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Public Perception of the Main Constraints of Water Supply Shortage and the Availability of Water Supply Resources in Libya

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Abstract

Water is a key driver of economic and social development. It also has a basic function in maintaining the integrity of the natural environment. Bearing in mind that water is only one of a number of vital natural resources, it is imperative that water issues are not considered in isolation. Both public and private sector managers, have to make appropriate decisions on water allocation. Water shortage, which can extensively be comprehended as the absence of access to sufficient amounts of water for human and environmental uses.

This study aims at investigating the technical, financial, environmental and social constraints that affect water supply shortages in the study area. The results and findings were based on the 359 survey questionnaires that were collected and analysed using Statistical Package Social Sciences (SPSS) version 22.0 and Analysis of Moment Structure (AMOS) Software version 16.0. Statistical analysis showed that all the Environmental, Technical and Financial research items were at the high and very high levels of acceptance and only all cultural research items were at a high level of acceptance. The empirical results of structural equation modeling (SEM) indicate that the water supply management model fit indicates that the factors of this work are convenient and reasonably contribute to the performance of the water supply management model in the study area. This study has a number of recommendations for achieving sustainable water management and solving water shortage problems within the Libyan cities, such as Al Marj.

Keywords: water management; water supply shortages; environmental constraint; social constraint; Al Marj City; Libya.

JELClassification: Q01; Q25; Q26; Q28; Q54; Q58

Introduction

Water covers two thirds of the earth's surface, whoever 97% of it is unhealthy for human use. Of the remaining 3% two thirds are confined in glaciers and snow. Nearly 1% is available for human consumption. This remaining amount should be enough to satisfy the needs of all water consumers in the world (Alamin *et al.* 2010). In fact, water is a key driver of economic and social development. It also has a basic function in maintaining the integrity of the natural environment. Bearing in mind that water is only one of a number of vital natural resources, it is imperative that water issues are not considered in isolation. Both public and private sector managers, have to make appropriate decisions on water allocation (Bindra *et al.* 2014). Water shortage, which can extensively be comprehended as the absence of access to sufficient amounts of water for human and environmental uses (White 2012). As indicated by the Food and Agriculture Organization (FAO 2012). Water shortage "happens when the interest for water from all divisions (farming, urban communities, and environment) is higher than the accessible assets. In the past three decades, the water resource in Libya has a high priority in its development. Therefore, the water assets in Libya is requiring a high need in its advancement and then it is necessary to meet the water requirements of the increasing population growth and the huge demands from agricultural, domestic and industrial sectors (Wheida and Verhoeven 2007). Humans consume water for drinking, washing, sanitation and other routine activities. Water supply in urban regions and urban communities is likewise to clean streets, watering the gardens and both commercial and administrations uses. In this manner, the consumption of water is increasing with the population growth. The water requisite needed ranges from 300-600 liters/day per capita in numerous urban communities with limited water resources and then, to 10 - 40 liters/day for each capita in areas where water shortage happens (Nobre *et al.* 2016). Moreover, water is turning out to be progressively rare around the world according to several factors such as climate change, mismanagement and lack of the rainfall. Aridity and dry seasons are the common reasons for water shortages. All the more as of late, man-made desertification and water deficiencies are exasperating the regular shortage while populace is developing and the interest for water confronts an expanded rivalry among water client segments and areas. Not just precipitation is insufficient plenteous in numerous districts, along these lines restricting the amount of water assets accessible, additionally the nature of water is progressively making that water assets get to be inaccessible for more stringent prerequisites (Pereira 2005). Libya as a parched country represents 94.5% territories with ceaselessly rare freshwater. Scarcely, only 5% of the nation gets more than 100 mm of rain every year (Bindra *et al.* 2013).

Furthermore, the climate in the country is dry and semi-parched with temperatures extending between 13^0C in January and 25^0C in August and generally high dampness (between 73.3% in winter and 61.6% in summer) due to the country location which is most of the cities located in the coastal area of the Mediterranean sea (El Osta and Masoud 2017). A household water deficiency is a critical problem in developing countries due to mismanagement and lack of the water resources and climate change in Libya as general and in the city of Al Marj as specific. Moreover, water scarcity is an imbalance between demand and availability and then pure water is becoming a scarce commodity in Libya, especially in the eastern part of Libya and water is bought and sold in the city (FAO 2009).

1. Literature Review

Future changes in climate and socioeconomic systems will drive both the availability and use of water resources, leading to evolutions in scarcity (Graham *et al.* 2020). Climate change can affect water chemistry and depth in several ways (Depla *et al.* 2009; Minella *et al.* 2011). For instance, a change in run-off and weathering rate can modify the concentration of cationic and anionic species in the receiving water environments. Hamad *et al.* (2017) stated that according to the environmental constraints in Nigeria, approximately 60%–70% of the population is currently without sufficient water. Hoekstra and Chapagain (2006) claimed that the importance of water shows the extent of water use in relation to production and human consumption. Adekunle and Eniola (2008) investigated the quality of drinking water and reported a total hardness of 51–175.5 mg/L and conductivity of 65–318 µs. Their results revealed Ca and Mg+2 in the ranges of 33.7–102.3 mg/L and 3.5–57.1 mg/L, respectively. As high counts of E. coli and coliform were found in the study, the main sources of pollution were identified as the direct runoff from the industries and the refuse dumps within the Asa Dam Industrial Estate in Kwara, Nigeria. Khan (2011) conducted a study on water pollution in Aligarh City, India. This report revealed excessive ratios of trace elements (Ni, Zn, Fe, Pb, Cd, Co, Cu, and Mn), some of which were identified in drinking water. Hence, the water was considered polluted and cited as the cause of the poor health of the residents and the spread of diseases in Aligarh. Hamad *et al.* (2017) stated that according to the environmental constraints in Nigeria, approximately 60%–70% of the population is currently without sufficient water. Fereres and Soriano (2006) explained that the prediction of water withdrawals based on international measurements projects increases in future demand to

meet the needs of the urban, industrial, and environmental sectors. Khan *et al.* (2011) conducted a study in Bangladesh and found that the average estimated intake of sodium from drinking water is 5–16 g/day in the dry season and 0.6–1.2 g/day in the rainy season. Therefore, the problem of saline intrusion into drinking water has multiple causes and is likely to be exacerbated by climate change-induced sea level rise.

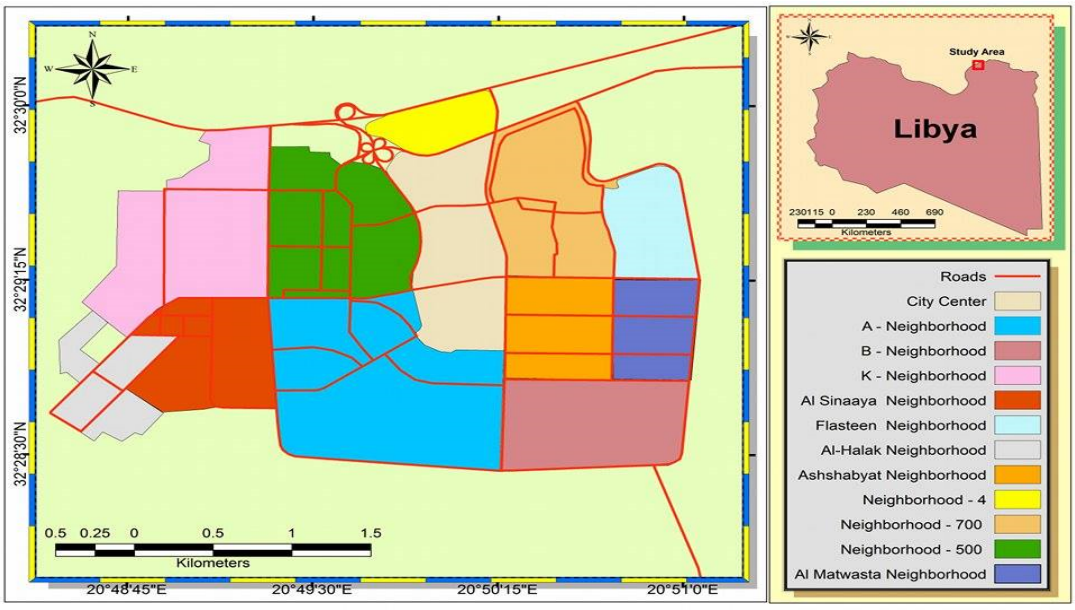
The water sector is a fundamental and basic part of any national economy, and it is directly linked to the growth of other sectors, especially agriculture (Boboevich *et al.* 2014). The economic impact of water scarcity is characterized by an inappropriately high expense input relative to the agricultural product output or yield. Therefore, the household income from agricultural activities remarkably declines, and the rate of investment in the agricultural sector drops (Bayad *et al.* 2015). Water shortage and scarcity lead to desertification that affects livelihood and accelerates rural–urban migration. Severe drought and associated crop failures and pasture shortage contribute to a pattern of more rapid rural population decline in desertified provinces than in nondesertified provinces (Amiraslani *et al.* 2011). In Nepal, Sun *et al.* (2010) demonstrated and expounded that as many users are at each water point during peak hours, households located far from the piped tap stands must search for other unprotected sources. Vörösmarty (2010) found that nearly 80% of the world population is exposed to the serious threat of water shortage and scarcity. Geels (2005) suggested to improve water circulation in urban canals using steam engines to pump in fresh water and remove polluted water.

2. Research Method

2.1 Study Area

The study was conducted in city of Al- Marj in Libya which is located in north-eastern of Libya and lies on the coast of the Mediterranean Sea. It covers an area of approximately 10,000 km^2. The regulatory seat of Al-Marj city was known as Barca. Al-Marj is arranged on the Cyrenaica level at the western edge of Jebel Akhdar and has an expected population of 85,315 starting 2012 with coordination:32°29'12"N 20°50'02"E (Hamad *et al.* 2017a).

Figure 1. The study area



The study area is considered one of the most important areas in Libya in terms of its location of the Green Mountain as well as its agricultural vital, including irrigated and non-irrigated cultivation and animal wealth as well as the economic activities. The survey of the study was conducted in the city of Al-Marj in Libya (See Figure 1). The map was produced by *Arc GIS Arc Map version 9.3.* The study area is influenced by the Mediterranean climate, which is characterized by hot dry summers, and mild rainy winters. The study area has a dry climate as of a semidesert, showing poor rainfall and high evaporation rates and a clear appearance of aridity which prevails overall in the area. The climatic characteristics come from Al-Marj meteorological station, the nearest to the study area. The average annual rainfall is 380 mm/year. December, January and February have the highest rates of rainfall and lower temperatures during the year, while the average annual temperature was 18.8 degrees Celsius. The highest relative humidity appears in January and February, with an average of 71%, and decreased during

May and June with an average of 50%, the highest wind speed appears in December, January and February, which amounted to 10 miles/hour, the average annual wind speed was 8.6 mile/hour (El-Barasi *et al.* 2011).

2.2 Data Collection and Analysis

A survey was conducted to collect data from the residents' perception in the study area. The structured questionnaire aimed to confirm the severity of the factors and effects of water supply shortages identified from the literature review as well as their relevance in the Libyan's water supply management system. The survey instrument was first piloted of study sample in order to ensure the questions were straightforward, easy to understand and substantial. In addition, a Cronbach's alpha evaluation was carried out to evaluate the measurement reliability of the study. The aim of the pilot study was to check on the experimental procedure before proceeding with the main study, to improve the reliability of the results, and to check errors and level of difficulty of the questions in the questionnaire. Non-probability sampling (convenience random sampling techniques) was employed to avoid biases and to ensure that each resident carries an equal chance of being selected. Based on the city population size, 500 questionnaires were distributed to the residents in the city, of these, only 359 questionnaires were filled up and returned back, yielding a response rate 71.8% (see Table 1). Numerical data collected using survey instrument were analysed using inferential and descriptive statistics based on SPSS and AMOS software.

Table 1. Response rate of data collection

Details	Number of Questionnaires	Percentage
Total questionnaires distributed	500	100%
Total questionnaire received	393	78.6%
Questionnaire with missing values	34	6.8%
Usable questionnaire	**359**	71.8%

3. Results and Discussion

3.1. Respondents' Profile

Analysis of the demographic characteristics of the respondents showed that most of the respondents' age were between 20-30 years old. The respondent's knowledge was considered appropriate in providing substantial information required to investigate the Technical, Financial, Environmental and Social constraints that affects water supply shortages in the study area. Age as an import demographic variable can be used to determine the factors that affect water supply shortages (Tan 2005). Considering the age limit of this study which confines to residents in Al-Marj city, detailed representation of residents age that participated in this study are analysed statistically to explain the characteristics of the respondents. Therefore, based on the result, residents within the age of 20-30 years old were 238 (66.3%)residents participated most followed by 31-40 years old were 64 (17.8 %) residents, 41-50 years old were 31 (8.6 %) residents, 51-60 years old were 17 (4.7%) residents, and above 60 years old were 9 (2.5). Mainly, the study comprised of different races namely Libyans and other nationalities. In an attempt to understand the composition of respondents by race, data collected showed that Libyans are the major contributors to this study and comprises 330 respondents corresponding to (91.9 %), while other nationalities comprise 29 respondents (8.1%). The respondent's occupation of the residents that is working in the government institutions were 156 (43.5%), while 46 (12.8%) respondents were employed in private sectors and 157 (43.7%) were not employed. The respondent's monthly income was less than 450 LYD are 111 (30.9%), while a respondents of 80 (22.3%) are getting a salary of 451 -650 LYD a month, a respondents of 84 (23.4%) are getting a salary of 651 -850 LYD a month, and finally a respondents of 84 (23.4%) are getting a salary of more than 851 LYD. The respondents are living in different type of houses, most of them are living in a traditional house 216 (60.2%) residents, while 97 (27%) of the respondents are living in apartments, also 32 (8.9%) are living in a villa, and 14 (3.9%) respondents are living in an old house. The respondents are living in different house types and this will give an excellent analysis result of the factors that affecting water supply shortages and will provide many opinions and prospective regarding these factors. Finally, this section is showing the number of family members among the respondents, 175 respondents are having 4 – 7 (48.7%) family members, while 130 respondents are having more than 8 (36.3%) family members, and 54 (15%) respondents are having the smallest family members which was between 1 – 3 family members.

Table 2. Detailed description of the respondents' background

Type	Frequency	Percent
Gender		
Male	186	51.9%
Female	173	48.1%
Age range		
20-30	238	66.3%
31-40	64	17.8%
41-50	31	8.6%
51-60	17	4.7%
Above 60 years	9	2.5%
Race		
Libyan	330	91.9%
Others	29	8.1%
Occupation		
Government Employed	156	43.5%
Private Sector	46	12.8%
I do not work	359	43.7%
Monthly income		
Less than 450 LYD Monthly	111	30.9%
451 -650 LYD Monthly	80	22.3%
651 -850 LYD Monthly	84	23.4%
Mora than 851 LYD Monthly	84	23.4%
House type		
Villas	32	8.9%
Traditional house	216	60.2%
Apartment	97	27%
Old House	14	3.9%
Number of Members		
1 – 3	54	15%
4- 7	157	48.7%
More than 8	130	36.3%

3.2 Descriptive Statistics of Key Dimensions of the Study

After the discussion of overall response rate and data collected. Descriptive statistics of all the dimensions are presented that explains the trend of collected data as shown in Table 3. Therefore, the very first predictor, Technical factors are represented from $TECH_1$ to $TECH_{10}$, for the 2nd predictor Financial Factors FF are presented through FIN_1 to FIN_5, for Environmental factors ENV are presented through ENV_1-ENV_5 and finally the social factors SOC are presented through SOC_1 to SOC_5. In addition, all these predictors and their dimensions' total number of respondents are 359. The main value for the $TECH_7$ is maximum in all the dimensions and it is 4.26 while for the $TECH_4$ the mean value is minimum which is 3.78.

Table 3. Descriptive Statistics of the Study

No.	Items Code	Mean	Std. Deviation
Technological Factors			
1	$TECH_1$	3.82	.876
2	$TECH_2$	4.11	.958
3	$TECH_3$	4.04	.925
4	$TECH_4$	3.78	.965
5	$TECH_5$	4.12	.839
6	$TECH_6$	4.04	.761
7	$TECH_7$	4.26	.794
8	$TECH_8$	4.25	.765
9	$TECH_9$	4.00	.941
10	$TECH_{10}$	4.03	.792

No.	Items Code	Mean	Std. Deviation
Financial Factors			
1	FIN_1	4.09	.831
2	FIN_2	4.06	.801
3	FIN_3	4.23	.803
4	FIN_4	4.03	.827
5	FIN_5	4.16	.822
Environmental Factors			
1	ENV_1	3.97	.823
2	ENV_2	4.11	.877
3	ENV_3	4.05	.816
4	ENV_4	4.13	.802
5	ENV_5	4.05	.826
6	ENV_6	4.09	.808
Social Factors			
1	SOC_1	3.8022	.88273
2	SOC_2	4.1504	1.74160
3	SOC_3	4.0752	.97306
4	SOC_4	3.8719	.89709
5	SOC_5	4.2173	.81029

All the dimensions for the selected predictors, 21 have above 4 mean value while only 4 dimensions are those which have a mean value of below 4. As a result, these findings indicate the facts that majority of the respondents have provided their responses in range of agree and strongly agree on 5 points Likert scale. The value of standard deviation for the SOC_3 is maximum which is 1.74 in all the dimensions of the selected predictors. While for the $TECH_8$ the value of standard deviation is minimum; 0.765.

3.3 Descriptive Statistics. Mean and Standard Deviation

This section describes the acceptance level for all the items of the variables in the model using mean and standard deviation. In this analysis section, the mean and standard deviation values provide initial insights into the respondents' perception of the dimensions and subdimensions of the research variables. Sample statistics are tabulated according to the dimensions and subdimensions of the structure of the research instrument. The classification for the rating scale is used to investigate the level of each item in the variables shown in Table (4). The rating ranges from very low to excellent (mean score of 1.5 – 4.5).

Table 4. Rating Score

Rating score	Mean Score
Very Low	Less than 1.5
Low	1.5 <Mean score < 2.5
Moderate	2.5 < Mean score < 3.5
High	3.5 < Mean Score < 4.0
Very high	4.0 < Mean Score <4.5
Excellent	Mean Score ≥4.5

Source: Abd Majid and McCaffer (1997)

3.3.1 Acceptance Level of Technical Items

The acceptance levels of the technical factors of water supply shortage are provided in Table (5). The analysis provides the acceptance levels of the research items that were analyzed to draw a conclusive finding in the present study. All research items were at the high and very high levels of acceptance and were thus appropriate. Felbab–Brown (2017) found that in Pakistan, a large portion of the water supply is stolen through illegal connections before the water reaches Delhi and Mumbai. Another study conducted by Short and Oldach (2003) in Jordan revealed issues associated with the installation and operation of pumping systems due to the lack of technical expertise. A study conducted in the United Kingdom in 2015 reported that water pipe failures are associated with pipe characteristics, material properties, and environmental and loading conditions, such as corroded pipes, which could contribute to the development and acceleration of failures (Rezaei *et al.* 2015). Landowners generally receive low compensation for the construction of water pipelines and thus tend to refuse the establishment of water pipelines in their lands; meanwhile, the law does not protect installation companies (Gillette and Kolpa 2008). Doe (2007) revealed that illegal connections and unplanned townships have resulted in

the scarcity of water in Teshie City. Hope (2014) conducted research in Kenya and revealed that over two in five households (44%) do not pay for water from their hand pumps. In Libya, Hamad *et al.* (2017) found that the lack of technical support and training seriously affects water supply management. Libya faces many problems mainly related to managerial and technical failures. Moreover, reports indicated that the Libyan government does not fund the water supply sectors equally to support water requirements. Furthermore, the water distribution system in Libya is ancient and faces leakages and obsolete equipment, as well as issues with the size of the network pipeline. Only limited repairs are being done on critical infrastructure in each city in Libya. Since the Libyan revolution in 2011, the country has been challenged by damaged public utilities, such as water pipe systems, and electricity generation.

Table 5. Level of acceptance of items for technical constraints

Technical Factors	Mean	SD	Level of acceptance
1. Illegal connections	3.96	0.664	High
2. lack of technical expertise to handle the pumps	3.89	0.638	High
3. Few pipelines cannot support fast expansion of water to township	3.85	0.678	High
4. Land owners do not want new pipe lines to pass their lands	3.92	0.628	High
5. Unplanned township/community	3.95	0.666	High
6. Electricity power outage problems	4.10	0.618	Very High
7. Management problem	4.14	0.680	Very High
8. Lack of maintenance	3.88	0.756	High
9. Electricity issue	4.06	0.716	Very High
10. Water leakage always creates a problem	4.11	0.766	Very High

SD: Standard Deviation

3.3.2 Acceptance Level of Financial Items

The acceptance levels of the financial factors of water supply shortage are provided in Table 6. In this section, the analysis provides the acceptance levels of the research items that were analyzed to draw a conclusive finding in the present study. All the research items were at high and very high level of acceptance, indicating all items appropriate. Based on research in developing countries, Van Houtven *et al.* (2017) suggested that households were willing to pay approximately $3 per month for improvements in water access. In Parral, Mexico, Vásquez (2009) indicated households were willing to pay from 1.8% to 7.55% of reported household income above their current water bill for safe and reliable drinking water services. Beaumais *et al.* (2014) estimated the highest relative willingness to pay for better tap water quality was found in countries with the highest percentage of respondents unsatisfied with tap water quality because of health concerns. They reported the willingness to pay in Mexico, Korea, and Italy was estimated at 10.1%, 6.4%, and 8.8%, respectively, of the median water bill. In Sudan, cities were affected by unequal distribution of water, and the variance between water supply and demand is growing with time due to the rapid population growth and aridity.

Table 6. Level of acceptance of items for financial constraints

Financial Factors	Mean	SD	Level of Acceptance
1. Are you willing to pay for improved the water supply?	3.98	0.592	High
2. The rate of our monthly water bill is very much expensive	3.99	0.599	High
3. If there is any improvement in water shortages by local authority, are you willing to pay for the improvement of water supply?	4.03	0.671	Very High
4. There is no an equal distribution of water in our city	3.78	0.628	High
5. If there is a problem in water connection, most of the time I faced financial troubles to fix that issue	3.761	0.733	High

3.3.3 Acceptance Level of Environmental Items

The acceptance level of environmental factors on water supply shortage is provided in Table 7. In this section, the analysis provides the acceptance levels of the research items that were analyzed to draw conclusive findings in the present study. All the research items were at the high and very high levels of acceptance and were thus appropriate. Adekunle and Eniola (2008) investigated the quality of drinking water and reported a total hardness of 51–175.5 mg/L and conductivity of 65–318 µs. Their results revealed Ca and Mg+2 in the ranges of 33.7–102.3 mg/L and 3.5–57.1 mg/L, respectively. As high counts of *E. coli* and coliform were found in the study, the main sources of pollution were identified as the direct runoff from the industries and the refuse dumps within the

Asa Dam Industrial Estate in Kwara, Nigeria. Khan (2011) conducted a study on water pollution in Aligarh City, India. This report revealed excessive ratios of trace elements (Ni, Zn, Fe, Pb, Cd, Co, Cu, and Mn), some of which were identified in drinking water. Hence, the water was considered polluted and cited as the cause of the poor health of the residents and the spread of diseases in Aligarh. Hamad *et al.* (2017) stated that according to the environmental constraints in Nigeria, approximately 60%–70% of the population is currently without sufficient water. Hoekstra and Chapagain (2006) claimed that the importance of water shows the extent of water use in relation to production and human consumption. Fereres and Soriano (2006) explained that the prediction of water withdrawals based on international measurements projects increases in future demand to meet the needs of the urban, industrial, and environmental sectors. Khan *et al.* (2011) conducted a study in Bangladesh and found that the average estimated intake of sodium from drinking water is 5–16 g/day in the dry season and 0.6–1.2 g/day in the rainy season. Therefore, the problem of saline intrusion into drinking water has multiple causes and is likely to be exacerbated by climate change-induced sea level rise.

Table 7. Level of acceptance of items for environmental constraints

Environmental Factors	Mean	Std. Deviation	Level of Acceptance
1.There is a problem of water contamination in my city.	4.03	0.671	High
2. There is a great need of basic knowledge for the appropriate and faire use of water.	3.78	0.628	High
3. The problem of minimum water level and low flow also exists in my city.	4.03	0.671	Very High
4. Reasonable beneficial use of the water is very much necessary.	3.99	0.599	High
5. Sometimes, there is a salty taste experience in drinking water.	3.94	0.649	High

3.3.4 Acceptance Level of Cultural Items

The acceptance levels of the cultural factors of water supply shortage are provided in Table 8. In this section, the analysis provides the acceptance levels of the research items that were analyzed to draw conclusive findings in the present study. All the research items were at a high level of acceptance and were thus appropriate. The water sector is a fundamental and basic part of any national economy, and it is directly linked to the growth of other sectors, especially agriculture (Boboevich *et al.* 2014). The economic impact of water scarcity is characterized by an inappropriately high expense input relative to the agricultural product output or yield. Therefore, the household income from agricultural activities remarkably declines, and the rate of investment in the agricultural sector drops (Bayad *et al.* 2015). Water shortage and scarcity lead to desertification that affects livelihood and accelerates rural–urban migration. Severe drought and associated crop failures and pasture shortage contribute to a pattern of more rapid rural population decline in desertified provinces than in nondesertified provinces (Amiraslani *et al.* 2011). In Nepal, Sun *et al.* (2010) demonstrated and expounded that as many users are at each water point during peak hours, households located far from the piped tap stands must search for other unprotected sources. Vörösmarty *et al.* (2010) found that nearly 80% of the world population is exposed to the serious threat of water shortage and scarcity. Geels (2005) suggested to improve water circulation in urban canals using steam engines to pump in fresh water and remove polluted water.

Table 8. Level of acceptance of items for cultural constraints

Cultural Factors	Mean	Std. Deviation	Level of Acceptance
1. Water supply shortages affects local and commercial activities.	3.86	0.664	High
2.Water supply shortages causes wasting time searching to get water.	3.94	0.722	High
3. I am not satisfied with your drinking water services.	3.89	0.728	High
4. I feel there is a threat of a drinking water shortage in the area where you are living.	3.77	0.804	High
5. There is a great need of suggestion to improve water supply.	3.94	0.656	High

3.3.5 Acceptance Level of Residents' Perception of Water Supply Shortage Items

The acceptance levels of residents' perception of the water supply shortage factors of water supply shortage are provided in Table 9. In this section, the analysis provides the acceptance levels of the research items that were analyzed to draw conclusive findings in the present study.

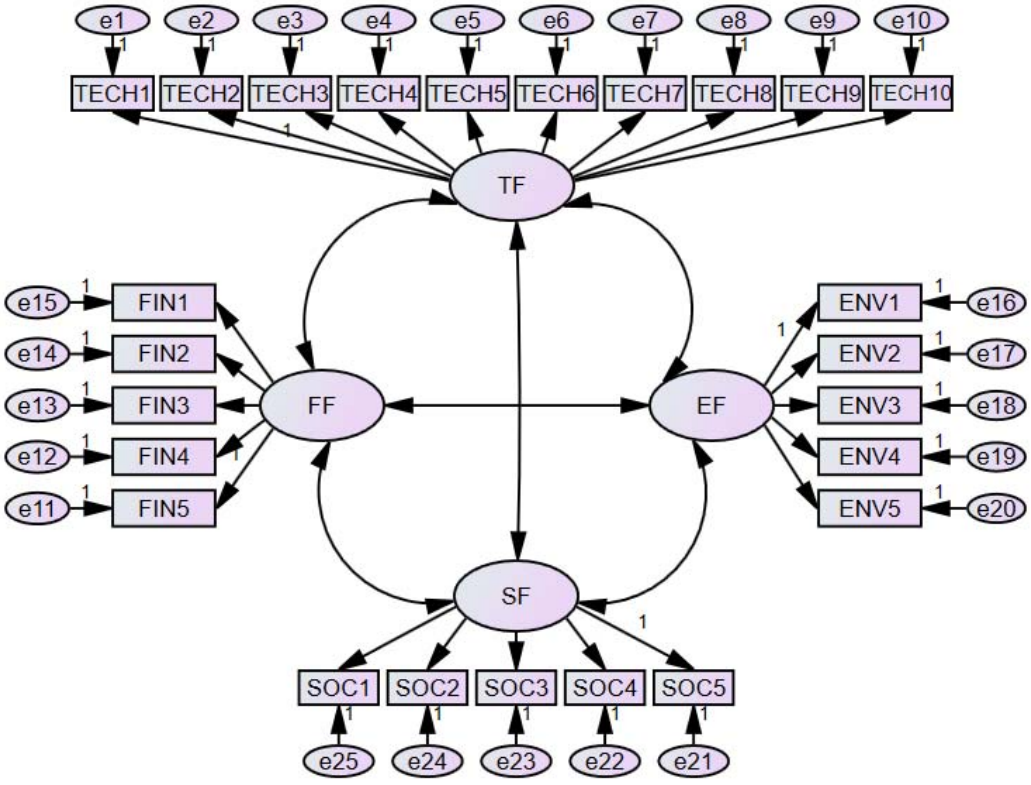
All research items were at high levels of acceptance and were thus appropriate. Aini *et al.* (2001) investigated the water supply shortage in Malaysia and established a moderate consumer satisfaction toward the management of the water crisis by the state water authority. In this study, the consumers were especially unsatisfied with the quantity and quality of water provided and the distance from where to fetch the water from the static tanks. Most of the respondents adopted a coping strategy by prioritizing their daily activities. Jun and Chen (2001) conducted a study in China and found numerous water problems, which can be categorized into three major types, namely, floods, droughts, and water pollution. As a result of natural causes and human influence, water problems are extremely complicated and highly variable (temporally and spatially). Papapostolou *et al.* (2020) stated that water resource availability, in terms of quality and quantity, is a crucial issue in many areas of the world. Hardin *et al.* (2010) suggested to implement the proper maintenance of water distribution networks to reduce the loss of drinkable water through leakage. The scarcity of water in Jordan makes the management of this vital resource considerably complex from the political, technical, socio-economic, and environmental perspectives. Mekonnen and Hoekstra (2016) found that two-thirds of the global population (4.0 billion people) live under conditions of severe water scarcity at least one month every year. Nearly half of those people live in India and China. Half a billion people in the world face severe water scarcity all year round.

Table 9. Level of acceptance of items for residents' perception of water supply shortages

Residents' Perception of Water Supply Shortages	Mean	Std. Deviation	Level of Acceptance
1. The current water supply service is satisfactory.	3.971	0.606	High
2. Water supply shortages causes obstacles of occasions in our city.	3.868	0.674	High
3. During some days of the week there is no water or water pressure.	3.951	0.634	High
4. There is a great need of timely maintenance of water shortage in my city.	3.885	0.689	High
5. I'm very much concerned about water scarcity in my area in the next 10 years.	3.893	0.684	High

3.4 Structure of the Research Model

Figure 2. Confirmatory factor model of the study model of the study



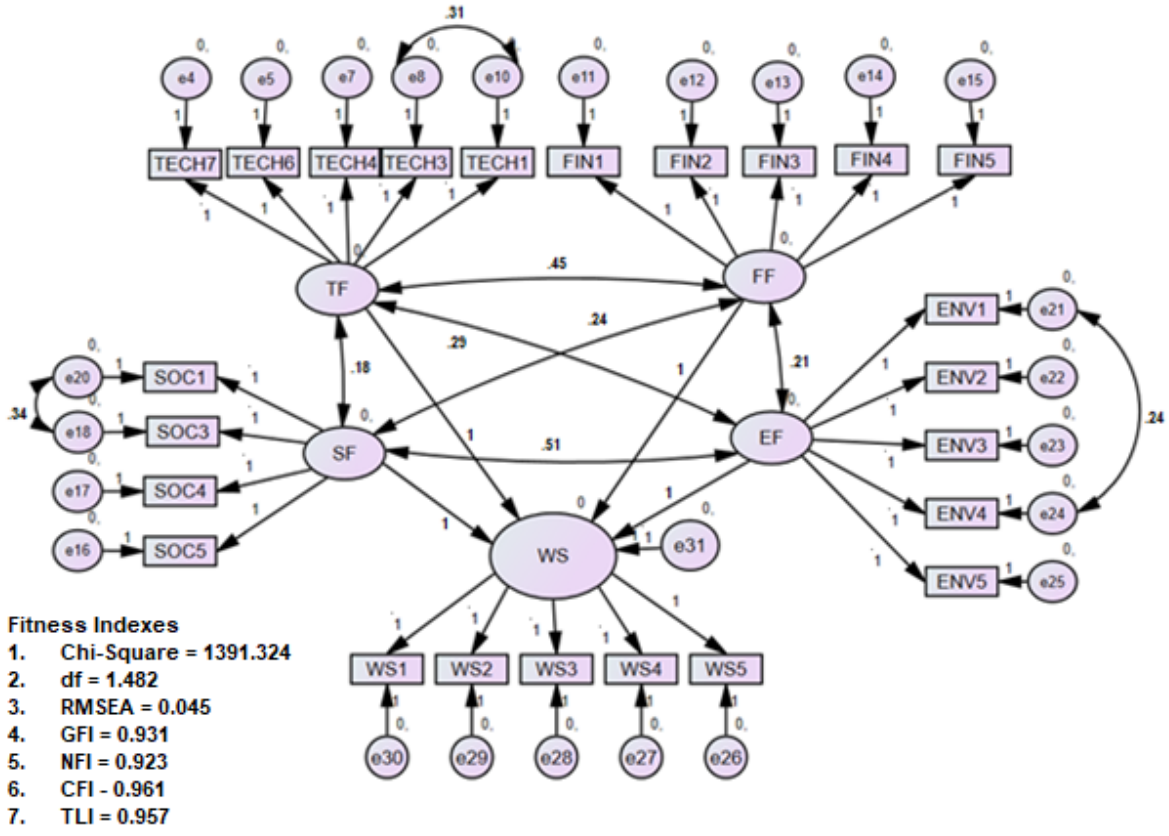
The proposed research model for water supply shortage is validated using four latent constructs. For the measurement model, CFA is conducted to check the internal validity and reliability in the present study. Four explanatory variables are constructed and developed. These included the first Technical Factors (TF) as the first explanatory variable which include 10 dimensions.

Followed by the second explanatory variable, Financial Factors (FF) which include 5 dimensions. Environmental Factors (EF) is the third explanatory factor and it includes 5 dimensions. The last explanatory variable is the social factors (SF), and it includes 5 dimensions. These explanatory factors are known as latent factors with key indicators, and the dimensions are known as the exogenous variables of the study. The value of the target coefficient is the ratio of the chi-square of the first-order model to that of the second-order model. Figure (2) shows the developed model for the four independent variables of TF, FF, EF, and SF.

3.5 Structural Equation Model (SEM)

It can be seen in Figure (3) that the chi-square/df value is less than 3.0, which signifies that the suggested research model, as theorized, is a good model (Tabachnick and Fidell 2007). The RMSEA value of less than 0.08 indicates good model results (MacCallum *et al.* 1996). The NFI, CFI, GFI, and TLI values exceed 0.90, thus indicating the good results of the model (Tabachnick and Fidell 2007; Bentler and Bonnet 1980; Hu and Bentler 1999; Barrett 2007). Furthermore, RMSEA=0.048, GFI=0.977, NFI=0.933, and CFI=0.926. Therefore, it can be stated that the water supply management model's fit outcomes show that the factors of this study are convenient and reasonably contribute to the performance of the water supply management model.

Figure 3. Structural Research Model of Water Supply Shortages



3.6 Hypotheses Testing

As indicated in Table 10, technical factors (TF) exert a considerable effect on a city's water shortage. The value of the estimates is 0.665, which indicates that on average, TF affects water supply and shortage. The standard error for the TF to WS measurement is 0.129. Critical ratio is the ratio between regression weight over standard error. This value indicates that below zero regression weight has 2.09 standard error. The outcomes for the financial factors (FF) indicate an adverse effect over water supply and shortage in the city of Al-Marj. The value of

the regression coefficient for FF to WS is 0.828, which indicates that on average, the effect of FF on WS is positive. The value of CR is 8.35, which indicates that the standard error in the regression weight to explain WS is 8.35 below zero. For TF and FF, the research hypothesis is accepted, and the two factors exert a considerable effect on water supply and shortage. The third explanatory factor for water supply and shortage is environmental factor (EF). For EF, the estimated value of the standardized coefficient is 1.40, which indicates EF's significant effect on the value of WS. This change is highly significant at the 0.01% level, and the p-value is <0.001. The value of the standard error for the EF is 0.156 while CR explains a standard error in the regression weight of 8.995. The fourth explanatory factor for the WS in the city of Al-Marj is socio-culture or social factor (SF), which indicates a standardized regression of 0.016. The value of the standard error for SF is 0.070 with CR of 7.571. However, the impact over WS through SF is considered as insignificant as the p-value is <0.05. All the standardized regression weights for the individual factors of each of explanatory variable are also presented. The standardized regression estimate for the FF through FIN_4 is 0.770, and standard error is 0.066 with a CR of 14.67. The value of the estimates for EF and FIN_4 is highly significant as the p-value is <0.000. All regression estimates in Table show significant positive relationships between FF and FIN_3; between SF and SOC_4 and SOC3; between EF and ENV_2, ENV_3, ENV_4, and ENV_5; between TF and $TECH_6$, $TECH_5$, $TECH_4$, $TECH_3$, $TECH_2$, and $TECH_1$; and between WS and WS_4, WS_3, WS_2, and WS_1. The standardized regression estimates and their significant p-values squared multiple correlation or SCM are presented in Table (10) and explained by each predictor factor of the proposed model.

Table 10. Regression Weights

Variables	Directions	Variables	Estimate	S.E.	C.R.	P
WS	<---	TF	.665	.129	9.049	.002**
WS	<---	FF	.828	.156	8.358	.001**
WS	<---	EF	.642	.156	8.995	.000
WS	<---	SF	.560	.070	7.571	.006
FIN4	<---	FF	.770	.066	14.677	***
FIN3	<---	FF	.736	.064	13.995	***
SOC4	<---	SF	.754	.118	8.383	***
SOC3	<---	SF	.477	.093	7.321	***
ENV2	<---	EF	.764	.081	14.197	***
ENV3	<---	EF	.759	.075	14.110	***
ENV4	<---	EF	.675	.074	12.554	***
ENV5	<---	EF	.642	.076	11.926	***
TECH6	<---	TF	.710	.091	11.292	***
TECH5	<---	TF	.638	.098	10.321	***
TECH4	<---	TF	.566	.112	9.275	***
TECH3	<---	TF	.666	.109	10.718	***
TECH2	<---	TF	.507	.110	8.405	***
TECH1	<---	TF	.692	.104	11.061	***
WS4	<---	WS	.632	.085	11.000	***
WS3	<---	WS	.751	.089	12.753	***
WS2	<---	WS	.751	.094	12.792	***
WS1	<---	WS	.687	.088	11.819	***

Note: SE, CR and P stands for standard error, critical ratio & *p*-value or level of significance
***, ** indicates standardized coefficients are significant at 0.001, and 0.005

The route analysis of the SEM outcomes expounds the hypotheses (H1, H2, H3, H4) and completely corroborates them. The outcomes are significant due to the CR for all the factors >1.695 and p-value<0.05. Meanwhile, the estimation parameter values for all the paths are more than 0.200. Figure (3) shows the full SEM model, which indicates that the model matches and fits the data well. Thus, another fit measurement specifies the goodness of fit of the proposed water supply management model.

Hypothesis 1: A significant relationship exists between social factors and water shortage.
Hypothesis 2: A significant relationship exists between technical factors and water shortage.
Hypothesis 3: A significant relationship exists between financial factors and water shortage.
Hypothesis 4: A significant relationship exists between environmental factors and water shortage.

Conclusion

One of the urgent issues in the lifetime of every person, plant, animal and totally our environment is the water. The findings of this study indicated that the water supply management model fit indicates that the factors of this work are convenient and reasonably contribute to the performance of the water supply management model in the study area. In addition, the findings revealed positive relationship between the three explanatory factors (financial factors, technical factors and environmental factors) with water shortage are exiting. The fourth explanatory factor for the social factor (SF) was considered as insignificant over water shortages. This problem can be solved when a stable government works fairly with every authority in Libya. This will definitely support us to be able to repair any malfunction and to provide all our needs. In additions, the water shortage issues could be solved if the future government installs several desalination plants in Libya to supply each city with sufficient and clean water. Lastly, financial support is the backbone of solving this problem and activating the laws of water management in the city.

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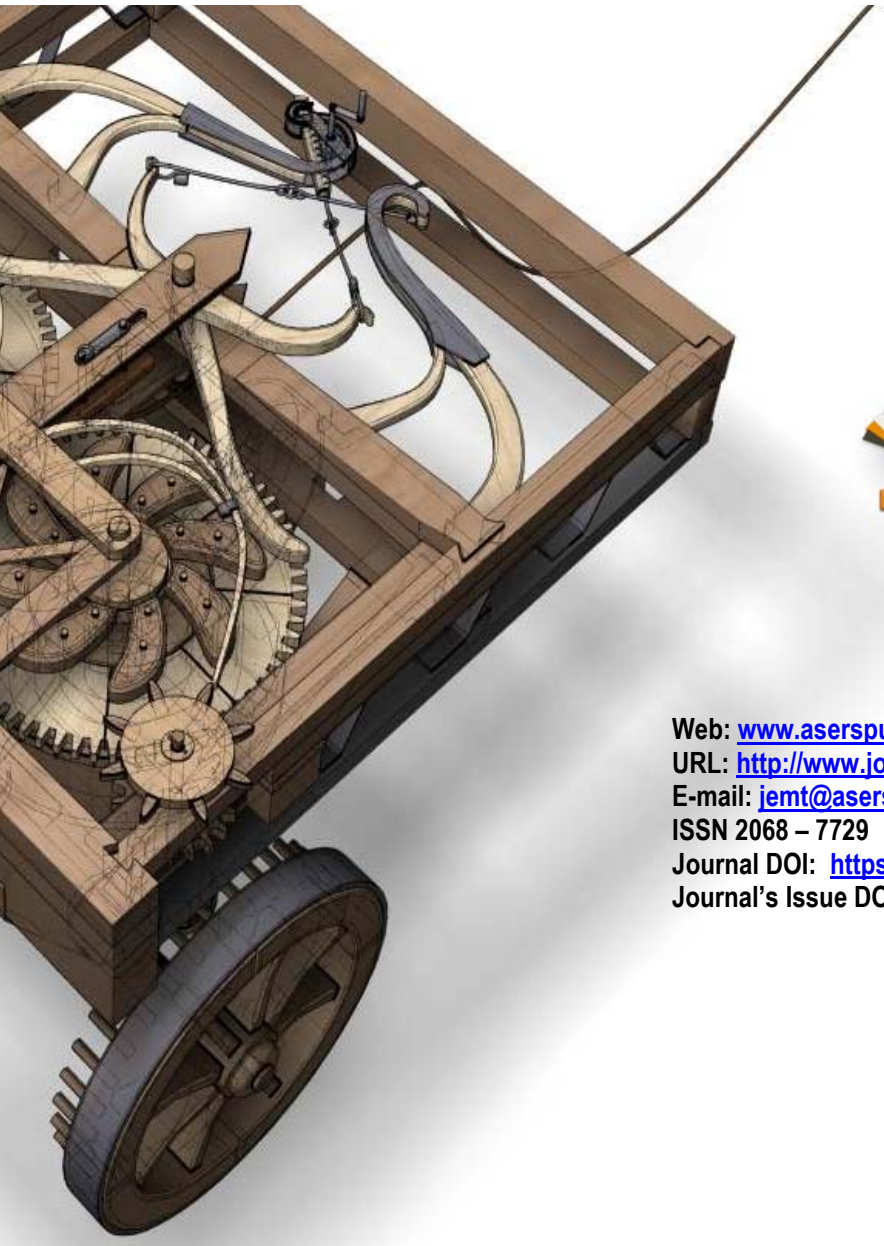

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