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Assessment of urban water supply in Managua, Nicaragua

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ABSTRACT

This paper describes Managua's water supply system. It outlines key issues such as: the configuration of the system, number of household connections, water production and consumption, Non-revenue Water (NRW), service level, water tariff structure and the financial situation of the state-owned water utility (ENACAL). The analysis of the data collected shows that Nicaragua has reached 99% coverage of safe drinking water in urban areas and has met Target 7.C of the MDGs. Nevertheless, it is still a challenge to provide a better level of service in terms of both water quality and continuity of supply. Managua city has a continuous water supply of between 3 and 24 h per day and some areas have long-term water shortages. The study also showed that ENACAL and its main water system (Managua) has a NRW above 50% and a non-cost recovery water tariff. This has created an unsustainable financial situation in the national water utility, which is reflected in the lack of maintenance and lack of replacement of old infrastructure, leading to a "vicious circle" of ineffective service and non-willingness to pay for water supply services. Without UWDM plans, measures or strategies in Managua, there is a low probability that ENACAL's financial situation will improve, making it unlikely that the current water service level will improve in Managua city.

Keywords: Financial deficit; Managua; Urban water demand management; Water supply system; Water tariff structure; Water utility

1. Introduction

Assessments of water supply systems are key to understand water utilities and to develop frameworks that help their financial and operational performance. Nevertheless, assessments are challenging and requires the evaluation of different aspects. As some authors argue, water management is very complex itself since it involves many stakeholder and it is related to operational, technical and financial factors [1]. Although water utilities around the globe are responsible to provide adequate, reliable, and safe water to all; this remains a challenge [2]. In Nicaragua and in other developing countries, this challenge is influenced further by aspects such as migration, population growth, urbanization and limited resources and political interference [3–9].

In this context, this paper aims to give an overview of the current conditions of the local water supply system on Managua City. This assessment describes the water supply system that is operated by ENACAL (National Water Utility) and focuses on analyzing the utility's overall performance. This review and analysis is required in order to better understand the current situation of the Managua's Water Supply and aspects of the National Water Utility, which faces operational and financial issues affecting its adequate performance. This paper brings together different general concepts and relates them to the situation of Managua's water supply system. The paper outlines key problems the company faces and the factors that are influencing them such as reliability of the water service, non–revenue water (NRW), affordability and willingness to pay.

Furthermore, the major purpose of this review paper is to identify relevant gaps and data in order to serve as a starting point for new research endeavoring the development of new strategies and measures that can help the water utility to improve its financial performance and the operational aspects of the Managua's Water System.

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2. Research methodology

The research methodology was based on a descriptive statistical analysis by Summarizing Data. Authors collected, organized (by years and/or range of time, topics, or even authors), and analyzed data in order to understand and create tables and graphs that help to better illustrate the statistical information collected with the purpose to show if there is (or not) a trend [10]. The information collected is "official information" provided by sources such as ENACAL, INIDE, BCN, etc. Other useful data and information was obtained from specific consultancy reports, mainly from The World Bank, Inter American Development Bank (IADB), The Japanese International Cooperation Agency (JICA) and others (all cited in this article).

The descriptive statistical analysis was carried out with an in-depth literature review and data collection of previous statistical reports and studies from the last two decades about ENACAL Nicaragua and its main water supply system, Managua.

Three criteria were taken into account for selecting the literature and data for this paper. These criteria included relevance of the information, authority and currency. For the relevance criteria, the consideration was firstly, that statistical reports should be official, public and available; and secondly papers should be related to UWDM in the region or in developing countries. For the authority and currency criteria, official information and papers should be from the last 20 years and be published by official institutions or authors specialized in the field. It was considered 20 years because in the country there is lack of public available official report about the water utility, and there are not many recent peer review papers in Nicaragua nor Managua about the topic.

Summarizing Data analysis sought both, to understand the current situation of ENACAL and to discuss the statement that this public water utility in Nicaragua is in a financial deficit, facing serious operational problems in Managua water system (it's largest). Bearing this in mind, data analysis was based on authors own experience on the topic and on the general existing information about Urban Water Demand Management. Behaviors of figures including NRW, Water rates and financial deficits throughout the years were discussed to emphasize the overall performance of the water utility.

2.1. Nicaragua's water supply background

Nicaragua is a small country of approximately 130,373.4 km^2 located in the central American Isthmus [11]. Estimates show that Nicaragua's populations in 2005 was approximately 5.1 million residents [12] and was projected to reach 6.1 million in 2016 [13].

In regards to water service, Nicaragua´s urban water supply has two main components: municipalities, which operate and own 44 water supply systems in a varied legal array [14,15] and ENACAL, the state-owned water utility with a concession[1] to operate only in urban areas providing water in 110 out of 154 municipalities. With these two main components, the water coverage in the country has improved in the last 25 years. The national water service coverage increased from 73% in 1990 to 87% by 2015 [16–18].

Managua is the capital city of the country. It is located in Pacific region boarding Lake Managua in the north and extending south towards "Sierras de Managua". The municipality has a total area of 267.17 km^2 [11] from which 150 km^2 are considered urban area [19].

The city has both, surface and groundwater resources. Regarding surface water, within the city there are one lake (Lake Managua) and four small lagoons (Tiscapa, Nejapa, Asososca and Xiloa). Lake Managua is the largest surface water body within the city and has an area of approximately 1,050 km^2 [20,21]. However, its use is limited because of pollution. Since the last century, Managua's sewage has been deposited into Lake Managua, as well as pesticides, and chemicals from factories [22]. The other four small lagoons are of volcanic origin and all are located within the city limits but only one of these is used for water supply (Asososca Lagoon) [21,23].

Regarding groundwater resources, Managua's main source of water supply is "Las Sierras" aquifer. This aquifer provides 90% of the water to the system through 165 wells; while only 10% is abstracted from Asososca Lagoon [24].

2.2. Managua's urban water supply system

2.2.1. Household connections and population

Managua is the largest populated urban city in Nicaragua. As a result, it is the largest water supply system in the country providing water to all its residents. According to the 2005 national census, number of urban residents in the city were 937,489 [25]. and was estimated to reach 1.04 million residents by 2015 [13,26].

Since population is increasing, household connections to the water supply system are consequently increasing as well. According to INIDE's statistical yearbooks [27–30] and official information provided by ENACAL-Managua, the number of household connections in urban areas of the water supply system has increased from 169,843 connections in 2003 [27] to 271,921 connections in 2015 [31].

The population served, as depicted in Fig. 1, is an estimation based on the average number of inhabitants per

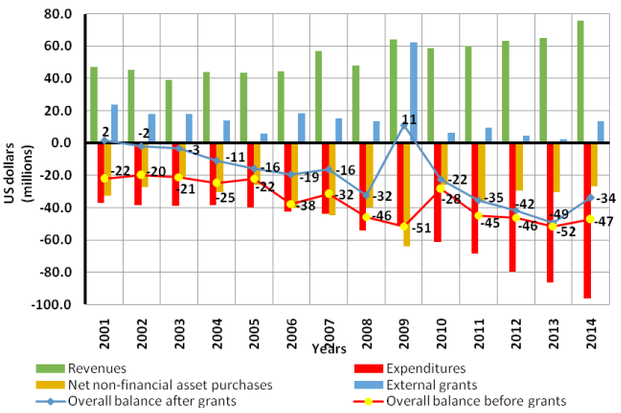

Fig. 1. Household connections and number of consumers in Managua´s urban area.

[1]Water Supply Concessions are granted to ENACAL when water supply systems are above 500 household connections by INAA according to Law No. 297.

household (5.2) from the 2005 national census. This figure shows that the population currently served is higher than the projected population for the year 2015 for Managua city, which could be explained either by a growth rate that has surpassed the projections made by INIDE in 2005 or there has been a decrease in household population density due to an increase of social housing programs by Nicaragua's Government. This situation can only be verified with the next national census, to be published in 2017.

Source: Authors' own elaboration based on INIDE's statistical yearbooks [27–30] and ENACAL's official information [31] considering 5.2 inhabitants per household as established in the 2005 National Census [25].

As some authors state, population growth increases challenges to the water utility [3–5,8,9,32,33]. This is because an increment in population also means an increment in the water demand that the utility should satisfy. Furthermore, it means investment and the implementation of many other measures for the company to cope with residents needs of water. Implementation of new household connections required the analysis of the whole water supply system in terms of flow capacity, water level pressures, accessibility to the grid and others. In addition, the utility also should consider what type of consumptions the residents are demanding. Some customers require more volume of water than others depending on their activities. For example, by 2015, 94% of the total number of connections were domestic and the remaining 6% were non-domestic: commercial, governmental and industrial [31].

Besides, increment in households requires the investment in water metering, if the company wants to accurately measure the water consumption. However, this is sometime not possible because of the high cost investment and because residents oppose to pay for it. ENACAL-Managua has not implemented a water meter management programme to install and check the accuracy of water meters regularly because its high costs [31]. Customers who cannot afford a connection fee nor the cost of a water meter have a fixed rate. In 2016, ENACAL reported having 70,342 connections with a fixed rate and with no water meter [31]. This figure represented approximately 26% of its total connections which also possibly mean a certain percentage of NRW and some economic losses.

Other factor that should be taking into account is that when population grows, chances are for increments in the number of illegal connections. In Managua's illegal settlements (slums) more than 60% of the connections are illegal according to the World Bank [34] which means that these are households without any metering, leading to an increase of NRW for the utility. However, an in-depth quantification of NRW due to these connections in the city has not been conducted in poor urban areas, and need further analysis and verification.

2.2.2. Managua's water supply system configuration

The system configuration of Managua's water supply system consists of abstraction, storage, chlorination and transport. Water is delivered to customers throughout a grid using pipes of different diameters and materials. Pipes' diameters vary from 2.54 cm to 91.4 cm and are made of materials including: polyvinyl chloride (PVC) ductile iron (DI), galvanized iron (GI) and asbestos cement pipe (ACP). The total pipe length of Managua´s water supply is approximately 1,942 km.

The grid basically follows the city's configuration of streets and avenues. However, it is important to bring out that, after the 1972 earthquake, Managua grew without an architectural master plan [3,35] and some neighborhoods has expanded with no control. This is an issue for the utility in the way that some pipes of the grid can be located under houses or in places where they are inaccessible. Likewise, the utility does not have a map of the old system configuration. Consequently, it impedes the proper maintenance and operation of the water system.

In such context, ENACAL has tried to improve the water system configuration following recommendations of previous studies made on the city. For example JICA [15] diagnosed the status of Managua water supply system and stated measures to establish a better control of flows and water level pressures within the city.

Following such recommendations and due to the city´s topography, currently, the water supply system on Managua is configured to distribute water into nine macro-regions within three hydraulic zones: 1 – Low Zone, 2 – Upper Zone and 3 – High Upper Zone, as shown in Fig. 2. While the three hydraulic zones are defined depending on the altitude (elevation above sea level), the macro-regions depend on the longitude within the hydraulic zone (west, central and east) [23].

2.2.3. Water delivery for Managua´s water supply system

Underground is the main water source for Managua's water supply system as shown in Table 1, 190% of the water for Managua's residents is extracted from five wells fields namely *Managua I*, *Managua II*, *Las Mercedes*, Valle Gothel/Veracruz, and Sabana Grande, which together account for 54 wells plus 111 wells spread out and located in different parts of the city [23,24]. The other 10% of the total water delivery is obtained from *Asososca Lagoon* which is a surface water source [24].

As a result of the increment of water demand in the city, water delivery has consequently increased in the last recent 10 years. While in 2005 water delivery in the city was 379,389 m^3/d [15], by 2015 it increased to 468,794 m^3/d [24]. These figures show an increment of approximately 23% of water abstraction and delivery. For a utility, such increment represent investment on infrastructure, energy consumption, water treatment and others, which are factors that further influence the company's performance. If the company does not get enough income, it would be very difficult for it to improve the system and to accomplish residents' needs of a reliable service.

Fig. 3 shows the location of: major wells fields, Asososca Lagoon and spread out wells existing in Managua city, as well as their distribution areas.

2.2.4. Reliability of water services in Managua city

According to JMP, urban areas in Nicaragua have reached 99% of "access to safe drinking water" [18]. However, the access to water supply as defined and reported by JMP [18]

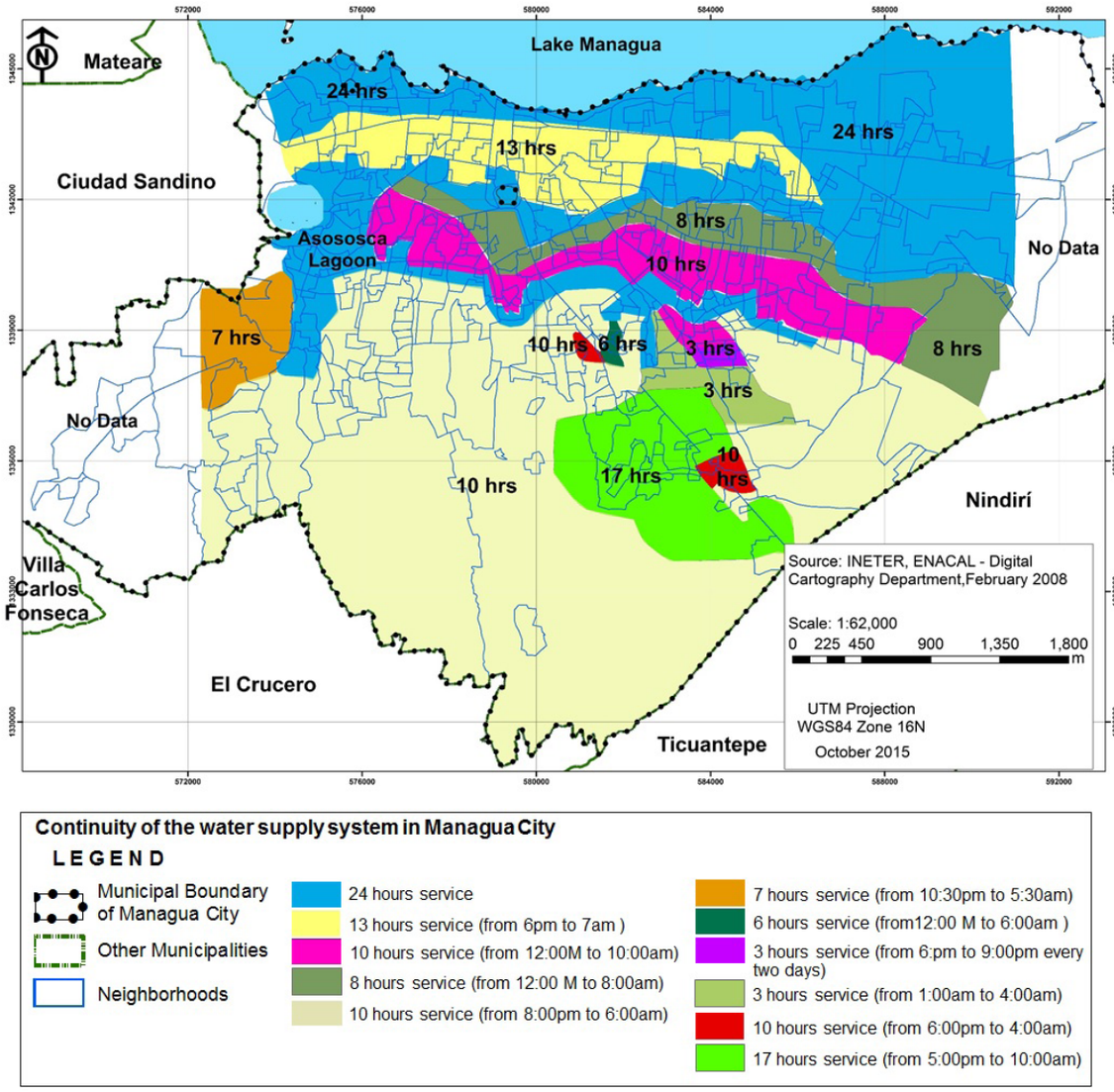

Fig. 2. Map of hydraulic regions and configuration of Managua´s water supply system. (*Source*: Author´s own adaptations based on [15,23]).

Table 1
Managua´s current water sources and production

Source	Description	Number of wells		Water production m³/d				
		Year 2005	Year 2012	Year 2005	Year 2012	Year 2013	Year 2014	Year 2015
Managua I	Wells field	15	15	53,603	49,302	49,132	59,837	60,019
Managua II	Wells field	16	14	45,667	43,510	43,708	42,338	43,462
Las Mercedes	Wells field	13	13	56,050	58,095	51,316	51,583	37,886
Valle Gothel/Veracruz	Wells field	–	7	–	14,562	14,533	14,888	19,571
Sabana Grande	Wells field	–	5	–	19,360	20,772	19,745	20,755
Asososca Lagoon	Lagoon	–	–	56,516	61,818	61,736	55,721	45,657
Other wells	Spread out wells	78	111	167,553	240,885	224,731	236,328	241,444
Total		122	165	379,389	487,532	465,928	480,440	468,794

Source: Authors' own elaboration based on [15,23,24].

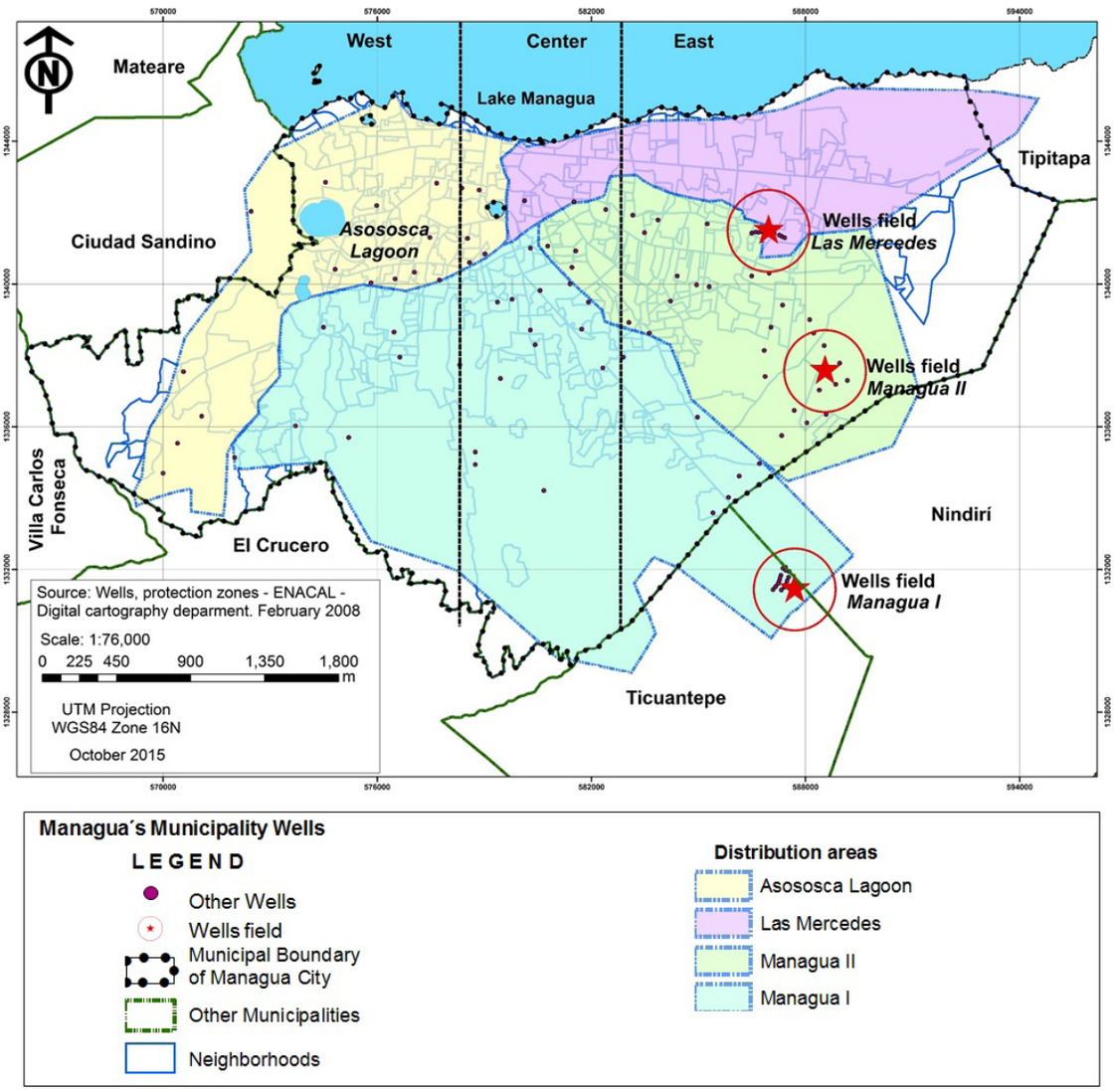

Fig. 3. Map of Managua´s water sources and their distribution areas. (*Source*: Author's own adaptation based on González [23]).

is rather broad and does not take into consideration water service quality or reliability or in lot connection.

Residents demand not only for access to water, as some authors emphasize. Customers demand sufficient, reliable and safe drinking water and it is the responsibility of water utilities to satisfy such demand [36,37].

In the case of Managua, reliability of the service has been a constant issue for ENACAL. In the city, some areas have been frequently affected by long-term water shortages, sometimes for hours or even days [7,38]. In extreme cases the water supply service is only 3 h every 2 d [39]. In other cases, the service is from 2 to 24 h/d [34]. Fig. 4 shows the reliability of the water supply service in Managua city.

This lack of reliability "which results in serious supply problems, including low pressure, inequitable distribution of the water available and water quality deterioration" [5] is affecting ENACAL overall performance. However, a deep analysis of causes should be undertaken.

2.2.5. Non-revenue water (NRW)

Non-revenue water (NRW) is another factor affecting water utilities. NRW is the total amount of water delivered but non-billed due to various reasons which could include non-billed authorized and/or unauthorized consumption and physical losses [40,41]. Physical losses seem to be the major factor for NRW. These are normally caused due to declining infrastructure and poor maintenance.

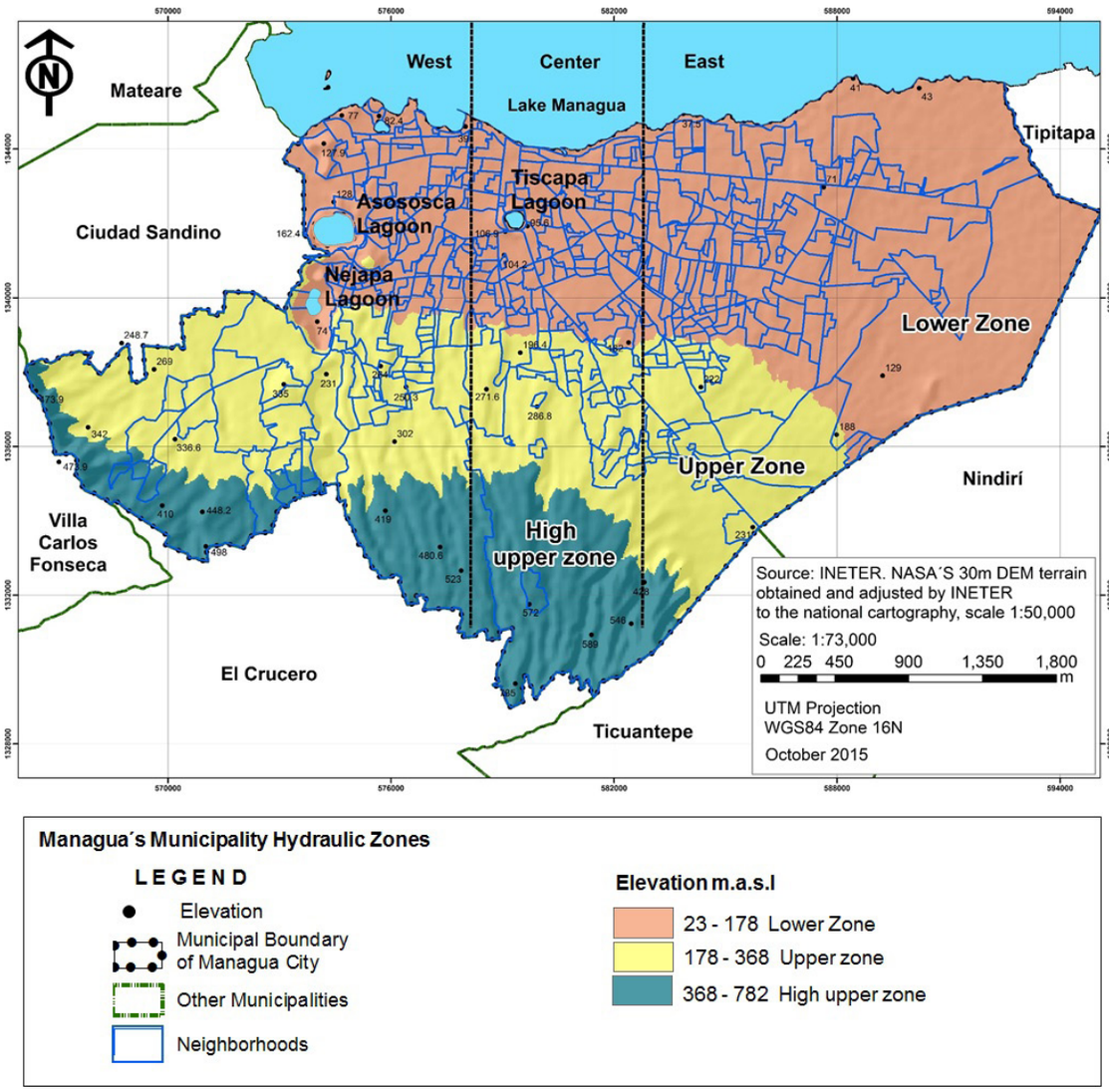

Fig. 4. Map of the continuity of water supply services in Managua. (*Source*: [39]).

According to [2] "water leakage… varies from 3% to 50%" in developing countries.

From 2003 until 2011, the average NRW in Managua was above 50% [27–30,42,43]. In 2003, NRW was approximately 57%, and by 2011, it had increased to 59%[2], while in other large cities in Latin America and the Caribbean, the mean NRW was 42% [44]. This means that more than half of the water produced in Managua's water system is lost due to both physical (real) losses and non-billed customers [1]. However, no detailed information is available on the components of NRW in Managua's water system.

There is only one reliable study made by JICA in 2005 which analyzed the water demand of Managua city. This study can give an approach of the magnitude of water loses. JICA [15] projected that the water demand for Managua was going to reach 397,739 m^3/d. Base on such projection, recommended a sustainable abstraction and delivery of water with no need for the constructions of more wells in the city. Water demand for 2015 was supposed to be satisfied throughout a sustainable delivery of 402,950 m^3/d [15]. Nevertheless, this value was surpassed, since water production in 2015 was 468,794 m^3/d, and the recommendation "that more abstraction wells were not needed" was not followed.

Currently, It is estimated that the average water consumption per capita in Managua ranges from 202 lpcd to 257 lpcd [29]. However, the water delivery per capita ranges from 438 lpcd to 529 lpcd [29]. These figures also

[2]This year is the last available official report, because the company then stopped reporting.

show that the water utility is delivering more water than demanded.

About physical losses in Managua, they are not far from values stated by Sharma and Vairavamoorthy [2]. It is estimated that physical losses in the city range from 30% to 40% [23,45] which are very high values. By 2005, Managua's physical losses were estimated at 46 million m^3/y [15].

Yet the lack of operative control of leaks and the absence of a leakage management programme is a factor contributing to high NRW [46] in ENACAL-Managua. ENACAL-Managua has not developed measures nor implemented a plan to reduce NRW. This is because its financial situation barely allows the utility to continue operating.

2.3. ENACAL's water tariff

In developing countries, lack of effective cost recovering water rates is one of the major obstacles for water utilities [8,33,47]. Rates that tend to be underestimated, "do not reflect the real cost of water" [1,48] and in turns affects water utilities financial performance. This brings up the question of whether a lack of effective cost recovering rate is the major problem of ENACAL.

The Nicaraguan water rate is based on an increasing block rate type, since "non-linear rates for water supply services are widespread" [49], which can be observed in Table 2. The water tariff approved in 2001[3] for ENACAL by the Regulatory Agency (INAA) was approved has two different tariff structures, one for Managua and another for the rest of the country.

Managua's water tariffs take into consideration social fact Managua's water tariffs take into consideration social factors such as poverty and affordability to pay, along with the types of use [50,51]. This differentiates as well domestic use: domiciliary and residential, depending on the type of household and/or neighborhood. For the rest of the country water rate does not differentiate and only uses the term "domestic user" [52].

Water rate structure is based on a system of cross-subsidies between fixed and variable costs, consumption and types of use [50]. While subsidies for fixed prices vary from 28% for major water consumers (industrial, commercial and institutional) to 91% for the poorest sector, subsidies for variable costs range from 60% to 77% for the poorest sector and from 4% to 14% for major consumers [50] §T.

Previous studies have emphasized how water rates have influenced the financial situation of ENACAL. [33] for example, highlighted that the steady water rates from 2001 "has put ENACAL at the verge of Bankruptcy". They further emphasized that is because the utility's income decreases due to the freeze rates, which are bellow productions costs, and due to the constantly increase on energy costs [33].

The issue is that it has not been allowed for the utility to update its water rates since 2001. Despite the company (ENACAL) has tried to get the approval from its regulator (INAA), it has not obtained a positive answer [33]. This case is not just happening to ENACAL. Vásquez, Franceschi [53] pointed out that other water utilities in the country such AMAT (Aguadora de Matagalpa) have the same issue and have not been able to update their water rates. As water utilities in the country are under a legal arrangement in which INAA has to approve it, utilities have to submit petitions to adjust their rates. Besides, it should be considered social and overall politics aspects, this because water rates are "much politized matters" [33].

In Nicaragua, adjusting the water tariff is a political cultural issue because in the 1980s the water supply as well as other public services were heavily subsidized, and therefore there was very little impact on household expenditure. It also became political through the Latin American anti-privatization movement also enrooted in Nicaragua. These are some of the reasons why increasing the water tariff is seen as a move towards privatization, and therefore opposed by Nicaraguan society [54].

Furthermore, increases in water tariffs could be a matter of willingness to pay, since ENACAL has not been able to provide an adequate service to its customers (due to various financial constraints). The water supply service is having troubles delivering reliable services causing residents

Table 2
ENACAL's water tariff indexed up to the year 2006

Consumption range (m^3)	Managua	Other areas
Domestic		
0.1–20	0.15	0.17
21–30	0.29	0.24
31–40	0.30	0.26
41–50	0.31	0.27
More than 50	0.55	0.29
Subsidized domiciliary		
0.1–20	0.08	0.08
21–30	0.10	0.11
31–40	0.12	0.13
41–50	0.12	0.13
More than 50	0.13	0.14
Residential		
0.1–20	0.31	Non-existent
21–30	0.31	
31–40	0.31	
41–50	0.31	
More than 50	0.70	
Major consumers (commerce, industry, government)		
0.1–20	0.36	0.36
21–30	0.36	0.40
31–40	0.36	0.40
41–50	0.36	0.40
More than 50	0.76	0.76
Domestic average (US$)	0.27	0.18
Total average (US$)	0.31	0.28

Source: [52].

[3]INAA approved the water for INAA in 2001 which was indexed in 2008 to keep up with inflation but it was indexed up to the year 2006 which was the year in which ENACAL's water tariff validity expired.

dissatisfaction. Despite, some studies undertaken in other cities in the country have shown that people is willing to pay up to double for reliable and safe drink water [53], this is still a gap in Managua city where residents in slums with illegal connections are potentially influenced for a low willingness to pay.

Certainly, water tariff structures are very complex [55]. This seems to be the case for ENACAL whose financial situation is going on deficits apparently due to the water rate [33]. This is opposite to what has been recommended by the World Water Commission which "strongly endorsed the need for full-cost pricing of water services" [56].

2.4. Financial situation of ENACAL

Financial information on ENACAL-Managua is only reported in the general balance sheet countrywide and not separately for each area. Therefore, the information discussed in this section refers to the financial performance of ENACAL at a national level.

ENACAL, at national level, lost US$ 35.37 million per year (on average) in the period 2001–2014 [12,57]. High physical losses and the steady low water rate[4] make operations economically unsustainable. ENACAL´s losses are paid through the National Budget [8] using international loans, grants, and money from taxpayers.

ENACAL has been "at the verge of bankruptcy" [33] for years. The bankruptcy situation remains, but through subsidies from the Central Government [8,33], it continues operating.

Fig. 5 illustrates the financial situation of ENACAL in the period 2001–2014. Losses statistically analyzed in the period 2001–2014 do not include the value loss of aging infrastructure or any other asset of value loss. According to Mutikanga, Sharma [5]: "Low tariffs and a tendency to rely on loans and aid seriously hamper investments in the distribution systems", this tendency is not an exception in Nicaragua's main water utility, ENACAL.

ENACAL has a financial deficit [8], this has led to constraints that do not allow proper maintenance or investment in its water system [8,33,38,58], which creates a "vicious circle" of non-willingness to pay [33] and poor service [5,15,38,59]. Therefore, there is a need to carefully review the current water rate structure as well as the operation and maintenance costs of water supply systems under ENACAL and to make necessary changes to ensure the sustainability of urban water supply systems in Nicaragua [60].

3. Discussion

Providing water services to residents is very challenging for water utilities in developing countries. This is not quite different from ENACAL's situation at its water supply system in Managua city. Literature review has provided

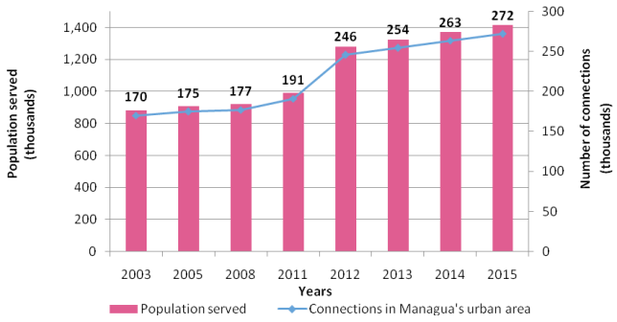

Fig. 5. General balance sheet of ENACAL-NICARAGUA. (*Source*: [12,57]).

some evidence of this, as presented in this review paper. The current situation of the Managua's water supply system is leading the water utility to a financial deficit situation. Nowadays, the utility faces many obstacles including deficiencies on reliability and water level pressures, illegal connections and high NRW which altogether constrains the company's performance.

Even the water supply system on Managua City is very basic and water resources are available at sufficient quantity, the company is not able to operate efficiently to satisfy residents' water demand. Urban water demand management (UWDM) plans, strategies and measures have not been implemented on Managua's water supply system, rather it has been driven by trying to expand the coverage. This is a problem since expanding the grid to increase coverage does not guaranty the reliability of the service. Contrary, it could affect water level pressure and NRW, if an adequate analysis for expansion is not undertaken.

Some study has emphasized such situation for no need of more water resources. For instance, there is a comprehensive study made by [15] for the Managua water supply system, which pointed out that the amount of water already produced in 2005 was enough to supply the future demand in a 20-year scenario for the urban area. If this is true, how it comes ENACAL is still increasing water production and continuing drilling wells around the city? The answer could be that ENACAL does not have an efficient management program to maintain and operate its water system and is easier for the company to just look for more water sources.

The JICA study recommended to carry out leakage management programmes to reduce NRW and to optimize the water supply. Nevertheless, such recommendations were not implemented and the utility continued having troubles to operate the system. Evidence of this are the continuous shortages and poor reliability of the service.

Customers not only demand for the access to water service, they also demand for sufficient, reliable and safe drinking water. However, to satisfy such demands in Managua it is still a challenge for the water utility. In Managua, residents complain about the water service due to a very poor reliability and low water level pressures. In some areas, the service is for less than three hours per day and in some cases every two days. These facts are very extreme, but the causes are not well

[4]Water systems operated by ENACAL have a single national water tariff, even though they differ in aspects such as: elevation above sea level, mean annual precipitation, number of connections, and type of use, location and type of water sources, size of concession area and income of the population served.

known yet. Someone could suggest that this is a consequence of lack of operation and maintenance of the system, but an in-depth study is needed to clarify this gap.

NRW is another issue for ENACAL at its main water supply system. In Managua, NRW is above 50%, which means more than half of the water delivery is lost. As JICA pointed out, if leakage control were undertaken in Managua, NRW would be reduced and more water would be available for residents at better level pressures and with no shortages. JICA study is already more than 10 years old, and the conditions in the city might have changed, however NRW is still going up. Non-recent study has been conducted and the factors influencing NRW remains unknown. JICA suggested leakages, but in Managua there are also slums with high number of illegal connections which also obtain water from the system. This illegal consumption is a very important factor influencing NRW and affecting the water systems in terms of water level pressures and flows.

ENACAL needs to develop new plans and strategies to improve the water supply system. UWDM seems a good solution for the utility. If UWDM plans, strategies or measures are not implemented, there is a low probability that ENACAL's will improve its operation and maintenance. This is also related to a poor financial performance which is affected by water rates and willingness to pay.

Managua's water rate is non-cost recovery, which results in poor maintenance and no replacement of old infrastructure [8,33,61], this has further led customers to take private actions such as installing water storage tanks, and buying bottled water for consumption [38,59], this means that customers have to buy water from private vendors at higher prices [56,60–62] which is not affordable for the urban poor [6,59,63].

Water utilities in developing countries are facing the need to extend water supply service coverage although new customers cannot always afford to pay [64–66]. Furthermore, there is a general fear among water utilities that increasing water tariffs could create political unrest [6,8] in "…deep rooted political cultures…" [65], although an increase in water tariff or proper pricing of water can be a way to achieve sustainability and equity [60] if people´s willingness and affordability to pay is well assessed and accounted for [67]. A study carried out in a small village in Nicaragua showed that people who lack water are willing to pay for it [68]. A comprehensive study on affordability and willingness to pay for water services should be undertaken, because "it becomes essential to know whether people in different settings are ready to financially support the system for improving and maintaining the quality of service" [58].

Based on a literature review and statistical analysis of the data collected, it can be stated that there are ample prospects and opportunities to apply UWDM plans, strategies and measures in Managua's water system, such as proper water pricing and tariff structure and water loss management. Moreover, there are favorable conditions for implementing UWDM in the near future triggered by population increase, urbanization, water resources depletion, unsustainable financial structure and demands for improved water service level, which might lead to a higher willingness to pay for it.

4. Conclusions

Based on the literature review and data analysis of Managua´s water supply system, the following are the main conclusions of this research:

1. Managua's water supply system is in need of good financial and operational measures, as well as socio-political and legal arrangements as a starting point to implement appropriate UWDM strategies aiming to improve the structural and technical components within the system.
2. NRW is high (around 59%) in Managua's urban water supply system which is causing not just economic losses but also an unsustainable use of water resources without improving the service level in Managua city. Therefore, reduction and control of NRW should be among the first UWDM measures or strategies to be implemented.
3. The water tariff of ENACAL-Managua is non-cost recovery. As a result, the water utility has to rely on international loans, aid and money from taxpayers, making it difficult to replace aging infrastructure and conduct appropriate operation and maintenance. This leads to a "vicious circle" of low service level and low willingness to pay by customers.
4. A new water tariff structure is needed to keep up with the coverage expansion, replacement of old infrastructure and implementation of an operation and maintenance programme. The new tariff structure must be suitable socially and financially (cross-subsidies).
5. If no UWDM plans, strategies or measures are implemented, there is a low probability that ENACAL's finances will improve. Therefore, without funds to implement UWDM programmes such as leakage management control, commercial losses management or asset management control, it is unlikely that the current water service level will improve.

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