The Journal of Social Sciences Research
ISSN(e): 2411-9458, ISSN(p): 2413-6670
Vol. 4, Issue. 5, pp: 74-79, 2018
URL: http://arpgweb.com/?ic=journal&journal=7&info=aims

Academic Research Publishing Group

Original Research Open Access

Water Scarcity Index Calculation, Atlas Animas, Tecoanapa Municipality, Guerrero, Mexico

Sirilo Suastegui-Cruz
Centro de Ciencias en Desarrollo Regional, Doctorado en Ciencias Ambientales, Universidad Autónoma de Guerrero. Acapulco, Guerrero México

José Luis Rosas-Acevedo
Centro de Ciencias en Desarrollo Regional, Doctorado en Ciencias Ambientales, Universidad Autónoma de Guerrero. Acapulco, Guerrero México

Maximino Reyes-Umaña
Centro de Ciencias en Desarrollo Regional, Doctorado en Ciencias Ambientales, Universidad Autónoma de Guerrero. Acapulco, Guerrero México

América L. Rodríguez-Herrera
Centro de Ciencias en Desarrollo Regional, Doctorado en Ciencias Ambientales, Universidad Autónoma de Guerrero. Acapulco, Guerrero México

Elías Hernández-Castro*
Maestría en Ciencias Agropecuarias y Gestión Local

Felipe Gallardo López
Colegio de Postgraduados (COLPOS) Campus Veracruz, Mexico

Ana Patricia Leyva-Zuñiga
Centro de Ciencias en Desarrollo Regional, Doctorado en Ciencias Ambientales, Universidad Autónoma de Guerrero. Acapulco, Guerrero México

Abstract

Water consumption is a problem, as it is used inefficiently, besides that, the demand is growing much faster than nature can supply, so in the present study an analysis was conducted to determine the amounts of water used in domestic and agricultural activities in a rural town, that allows us to obtain the water shortage index. To define and know the different uses, a survey of people's perception of household water expenditure is used, both personal hygiene and at home, as well as the use in agricultural activities. Then, the water shortage index is calculated with the model IDEAM (Hydrology, Meteorology and Environmental Studies Institute) modified by Romero and Ortiz (2016), which was adapted to a rural area. The agricultural and domestic activities need 868, 500, 660 L/ha, equivalent to 72.8 % of the total water rains in the study area and, the amount that is not used is 344,982,477 L/ha, what represents the 27.2 % of the total 100 %, the latter is for the recharges of wellsprings to feed the micro-basin, representing problems of water scarcity.

Keywords: shortage; Rural community; Planning; Decision Making.

1. Introduction

Water consumption is a problem, since it is used inefficiently, besides the demand is growing much faster than nature can supply. This overexploitation causes scarcity problem (Cirelli and du Mortier, 2005).

The lack of potable water service, conditions the people productivity and competitiveness, in addition, their life quality and, lack of development policies. Factors such as population growth, pressure on water resources, pollution and resources degradation are determining factors in the search for new management models (Colmenárez and Salazar, 2016).

Around an estimated 40% of the world's population lives in areas with water problems of a moderate-high level (Cirelli and du Mortier, 2005; Santamaría and Pérez, 2003), until reaching a water stress (Esparza, 2014). The existence of urban and rural places, conditions their sustainable development, where the availability and access to the resource becomes a determining factor for survival and peaceful coexistence (Caire-Martínez, 2005).

Total coverage of drinking water (the one that reaches the homes) are 88% in Mexico and Brazil and, corresponds 95% to the urban area Coverage is 65%, in the rural área, 37% with a home connection and, 27% with easy access (Cirelli and du Mortier, 2005). Mexico ranks 12 the in countries that use water for agricultural purposes, with 4,779 cubic meters per capita. This fact is linking to the population increase and the need for food (Cirelli and du Mortier, 2005).

*Corresponding Author

The drinking water coverage piped in Guerrero occupies the last place with 70.9 % and the penultimate place with 66.1% in sewer network drainage coverage, both percentages below the national average (Reyes *et al.*, 2014). In Las Ánimas, a town in the, Tecoanapa Municipality in Guerrero, there is no data on per capita water consumption. Limited access to water consumption data is one of the main problems in Mexico, when it is necessary to analyze the water demand, mainly in rural areas, where the problem is more serious due to lack of support and infrastructure (Reyes *et al.*, 2014). The water resource is important because it is used in agricultural and domestic activities where the rainy season is used, for the sowing corn, beans, squash, hibicus vegetables, among other, crops and that are for self-consumption and the local market.

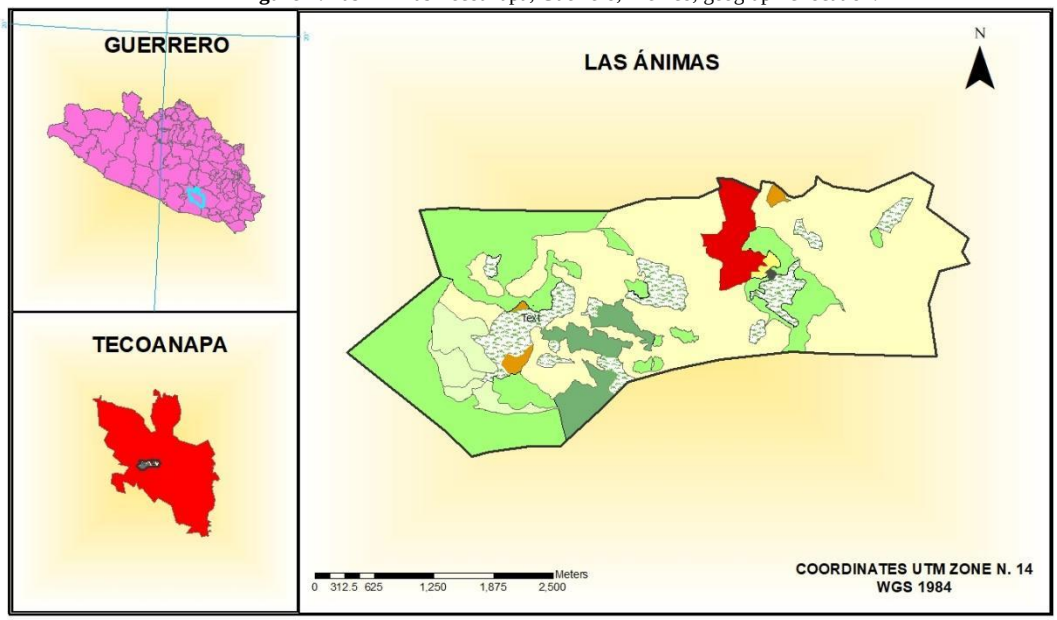
Despite its importance, the variation in the demand for potable water is estimated from continuous measurements of the expense in the pipeline that supplies an area. The curve of variation of the measured demand is assumed to be valid for any type of pipe in the network, regardless of the number of users it serves (Tzatchkov and Alcocer-Yamanaka, 2016).

Infante-Romero and Fernando-Ortiz (2008), made an adaptation of Instituto de Hidrología Meteorología y Estudios Ambientales IDEAM (2004) model, that is based on methodology to assess the water scarcity index at a municipal level, this model standardizes several methodologies to apply at a regional level. In the State of Guerrero little has been done about it, so our research objective is to adapt the shortage index model proposed by Infante-Romero and Fernando-Ortiz (2008), for Las Animas, the rural community of the Tecoanapa Municipality, based on the water use diagnosis made in the community.

2. Methodology

In the community of Las Animas the study was carried out (Figure 1), it is located -99.318611 in length and -16.972778 latitude, with 660 msnm of height, 1,513 inhabitants of total population, Instituto Nacional de Estadística Geografía e Informática INEGI (2010). Warm subhumid climate (Köppen modified by García (1993), with 31 °C an annual average temperature and 1200 mm average annual rainfall.

Figure-1. Las Ánimas Tecoanapa, Guerrero, Mexico, geographic location.



3. Economic Activity

70% of the population is engaged in agricultural activities such as growing corn *(Zea mays)*, pumpkin (*Ayotli sp*), bean (*Phaseolus vulgaris*) and Jamaica (*Hibiscus sabdariffa*). Most producers carry out this activity without technical advice (Instituto Nacional de Estadística Geografía e Informática INEGI, 2010).

The other 30% of the population is engaged in the service sector; according to the Instituto Nacional de Estadística Geografía e Informática INEGI (2010) there are inhabitants with a degree, who contribute with the establishment of some businesses.

4. Natural Resources

The community has three reserves for environment care and preservation, which are called conservation areas, where it is prohibited to fell trees and hunt animals, most of them are oak trees and wild animals for human consumption; wellsprings for domestic use and human consumption are also in conservation (Comisión Nacional Forestal CONAFOR, 2010).

Flora is composed of small ficus areas (*Ficus insipida*) and oaks (*Quercus rugosa*), called low deciduous forest (Comisión Nacional Forestal CONAFOR, 2010). Fauna, is composed by deer (*Odocoileus virginianus*), badger (*Meles meles*), rabit (*Oryctolagus cuniculus*), armadilo **(***Dasypus novemcinctus sp***)**, racoon (*Didelphis marsupialis*), skunk (*Mephitidae`sp*), iguana (*Ctenosaura pectinata*), rattlesnake (*Crotalus sp*), scorpion (*Scorpion sp*), gavilan

smuggle (*Rupornis magnirostris*), buzzard (*Coragyps atratus*) and a great variety of other birds (La Secretaría de Medio Ambiente y Recursos Naturales SEMARNAT, 2010).

For the present research, the quantitative methodology was used, where the target population was 1,527 people living in Las Animas, Tecoanapa, Guerrero.

A survey was carried out to estimate the water expenditure for domestic use, with a simple random sampling, with the formula of Scheaffer *et al.* (1987), with 270 people as a sample size.

$$n = \frac{Npq}{(N-1)(\frac{B}{Z_\alpha})^2+pq}$$

Subsequently, calculations and changes were made to the methodology of water scarcity index proposed by Instituto de Hidrología Meteorología y Estudios Ambientales IDEAM (2004) and modified by (Infante-Romero and Fernando-Ortiz, 2008).

$$DUS = [DUD + DUA + DUP + DUS$$

DUD: Domestic Use
DUA: Agricultural Use
DUP: Livestock Use
DUI: Industrial Use
DUS: Use Sector Services

This methodology was adapted to the rural area of Las Animas, Tecoanapa Municipality of Guerrero, where the research was developed, the variables were Agricultural Activities (Temporary Agriculture, Livestock, Irrigation Agriculture) and Domestic Activities (Personal Hygiene, Hygiene at home and Others), which were integrated into the following formula.

Remaining:

$$IEA = [AA + AD] - Pp$$

Where:
Pp = Average Precipitation
AA= Agricultural activities
AD= Domestic activities
IEA= Water Scarcity Index

According to the methodology, two equation types were generated, which correspond to the water scarcity problem at study community. The new equations were adapted.

That is to say:

whether $AA + AD > Pp$ Scarcity problems
whether $AA + AD < Pp$= Aquifer recharge

For the Agricultural Activities the equation was used:

$$AA = f(AT + G + P + P1) - Pp$$

AA= Agricultural Activities
P= Precipitation
AT=Temporary Agriculture
G= Livestock
P= Population
P1= Pantheon

For Domestic Activities: $AD = f(AP + AH + O)$
AD= Domestic Activities
AP= Personal cleanliness
AH= Toilet in home
O= Others

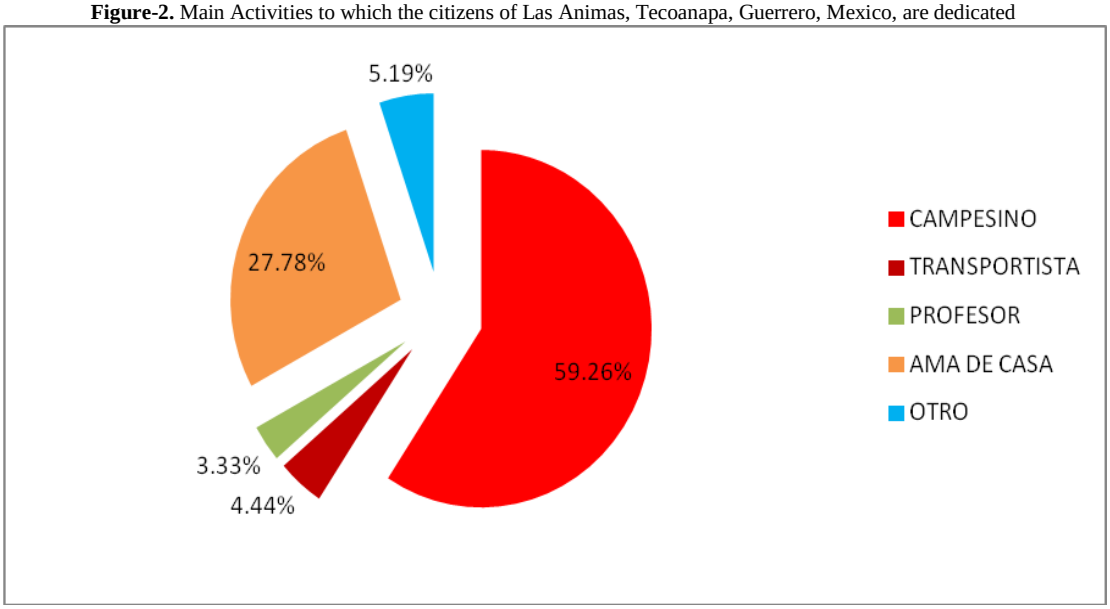
These were the most significant and most reliable changes to make decisions about water resource uses. Finally, the calculation of the scarcity index was carried out, where the data AA, AD and Pp were related.

5. Results and Discussion

Two periods are known in the community; rains the one and, dryness the other one. The start of the rainy season is variable, beginning in june or july and ending in october or november. These conditions may benefit or harm the community farmers depending on weather they able to establish their crops in rainy season and dry season, but, more importantly affects the springs in their recharges, for their exploitation.

The analysis shows 59.26% respondents are farmers, which indicates that a large part of the population is engaged in field activities and has a primary and secondary level (Figure 2).

Figure-2. Main Activities to which the citizens of Las Animas, Tecoanapa, Guerrero, Mexico, are dedicated



On the other hand, we can observe that use of water resources in domestic activities it's used throughout the year (temporary and dry); however, it is in the dry season, where its use becomes more important due to the various activities carried out by the inhabitants, such as personal hygiene, activities livestock and the agriculture. This activity requires greater water usage, in part, because it is a rural area and agriculture its main activity, men bathe daily a maximum three times (60 liters) and at least two (40 liters). This is nesesary due to the type of work.

At Las Animas community (Cuadro 1), it was found that average water used by people in personal hygiene was 63.37 liters per day. In household needs was 251.3 liters of water. It should be noted that these activities are carried out every third or fourth day. The consumption of water to irrigate the plants of their gardens or backyards was 28.0741 liters of water, this is done every third or fourth day, it depends on the type of plants.

In the case of total water consumption per person, in personal hygiene, household hygiene and watering plants, the average was 342 liters of water per day, emphasizing that some only clean every third or fourth day.

Table-1. Domestic Activities Analysis

Activities	Variables	Statistics
Personal Hygiene	Media Standard Deviation	63.3705 33.93182
House Cleaning	Media Standard Deviation	251.3704 131.5307
Other	Media Standard deviation	28.0741 12.69437
Total water Consumption	Media Standard Deviation	342.0187 152.9330

After having calculated the domestic water consumption, the water scarcity index in the locality was carried out, where agricultural activities were analyzed during the periods of rain and low water.

According to Instituto Nacional de Estadística Geografía e Informática INEGI (2010) 70% of the people of the locality work in the fields, for this reason, analysis of the water scarcity problem has great importance. Table 2, shows the activities that are carried out in the study area and the quantities of water needed for a certain activities.

Table-2. Water amount used in agricultural activities in Las Animas

Activitities	Hectares	Water used per hectare
Temporal Agriculture	617.84 Ha.	691,362,960 L.
Cattle raising	106.4 Ha.	119,061,600 L.
Population TOTAL	43.8 Ha. 768.84 Ha.	49,012,200 L. 859,436,760 L.

For calculation, 1 mm of precipitation equals 1 liter of water in 1 m^2, in the case of our analysis we worked in hectares, 1 h equals 10,000 m^2.

According to Toledo (2002), approximately 1,130,000 L/ha of water fall to Earth in the hydrological cycle, about 7,100,000 L/ha evaporate and return to the atmosphere, the rest, some 4,200,000 L/ha, recharge aquifers or return to the oceans by the way of the rivers. At Las Animas 1998-2016 average precipitation is 111.9 mm, which is equivalent to 1,119,000 L / ha, according to this, the polygon area has a total of 1,136 ha, which represents 1,271,184,000 L/ha; but if we consider the activities of the community (Cuadro 1), according to the calculation there

is a remaining amount (410,852,040 L/ha), so we should look for alternative methods for water conservation and retention.

According to Toledo (2002), 420,000 L/ha, are needed for human use. Whether volume is divided among the 6,000 million human beings that inhabit the Earth, each person would have about 70,000 L/ha per year. Asamblea General de las Naciones Unidas (2010), noted that a person needs between 50 and 100 liters of water daily.

The per person water consumption, in developed countries can reach 400 liters per day, compared to 25 consumed in areas of sub-Saharan Africa, or the 80 liters recommended by WHO for the vital needs of personal hygiene. In the case of countries such as: Mexico, Guatemala, Dominican Republic, Brazil and Chile, where the study was conducted the average is 135 liters per day (Duncan, 2003).

In Las Animas case, 342 liters are used, according to the data obtained in the survey, where it was considered that personal hygiene is daily, for the case of the activities of home hygiene and others, they are carried out every four days, which would be equivalent to 37,059 L/ha per capita per year, if this is multiplied by the 1,557 population inhabitants, it would have to be 57,700,863 L/ha per year needed to maintain the active population.

In the case of domestic activities, the results are 57,700,863 L/ha., of the rainfall average. It should be noted that 8.1 ha were found destined for irrigated agriculture, which indicates that 9,063,900 L/ha are needed for this activity; considering that the irrigation system used is by gravity fed (Montemayor-Trejo *et al.*, 2007). The final index of water scarcity in Las Animas, tells us that only 344,087,277 L/ha, will be used to recharge the wellsprings that form the river, where it is observed that it begins to see a problem of water scarcity and if this continues to increase, the problems will be more serious when the wáter is low. Table 3, shows the percentages used in the activities and the water that is not used.

Table-3. Accumulated percentages according to the Water Scarcity Index calculation at Las Animas, Guerrero

Activities	Water used L/ha	Accumulated percentage
Agricultural	868,500,660	68.30 %
Domestic	57,700,863	4.50 %
Water left over	344,982,477	27.20 %
Total average rainfall	1,271,184,000	100.00 %

The above without considering that the water resource may be threatened by pollution factors, by the agrochemicals used for agricultural production such as: fertilizers (ammonium sulfate, 20.5-00-00). To have an overview of this situation, a calculation was made of the quantities of products used in the community according to the hectares found (Table 4).

Table-4. Quantity of products (herbicides, fertilizers) used for corn production at Las Animas, Guerrero.

Corn liters (native)	Herbicide liters used Paraquat	Fertilizer ammonium sulfate 20.5-00-00
20 (1 Ha)	10 litros	500 Kgs
40 (2 Ha)	20 litros	1,100 Kgs
60 (3 Ha)	30 litros	1,800 Kgs
80 (4 (ha)	40 litros	2,400 Kgs

According to these results it is observed that doses are used that exceed those recommended for corn cultivation at Guerrero state, this situation is repeated in other crops types such as: pumpkin, tomato, chili, beans, etc., it is documented that excessive amounts can cause ground and Surface water contamination that have repercussions on environment and health (Gallay *et al.*, 2007).

6. Conclusions

In the case of domestic activities, to sustain the active population at las Animas, Gro., 7,700,863 liters per year are needed, which represents a low percentage for developed countries.

Agricultural and domestic activities, demand 72.8% of total water that falls in the study area, this according to activities that take place in the rainy season and dry season and, only 27.2% is for the recharges of wellsprings and micro-basin, as shown in table 3.

The scarcity water index used, is adapted to calculate the rural area in this study, because it reflects the approximations according to problems that are occurring in the locality, as discharges of sewage and contamination by products used in agriculture, among other thing.

References

Asamblea General de las Naciones Unidas (2010). El derecho humano al agua y al saneamiento. Available: www.un.org/spanish/waterforlifedecade/pdf/human_right_to_water_and_sanitation_media_brief_spa.pdf

Caire-Martínez, G. (2005). Conflictos por el agua en la Cuenca Lerma-Chapala, 1996-2002. *Regióny Sociedad*, 17(34): 73-125.

Cirelli, A. Y. P. and du Mortier, C. (2005). Evaluación de la condición del agua para consumo humano en Latinoamérica. Tecnologías solares para la desinfección y descontaminación del agua. *Solar Safe Water*: 11-26.

Colmenárez, A. and Salazar, E. (2016). Modelo para la estimación de la producción de agua de uso doméstico. *Compendium*, 19(36): 7-27.

Comisión Nacional Forestal CONAFOR (2010). Suelos forestales. Available: www.conafor.gob.mx/web/temas-forestales/suelos-forestales/

Duncan, M. (2003). *Domestic wastewater treatment in developing countries.* Editorial Earthscan: London. 3-10.

Esparza, G. J. (2014). *Contraste espacio-temporal de indicadores de interés hidrológico derivados desde teledetección. Proyecto fin de carrera Ingeniería Técnica de Obras Públicas, Especialidad en Hidrología.* Universidad Politécnica de Cartagena: Cartagena.

Gallay, R., Mendoza, C. and Benítez, V. N. B. (2007). Oxidación fotocatalítica de los herbicidas 2, 4-D, Diurón y Ametrina en agua a escala de laboratorio. Grupo de Investigación de Procesos avanzados para tratamientos químicos y Biológicos (GAOX). Facultad de Ingeniería de la Universidad del valle. 4-9.

García, E. (1993). *Modificaciones al Sistema de Clasificación Climática de Köppen.* Instituto de Geografía: UNAM.

Infante-Romero, H. A. and Fernando-Ortiz, L. (2008). Ajuste metodológico al índice de Escasez de Agua propuesto por el IDEAM en el Plan de ordenación y Manejo de la Cuenca del Río Pamplonita, Norte de Santander, Colombia. *Colombia Forestal*, 11(1): 165-73.

Instituto de Hidrología Meteorología y Estudios Ambientales IDEAM (2004). *Metodología para el cálculo del índice de Escasez de Agua Superficial.* Documento técnico: Bogotá, Colombia. 30.

Instituto Nacional de Estadística Geografía e Informática INEGI (2010). Censo general de población y vivienda. 1-10.

La Secretaría de Medio Ambiente y Recursos Naturales SEMARNAT (2010). Protección ambiental-especies nativas de México de flora y fauna silvestres-categorías de riesgo y especificaciones para su inclusión, exclusión o cambio-lista de especies en riesgo.

Montemayor-Trejo, J. A., Olague-Ramírez, J., Fortis-Hernández, M., Sam-Bravo, R., Leos-Rodríguez, J. A., Salazar-Sosa, E. and Chavaría-Galicia, J. A. (2007). Consumo de agua en maíz forrajero con riego subsuperficial. *Terra Latinoamericana*, 25(2): 163-68.

Reyes, P. D. A., González, G., J. and Guzmán, G. D. (2014). Evaluación de la cobertura de agua de consumo entubada y red drenaje de aguas residuales en el Estado de Guerrero. 20° Encuentro nacional sobre desarrollo regional en méxico. Cuernavaca, Morelos del 17 al 20 de noviembre de 2015. *AMECIDER – CRIM, UNAM*: 14-17.

Santamaría, J. S. and Pérez, M. B. (2003). Los conflictos por el agua en México. *Gaceta Ecológica*, (67): 61-68. Available: http://www2.ine.gob.mx/publicaciones/gacetas/389/conf_agua.html

Scheaffer, R. L., Mendenhall, W. and Ott, L. (1987). *Elementos de muestreo.* México, D.F.; Grupo Editorial Iberoamericana. 325: 4-30.

Toledo, A. (2002). El agua en México y en el mundo, de INE–Semarnat, México. *Gaceta Ecológica*, 64(2): 10-17.

Tzatchkov, V. G. and Alcocer-Yamanaka, V. H. (2016). Modelación de la variación del consumo de agua potable con métodos estocásticos. *Tecnología y ciencias del agua*, 7(3): 115-33.