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RESEARCH ARTICLE

ESTIMATING AND FORECASTING DOMESTIC WATER DEMAND IN MOUNTAIN PROVINCE, PHILIPPINES.

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Abstract

This study estimated the domestic water demand of a person in Bontoc, Mountain Province, Philippines. It uncovered the different household approaches on collecting and using water in the light of water scarcity. Forecasting future domestic water supply and demand leads to the determination of optimal future levels of water use and supply and hence to the design of an effective water demand management program.

Frequency distribution was used to describe the data gathered; Analysis of Variance was used to test the mean differences in domestic water consumption; and multiple regression analysis was used to define the domestic water demand equation, estimate, and forecast

This study found out that the two main sources of water managed by the Bontoc Water Unit discharged an average of 28 liters per second. The estimated average domestic water consumption of a resident in Bontoc, Mountain Province, Philippines is 90.09 liters per day on activities such as personal hygiene (44%), sanitary services (30%), cooking (16%), laundry (8%), and drinking (2%). Multiple regression analysis reveals that as household income increases and the household head educational attainment advances, per capita domestic water demand increases. However, as household size increases, per capita water demand decreases. From the forecasted data of domestic water supply and demand, there is an undersupply of water of 101,054 liters per day on 2016 with an annual 30% average increase.

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Introduction:-

Water is essential for the sustenance of man on earth - health, food, energy, transportation, nature, leisure, and all the products being used today is dependent on water. Water shortage is a persistent problem in urban and rural areas in the Philippines despite the abundance of water bodies. In Bontoc, Mountain Province, a second class municipality and the center of commerce in the province, water shortage had been the subject of protests and complaints by the residents since 1973. Manochon (2010) mentioned in her research that among the problems that beset the Bontoc General Water Services include: a) the unequal distribution of water in the community; b) lack of water supply to the houses at the tail end of the town which the local water management failed to address; c) inequitable or unfair payment of water fees for residential and business establishments; d) installation or connection of individual household water pipes without the consent of the Bontoc Water Services; and e) issues pertaining to the safety of the

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water for drinking or for home use. Most distribution pipes and fittings of the Bontoc water system have worn out causing leaks and increased frictional losses. According to Funabashi and Miyaoka (1984), 20-40 % of all the water in distribution systems is lost through leakage. In May 2014, the municipal officials of Bontoc declared its four central barangays in a state of calamity due to dire and widespread shortage of domestic water (Doga-ong, 2014).

The three major existing water sources are Sullong water source, Baybay water source, and the Balabag water source. Water from the three sources are collected through gravity flow system and directed to the 25,000-gallon capacity main tank before it is distributed. In the case of small urban systems designed by LWUA, water is first fed by gravity to a tank and from there released to the distribution system (Hebert and Yniguez, 1986).

This study examines the domestic water management in Bontoc, Mountain Province. It gathers information on the different domestic end uses of water and the flow patterns of the discharges of water from the sources. It connects the per capita water consumption of a person to the key factors that influence his domestic water consumption as basis for estimating and forecasting the domestic water demand per person per day. Knowledge of the water supply situation; domestic end uses of water; factors affecting domestic water consumption; and domestic water demand and supply forecasts become the driving forces in coming up with an effective water demand management program for Bontoc.

Empirical studies show that household water demand is largely determined by the household income. Demand for water moves in the same direction as household income. A study in Urban Kathmandu Valley reveals that higher economic class (class I) with 11% of the total population consume 149 lpcd, Class II (33% of total population) consume 109 lpcd, Class III (42% of the total population) consume 55 lpcd and Class IV (14% of total population) consume 31 lpcd (Joshi, Shrestha, & Shrestha, 2003). This finding is consistent with the study of Javier, Inocencio, & Padilla (1999) which reveals that average water consumption (for all household activities) increases as incomes increase as shown by the 48 liters per capita per day (l/c/d) consumption of the Metro Manila poor and 108 l/c/d of the rich. Dagnev (2012) claimed in his study that the source of household water affects the water consumption apart from income. Amin, Bamdad, Kamgar, Haghighi, Keshavarzi, Keshtkar, & Sharifzadeh (2006) reported that the low level of education of elders regarding environmental matters lead them to consume more water than do younger people. By contrast, Fan, Geissen, Liu, Ritsema, & Wang (2013) showed in their study that older people tended to use less water because of traditional practices of water usage (washing hands, showering, and sharing water among family members) and their unfamiliarity with water appliances.

Water consumption is also affected by the number of people staying in a house or household size. As the household size increases, the average consumption of a member of a family decreases (Fan, et al., 2013). The decrease in per capita consumption as the number of household members increases is attributed to the sharing of water needs in cooking and washing clothes, dishes, and cars.

Studies also show that the educational attainment of the household head influences the household water consumption. Madebwe (2011) revealed in his research that household heads with primary education and below demonstrate greater potential to save water and use it more efficiently while households with heads possessing secondary education and above consume water lavishly.

For this study, the estimated domestic water demand is a function of household income, household size, household head age, household head educational attainment, and household source of water. Price is constant at 50.00 pesos monthly charge per household. The relationship of domestic water demand and the factors affecting it in Bontoc, Mountain Province is defined in the equation below:

$$D_{wD} = f(I, S, A, E, R)$$

$$D_{wD} = \beta_0 + \beta_1 I + \beta_2 S + \beta_3 E + \beta_4 A + \beta_5 R$$

Where:

D_{wD} = Water demand per person per day (dependent variable)

β_0 = Constant water consumption at zero household income; constant household size, household head age, and household source of water; and no educational attainment of the household head.

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ = Coefficients that represent the effect in water consumption for every change in income, household size, household head educational attainment, household head age, and household source of water.

I = household income (independent variable)

S = household size (independent variable)

E = Educational Attainment of the household head (independent variable)

A = household head age (independent variable)

R = Source of water (independent variable)

Objectives of the Study:-

This study estimates and forecasts the domestic water demand and supply in Bontoc, Mountain Province. Specifically, it intends to answer the following questions:

1. What is the volume of water discharged from each source per collection period?
2. Is there a significant difference on the volume of water discharged per collection period?
3. What is the profile of the household according to age of household head, educational attainment of household head, household monthly income, household size, source of domestic water per household.
4. What is the estimated volume of domestic water demand per person per day on the following activities that cuts across household income, household size, age and educational attainment of household head, and household source of water?
 1. Drinking
 2. Personal Hygiene
 3. Sanitation Services
 4. Cooking and other Kitchen Activities
 5. Laundry?
5. Does the profile of a household significantly influence the average domestic water demand of a household member?
6. Is there a significant difference on the water demand of each person as to drinking, personal hygiene, sanitation services, cooking and other kitchen activities, and laundry?
7. What are the domestic water demand and supply forecasts?

Hypotheses:-

1. There is no significant difference on the average discharge/flow of water from the sources on the four gathering dates.
2. The profile of a household does not significantly influence the average domestic water demand of a household member.
3. There is no significant difference on the water demand of each person as to drinking, personal hygiene, sanitation services, cooking and other kitchen activities, and laundry.

Methodology:-

The study was conducted in Bontoc, Mountain Province. Bontoc is a second class municipality located 396 km north of the National Capital Region, and 146 km north of Baguio City. It has a mountainous terrain. Bontoc has a total land area of 39,610 hectares, representing 17 percent of the total land area of Mountain Province. The municipality sits beside the CHICO River, a main river system of Northern Luzon, that is fed by tributaries from the town barangays (ELA Bontoc, 2013). Bontoc has 16 barangays. Initial interviews with Barangay officials revealed that domestic water is not a problem among the 12 barangays. Only the four central barangays of Bontoc – Poblacion, Samoki, Caluttit, and Bontoc Ili experience severe water crisis because these barangays house the center of commerce in the municipality, national and local government offices, private and public secondary and tertiary schools, and the only hospital in the municipality. The focus of this study then is on these four central barangays.

This study made use of quantitative and qualitative methods to examine the domestic water management of households in Bontoc, Mountain Province. Data collection methods included archival research, informal interviews, and randomly sampled household surveys. Observational method was used in measuring the discharges of the water from the sources and the approaches of households in collecting and using water.

The local residents of Bontoc, Mountain Province are the primary respondents in this study. The household heads or representatives were the subject of oral and written interviews. A total of 351 questionnaires were randomly distributed to different households but only 336 were retrieved which accounts for about 96% retrieval. Secondary data were gathered from books and files of the different offices involved in this water system.

With the big number of household respondents, the researcher made use of sample sizes to represent the number of households for each barangay. Random sampling was used and the sample size of the population was determined through the Slovin's equation at a 95% confidence level. Stratified random sampling was utilized where the total number of households was grouped into four strata based on the four central barangays of Bontoc. The table below shows the population, number of households and sample size for each Barangay.

Table 1:-Sample Sizes of the Households

Barangay	Population	Number of Households	Sample Size
Bontoc Ili	4791	1105	134
Poblacion	3168	648	78
Samoki	2946	699	84
Caluttit	2071	452	55
Total	12976	2904	351

The data gathering on water discharges from the 2 sources took place during the dry and wet seasons. A container of known volume was filled with water flowing from the intake tanks and timed as it is filled. These activities were repeated 5 times on each source depending on the consistency of the acquired data. The researcher, together with the head of the Bontoc Water Unit (BWU) and some utility personnel, conducted the measurements on the four gathering dates per source.

The data were subjected to descriptive and inferential statistics. The data on discharges of water were tabulated and the means were computed to determine the average actual performance of the water sources. Analysis of Variance was used to compare the result of the mean discharges collected during the four collection dates on the sources of water. Multiple regression analysis was used to test the significance of the factors affecting domestic water consumption and to estimate the domestic water demand per person per day.

Findings of the Study:-

Volume of Water Discharged from Sources:-

The average volume of water being collected per day from the Balabag source is 1, 883, 096.64 liters while 388, 454.4 liters from the Sullong source.

The study shows that there is a significant difference in the discharges of water from the two sources per measurement period.

Household Profile:-

Age of Household Head:-

The average age of the head of a family in Bontoc is 48 years, the minimum age is 25 and the maximum age is 77. The head of the family represents the one who makes decisions for the family and the main breadwinner in the family. In Bontoc, it usually is the father. This data was included in the study to determine if the age of the head of the family influences the water demand of the household.

Household Head Educational Attainment:-

The educational attainment of the household head was included too on the same reason as age. It was found out on this study that the people of Bontoc generally are literate. Fifty eight percent of the household heads are college graduates while 13% stepped college. Seventeen percent are high school graduates, 10% are elementary graduates only, and only 2% did not go to school. This high percentage of college graduates can be attributed to the fact that the municipality hosts the lone state college in the province that charges low tuition fees. Despite the affordable school fees, students enjoy different scholarships from the Local Government Units and other funding agencies.

Household Monthly Income:-

Some studies on household water demand identified household income as a factor in influencing the water demand of a household. It was then included to determine if such finding applies to the people of Bontoc. The average household income in Bontoc is on a range of 20,000.00 to 29,999.00 pesos. The minimum household income is less than Php 10,000.00 while the maximum income is Php 69,000.00.

Household Size:-

The average size of a household in the Philippines is six (Inocencio, Padilla, Javier, 1999) which is also true in Baguio (Mason, 2012). In Bontoc, the average is five, as shown by the mean, median, and mode of the household size. This finding validates the information provided by the RHU (2014) report that the average number of family members in a household in Bontoc is five.

Sources of Domestic Water:-

The four central Barangays of Bontoc, the Province' Central Business District, have only two sources of water being operated by the Bontoc Water Unit (BWU). The sources are the Balabag source that has a mean discharge of 22 liters per second and the Sullong source with a mean discharge of 4.26 liters per second. These two sources supply barangays Bontoc Ili, Poblacion, Caluttit, and Samoki. However, many households tapped small springs to augment the water coming from the BWU or as main source of their domestic water. There are 14 additional springs that supply barangay Bontoc Ili, six for Poblacion, 12 for Caluttit, and 10 springs supply Samoki (BWU Report, 2014). These springs are mostly privately owned that charge monthly water fees from 400 pesos to 1000 pesos depending on the duration of water collection. Households underserved by BWU and private springs have resorted to private delivery trucks from which they could order water. Although these truck owners charge rates approximately 10 times higher than BWU, they provided many households with relief from the physical labor and time spent transporting water from springs, or using water from river sources.

Fifty six percent of the respondents claimed that they are connected with the Bontoc Water Unit but about 17% of them do not collect much from the pipes because there are only trickles of water coming out from the faucets especially during dry season. They claimed that those trickles cannot even fill a pail during the scheduled collection time. They instead resort to spring collection or water delivery. The respondents are still hopeful, though, that they would still soon be rationed with water from BWU when problems are fixed so they still maintain the pipes while others have already cut their pipes because of frustration due to the long wait.

This data accounts for 40% active connection from the BWU. This result supports the BWU (2014) report that 1244 out of 2904 households or 43% are being served by the Bontoc Water Unit. About 80% of the residents in Bontoc source out their drinking water from water refilling stations.

As for water collection, most of the households have installed big water tanks in their houses. Household heads that were interviewed revealed that they use six to 10 drums of water in a week. Some household heads commented that for a two-hour collection schedule, they collect only for an hour or sometimes more than two hours therefore it is not strictly confined to two hours duration. Use of water pumps to obtain more water during collection period depriving other households to collect on the same schedule was also observed. Others would leave their faucets open during collection period and let the excess water run off the drain when their tanks are full while their neighbors who do not have big tanks cannot collect any.

Volume Of Domestic Water Demand per Person per Day:-

The domestic water demand of a household per day was gathered in liters then divided by the household size to get the demand per person per day on activities such as, drinking, personal hygiene, sanitary services, cooking and kitchen activities, and laundry. Personal hygiene includes activities such as, taking a bath, washing hands, feet, and face, and brushing teeth. Sanitation services involve activities such as, toilet flushing, cleaning the house, cleaning the bathroom and comfort room, washing cars, and bathing pets. Cooking and other kitchen activities comprise food preparation and dish washing.

The estimated average domestic water demand of a person in Bontoc is 90.09 liters per day. The minimum demand is 24 liters per day and the maximum is 147 liters per day. The average water demand is way below the estimated standard of LWUA for Filipinos with a household size of 6 that is 140 liters per person per day (Hebert & Yniguez, 1986). It is, however, within the estimated basic water requirement range of 15.54 – 246.78 liters/capita per day in the Philippines (Javier, et al., 1999). The estimated per capita water demand was computed from activities such as drinking (1.9 liters), personal hygiene (39.9 liters), sanitary services (27.1 liters), cooking and other kitchen activities (14.1 liters), and laundry (7.1 liters).

The largest part of the pie is attributed to personal hygiene. This result corroborates earlier studies that personal hygiene accounts for 30% to 40% of the water demand of a person (Borg, 2013; Dagnev, 2012; Lu, 2007;

Innocencio, 1999). Taking a bath is the largest water consumer in this area (personal hygiene) at 85%. Majority of the residents make use of a pail and dipper to minimize water use. Others, usually under higher income brackets, use showers at an average flow of 10 seconds per liter. This study also shows an average shower time of six minutes for men and eight minutes for women. In the U.S., the average shower time is 6.3 minutes with an average shower flow of six seconds per liter (DeOreo and Mayer, 2012) while in UK, it is eight minutes (Kinver, 2011).

Sanitation services take the next larger slice. This activity, however, is the leading water user in giant countries because of the flush (DeOreo& Mayer, 2012; Nelson, 1999; Brandon, 1984). Each flush in the U.S. and U.K. drains about 16 to 24 liters (Gleick, 1996) so one flush is almost equivalent to four flushes in Bontoc, Mountain Province. Most toilets in Bontoc, Mountain Province are flushed manually using a dipper. This, according to the respondents, is a way of conserving water. One dipper of water is about one liter. Bontoc people use one liter to flush urine and use about four liters for solid waste. The average number of flushes per person per day is four which is also the average in the United States and Canada (DeOreo& Mayer, 2012). As an acquired practice, Bontoc residents use grey water from laundry to flush toilets, clean bathrooms, comfort rooms, and houses thereby, minimizing the use of water.

Cooking and kitchen activities get 16% of the per capita domestic water demand per day taking the 3rd largest component. This result is consistent with the update study of the residential end uses of water in the United States and Canada in 2012 which shows that 16% of the total average daily use is for cooking and kitchen services (DeOreo and Mayer, 2012).

It is noticeable that water demand in laundry activities accounts only for 8% as compared to the 12.5% in Manila (Innocencio, et.al., 1999). This can be attributed to the age-old practice of Bontoc residents that during week-ends, they bring their dirty clothes to the nearby river to wash clothes at the same time spend the week-end swimming and having a family picnic. Two percent of the per capita water demand goes to drinking water, a little lower than Manila and Pangasinan at 3% (Innocencio, et.al., 1999). Figure one below shows the distribution of domestic water consumption in percentage form among the different household activities.

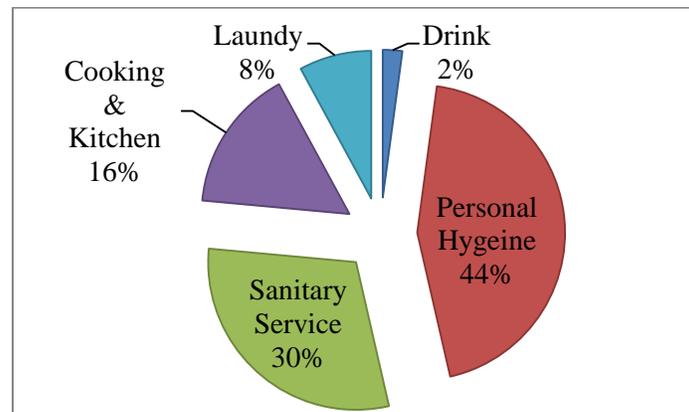


Fig. 1:- Average water consumption/ person

Estimating Domestic Water Demand:-

Domestic water demand is estimated from the result of multiple regression. The equation $D_{wD} = \beta_0 + \beta_1 I + \beta_2 S + \beta_3 E$ denotes the relationship of the domestic water demand (D_{wD}) as the dependent variable with income (I), household size (S), and household head educational attainment (E) as the independent variables. With the coefficients computed from the multiple regression analysis, the final equation to estimate the domestic water demand of a person per day is represented by

$$D_{wD} = \beta_0 + \beta_1 I + \beta_2 S + \beta_3 E$$

$$D_{wD} = 63.755823 + 9.6284609 (I) - 5.488522 (S) + 6.9919622 (E)$$

Where:

I = Household income

S = Household size

E = Household head educational attainment.

D_{wD} = Domestic water demand/ person/ day

Using the mean values of the household income, household size, and household head educational attainment yields a domestic water demand that is equivalent to the average domestic water demand of 90.09 liters per person per day.

A constant domestic water demand of 63.76 liters means that regardless of the factors influencing water demand, a resident in Bontoc still consumes 63.76 liters per day.

Influence of Household Profile on the Average Domestic Water Demand:-

Multiple regression analysis in this study shows that household head age and source of domestic water do not significantly influence the water demand of a household with p-values higher than 0.05 at a 95% confidence level. Household income and household size significantly influence the water demand with p-values way lower than 0.05 with 95% confidence level. With a p-value of 0.06, the household head educational attainment is significant at 94% confidence level such that it was still included in the second run of multiple regression analysis together with household income and household size. The result of the second run with only three independent variables show a more fitting regression with p-values lower than 0.05 at 95% confidence level.

It is observed from the output that average domestic water demand per day increases as educational attainment advances. It also increases as household income increases. This finding on income was also found true by a study of Mason (2014) in Baguio. The household size effects a negative progression on the average domestic water demand of a person because as household size increases, it decreases. These findings are supported by the study of Lu (2007) in Harbin China, claiming that the average volume of water demand of a person per day decreases as household size increases (Amin et al., 2006; Fan et al., 2013).

Difference on the Water Demand of a Person as to the End Uses of Water:-

To determine if there is a significant difference on the domestic water demand as to the different household activities, Analysis of Variance was used. With an F observed value (806.5419) greater than the F critical value (2.37724), the null hypothesis was rejected such that there is a significant difference on the average water demand as to activities such as, drinking, personal hygiene, sanitation services, cooking and other kitchen activities, and laundry.

Analysis of Domestic Water Supply and Demand Forecasts:-

Domestic Water Demand Forecast:-

This study made use of the projected growth rate estimated by the National Statistics Office (NSO) to project the population. At an average domestic water demand of 90.09 liters per person per day, the forecasted domestic water demand per day is computed using the forecasted population.

Domestic Water Supply Forecasts:-

The forecasts of water supply from the sources is presented in liters per day. The actual measured discharges of water per day is shown less than the 36.4% leakage allotment and the 7.3 % annual average decrease rate of surface water (Manohar & Mohan Kumar, 2014). The study reveals that about 800, 000 liters of water per day is lost due to leaks in the distribution pipes. This is an alarming situation in localities that are experiencing severe water shortage.

Projections of water supply and demand until year 2020 is shown in the chart on the next page.

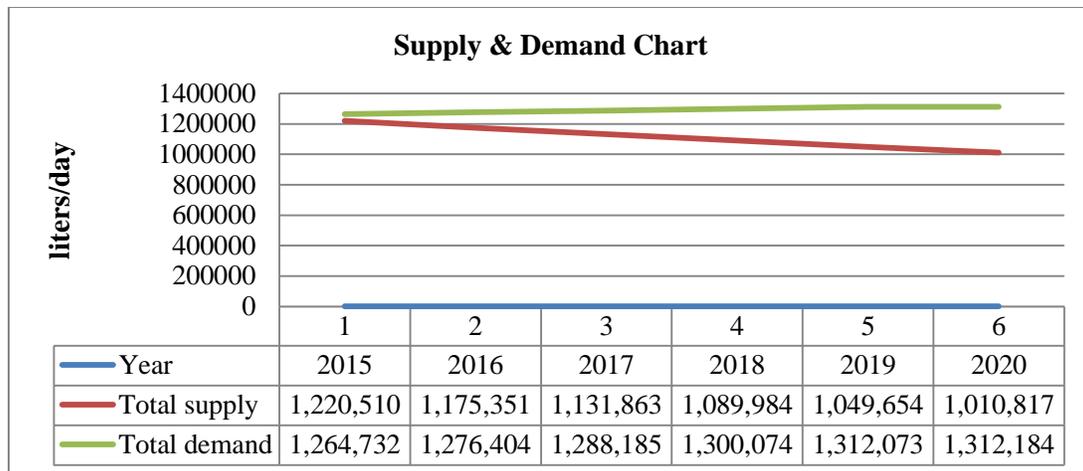


Figure 2:-Domestic Water Supply and Demand

The chart shows that there is an undersupply of domestic water from year 2016 to 2020. The 101,054 liters per day deficit on 2016 accounts for about 1,122 residents not rationed, a minimal deficit that does not warrant an intervention of sourcing out for another water source even until 2020. Considering that at present, there is only about 43% active household connection then water is drained somewhere along the way. The chart clearly shows that with time, supply decreases while demand increases making the gap between the supply and demand wider as years go by.

Conclusion:-

1. The average volume of water being discharged by the Balabag source is 1,883,096 liters per day while it is 388,454 liters per day in Sullong.
2. There is a significant difference on the volume of water collected from the sources per collection period.
3. A household head in Bontoc, Mountain Province, Philippines is on the average 48 years old, college graduate, and leads a household of 5. The household monthly income is on the range of Php 20,000.00 to 29,000.00. There is 40% active connection with the Bontoc Water Unit. Eighty percent of the households source their drinking water from refilling stations.
4. The average domestic water demand of a household member is 90.09 liters per day on activities such as personal hygiene (44%), sanitary services (30%), cooking (16%), laundry (8%), and drinking (2%).
5. The educational attainment of a household head, household monthly income, and household size significantly influence the average domestic water demand of each household member. The average domestic water demand of a person per day increases as educational attainment of a household progresses and the per capita domestic water demand per day increases. However, as household size increases, domestic water demand of a person per day decreases.
6. There is a significant difference on the water demand of each person as to drinking, personal hygiene, sanitation services, cooking and kitchen activities, and laundry.
7. From the forecasted data of domestic water supply and demand, there is an undersupply of water of 101,054 liters per day on 2016 with an annual 30% average increase. The deficit in supply by 2016 accounts for a 1,122 underserved residents.

Recommendations:-

1. Distribution pipes should be repaired to recover the 36.4% losses due to leaks. Water from the sources should all be directed to the intake tank before it is distributed for fair distribution. Since water access is a human right, all households should be connected to the Bontoc Water Unit but a clear cut policy on availing of water connection should be imposed. Metering of water demand should be imposed to regulate water use such that households shall pay only what they use. Fair rationing of water should be the main concern of those in charge in the water distribution.
2. Rehabilitation of the dams at the sources should be done so as to maximize the surface water catch.
3. Water conservation and grey water recycling should be observed especially by those who have higher income and with higher educational attainment to decrease the average water demand.

4. Households should use water efficient appliances to minimize water demand.
5. The Bontoc Water Unit should come up with a domestic water demand management program as a practical strategy to improve the equitable, efficient and sustainable use of water. Involvement of all sectors is paramount to successful programs of water scarcity alleviation. Forecast of demand and supply of domestic water is vital in the management of water resources so it should always form part of the water demand management program.

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