered a defeat against the Highlanders ranchers during the rebellion known as "Cristiada", between 1926 and 1929, during this period there was an unprecedented increase in the number of settlers mainly due to re-concentration campaigns bound by the federal government and Tepatitlán had to give asylum to a large number of people, if 8,000 people lived in the city in 1920 to 1927 had to be concentrated 25,000 people, but this increase in population walks parallel to the demand for water. This is the time in the history of the city in which a transformation is experienced. The city life starts changing forms of water management and this will also be important for change, unseen short term, culture regarding water management (Casillas, 2013). Agricultural and forest watershed "The Jihuite", is located in the town of Tepatitlán, northeastern state of Jalisco (Figure 3), is geographically located between latitude 20°50'57" and 20°55'50" N and 102°36'50 meridians and 102°43'W, at an altitude of 1900-2150 meters, with an area of about 5,900 hectares, the climate is sub-humid temperate. The average annual maximum, minimum and average temperature is 25.6, 7.6 and 16.6°C, respectively. The annual average rainfall is 816.3 mm. (Flores, et al., 2012). The topography of the basin is hilly with slopes of 1-58% (INEGI, 2008), most of the floor of the watershed is luvisol iron, clay or clay loam texture, depth of one meter, another type of soil that occurs in the northern part is the eutric planosol, clayey with depth of 40 centimeters or less. Land use indicates that about 30% of the area is devoted to annual crops, 10% temporary grassland, rangeland 55% to 5% native species used with roads, buildings and other uses. The ownership of land is the small property.

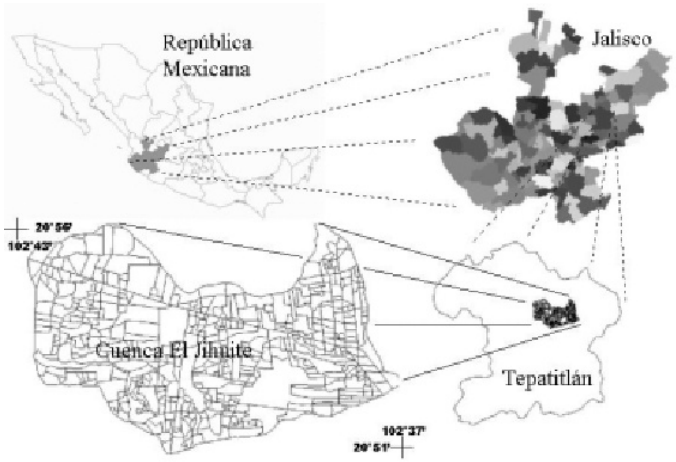

Fig. 3: Location of the watershed "The Jihuite".

The growth in agricultural and industrial activities in Highlands of Jalisco, represent an important supply of raw materials and basic foodstuffs for both the region itself and to other parts of the country, however, these activities affect the sustainability of natural resources water. The extent and boundaries of the watershed was performed using digitized aerial photographs, resulting in an area of 5850.63 hectares, over 53.97 acres of the reservoir of the dam for a total of 5904.6 hectares (Figure 4).

Fig. 4: Total area and land use in the watershed "The Jihuite".

Cultural ecology and borders

Cultural ecology (CE) had born within social anthropology, as concepts, theoretical and methodological theory of cultural change of Julian Steward contributions. For over 130 years, analyzes of the relationship between nature and culture or nature and society, permeate the reflections of anthropologists and Geertz states that environmental factors define the cultural manifestations and that all societies in the world would pass no excuses through the same stages of socio-cultural development, but seemed unaware of the influence of the environment on cultural advancement, however, Boas early twentieth century, showed the existence of deep cultural differences between communities, including people whose habitat was similar, at what Leslie A. White call "basic law of evolution of culture" than to support a story of cultural development, with a universal taxonomy thereof, stating the existence of almost universal parallels in adaptation processes environment and thus establish general levels of cultural development, according to the CE Steward "presents a problem and method", the question lies in whether human adaptations to their environments societies require particular ways behavioral, or cease freedom for certain kinds of possible behaviors". Conceptions of Frederick J. Turner that the boundary born", at the edge of the empty land and is primarily a frontier settlements, an ever-moving line that marks the advance of civilization", the same way; "That cultural system that best exploits the environmental resources necessary, will tend to expand in such a medium, at the expense of

less effective systems", with this approach the expansion or contraction of the border is explained in terms of the technological capacity of groups human (Fabregas, 2003). On the other hand Barth discusses how ethnic boundaries to a defined group of people, which are purely social and can not be territorial, ethnic boundary is located at the margins of culture of a people and their forms of social organization, but constitute its core, "the border is not on the shore but in the center," concludes that ethnic boundaries are maintained through a specific set of cultural characteristics, the persistence of the group depends on the continuity of these features, while the change is allowed precisely those features that are not involved in the definition of the border. In general, a boundary is created from human activity, of encounters and clashes with their own history and that of others, is modeled and transformed by the activity and growth of human group or for the consequences of their dominance over another group, so Fabregas and took from the CE proposed a comprehensive anthropology able to cover the multidimensionality of society and culture, this method requires maintaining the importance of empirical dimension without losing sight of the theoretical development and in terms of studies of regions and borders, long-term vision is the most important in monitoring changes empirical and theoretical elaboration. The regions or borders are a result of not only specific but changing human experiences. In CE each society "uses an adaptive strategy to manage their environment, exploit it to their advantage and ensure continuity of society itself, so essential to analyze the historical moment of adaptation and its particular context" (Fabregas & Tomé , 2002). The CE brings us to the relationship of a company with its environment, how access to basic resources and the historical process of forming regions is controlled, in this context, technology is a factor of prime importance in any adaptation process (Hernry Morgan) and the concept of low border this approach, is created when a natural environment is transformed into culture and introduced into the historical trend. Borders are spaces for relations between different CE and its historical dimension is crucial, are changing for the regions, in constant motion that generates social and cultural diversity.

The CE study region in Mexico

Several works of Manuel Gamio (1922) and Jorge A. Vivo (1951) point out the importance of understanding the natural environment in the analysis of a culture or society, Gonzalo Aguirre Beltrán (1950-1969) emphasized the preponderance of the environment and the interrelationship that human groups establish with him, to understand the formation and configuration of regions. The CE was contextualized theory in Mexico, thanks to the efforts of Angel Palerm and Eric Wolf (1954-1955), especially for analyzing ethnohistory of the central Mexico Palerm related Marxist

discussion about Asian Production Mode (APM) with the approach of Wittfogel around the eastern society and the method of the CE, to apply to ethnohistorical study of the Valley of Mexico (Acolhuacan area at Texcoco State of Mexico). The hydraulic society proposed by Krader (1975) who argues that it is not technology that gives its nature to society, anyway hydraulic technology is part of an adaptation strategy involving a basic factor to control water in the process food production. Wittfogel chose technological determinism in an environment that requires control of water to make production possible. Palerm aligning with Wittfogel established the existence of the "Hydraulic society" in the Valley of Anahuac. Brigitte Boehm (1986) identifies both Mesoamerica as a "cultural area" with associated bureaucracies that managed public affairs, such as the establishment of the State in prehispanic Mexico, the Wittfogel himself included Mesoamerica as a "marginal area" of "oriental despotism ", due to the importance of public water control works that existed in the Valley of Anahuac, conceived and executed by the State.

Jalisco and his Highlands

Fabregas argues that in the case of the historical process of formation of the Highlands of Jalisco, more important than the extent of the land and its productive capacity, was the existence of an agricultural economy subordinated to mining allowing capital accumulation and lie smallholders produced "for consumption", the colonial oligarchy could transform the cream of the crop in goods, to acquire these goods by the rest of the population, was necessarily mediated by the existence of low wages that complemented the household production, this control of the oligarchies on goods, resulted in increased debts of smallholders, and therefore increasing wage dependency, consolidating the division of labor that unbalance the family economy and seated structures in this. By sacrificing the rural economy, the family stopped being production unit to become mere reservation of labor, therefore mechanism lowering of wages, poor smallholders became tenants or sharecroppers, having to sell their land, generated the predominance of large properties. In this scenario locale of Highlands area, show that "the abundance or scarcity of land and its specific use" was completely determined by the social relations of production around social work "(Fabregas, 1986). Take argues that this shows that the CE must necessarily include political processes in environmental explanations (the relationship between economics, politics and society contribute more to configure the regional boundaries, the components themselves of the natural structure of the environment as watershed).

Panoramic and next

Certainly one of the major social challenges worldwide is appropriate and responsible use of natural resources such as water management, as its proper utilization depends not only from government policies but also necessarily the decisive participation of society, and that the better the situation of water resources, more timely supply in quantity and quality to ensure future generations understand it.

The diagnosis indicates that the quality of water bodies in the watershed under study, mainly from the dam, has deteriorated, mainly due to agricultural and industrial activities take place there; on one side are maize, sorghum and agave that on fertilized cause the hydraulic drag of nutrients, and the other discharges untreated wastewater from livestock farms and industries, resulting in the dam, a high concentration of nitrogen, phosphorus and organic matter encourage algae growth and decreased dissolved oxygen. Similarly denoted a marked variation in the pattern of rainfall in the watershed that directly affects both the surface intakes, and the natural recharge of the aquifer, causing sensitive diminutions in dynamic levels in deep water extraction wells.

In the later stages of the investigation and the approach of Cultural Ecology method of qualitative techniques were developed through field trips in the watershed to investigate the forms of local water management and perceptions of different stakeholders. Comparing the results with statistical and parametric analysis of quality and availability to set short- and medium-term sustainability scenarios.

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