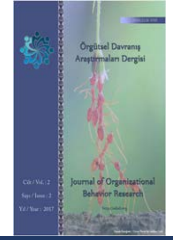




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A MODEL FOR WATER CRISIS MANAGEMENT AND THE PROSPECT OF URBAN DEVELOPMENT FOR COMING YEARS: A CASE STUDY OF BANDAR ABBAS

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ABSTRACT

According to population projection, Iranian city of Bandar Abbas will reach a high of 1057678 people in 2041 AH; that is 621927 individuals more than the census in 2011AH. In other words, 143% increase. Rising population will naturally bring about more pressure on natural resources of which water stands as the most important. The research results reveal that over the 30 years (2011 up until 2041) the water demand in Bandar Abbas would increase up to 118513 m³. In other words, water demand would increase more than two-fold. After the questionnaires were filled out, SPSS software was employed for analyses. The Results showed that five factors bear the greatest importance in proper water resource management: technical-executive, public participation and activities, political-institutional, educational-cultural-developmental, and economic-social achieved means scores of 3.94, 3.63, 3.65, 3.6 and 3.56, respectively. Obviously, the means scores of all these five factors exceed 3, indicating that they fall in the significance category of medium-to-high, a fact that renders them noteworthy in proper water resource management. Delphi-SWOT method is used to identify the key strategies in water resources of Bandar Abbas. The factor and sub-factors along with their importance were determined, and finally, 11 strategies were specified for water resource management of Bandar Abbas.

Keywords: Water Crisis, Water Resource Management, Delphi-SWOT, Strategic Approach, SPSS

INTRODUCTION

Water is the most valuable natural resource on Earth: no life is possible without water and every instance of life indicates the existence of water. The treasure element in the third millennium, water made the United Nations General Assembly in December 2003 proclaim the years 2005-2015 as the International Decade for Action 'Water for Life'. To some this means that the next decade would be better named as 'Water for Survival' (Kavoosi, 2012). The United Nations regards water crisis and water resource management as second most important issue in the world after overpopulation (Babraan & Honarbakhsh, 2007). Fresh water resources are so limited that constitute only a meager 2.5% of all waters on the planet while 97.5% of water resources are salt water. 21th century is named the century of water. Water resources are a complex issue as their amount is naturally unchanging and are recharged in various ways. However, climate change and global warming have led to retreating snow lines, melting down of permanent ice sheets in the Antarctic, retreating snows on Mount Kilimanjaro, all alarming indications that warn us against improper water consumption (Ghazi, 2015).

Forecasts say that water crisis will affect about 3.5 billion people until 2025 of whom less than 1.2 billion will have access to safe water resources. These estimates also predict that more than 4.5 billion people will be exposed to threats from water scarcity and water pollution. Such conditions will intensify the competition in accessing water resources worldwide and will render water as a basic challenge. As such, water resource planning is going to find an important position in political, economic, and social arrangements in nations and governments (Sohrabi et al. 2009). If water consumption per capita remains unchanged and the world population reached 9 billion in 2050 as the United Nations have predicted, the water consumed by human would be 10200 km³ or 82% of flowing fresh water on Earth. If demand per capita increases in addition to population, severe water scarcity would be dominant well before 2100 worldwide (Ardakanian & Sohrabi, 2006).

Water resource experts predict that the national, regional, and international conflicts over water will increase in near future and, given the universal need for clean fresh water, it is not far-fetched to say anticipate that future wars revolve around water resources. Over the last fifty years, 37 water-related conflicts and aggressions were recorded of which only 7 cases occurred outside Middle East. Today, water scientists and even politicians firmly believe that water resources, and shared optimal consumption of fresh water resources (which are limited, vulnerable basis of life, development and environment) determine the peace/conflict status of the present era. As a result, the second conference on water in March, 1994 in Netherlands dubbed water distribution as 'life distribution' (Sadeghi, 2006). All water scientists believe that when ratio of population to renewable fresh water resources exceeds certain point, water scarcity becomes apparent and the consequent tension and pressure would be unavoidable. Accordingly, this ratio has reached or exceeded this critical stage. In the meantime, the experts warn that lack of decisive action with regard to distribution of resources and optimal consumption models would expose two third of humanity to relative or severe water scarcity (Tazi Sadegh, 2005).

Studies show that population in Bandar Abbas was 17710 individuals in 1956 while it reached up to 435751 in 2011, that is 418041 more citizens. Since the amount of natural resources does not normally change, Bandar Abbas is currently facing a resource scarcity. To put it another way, rises in population, hygiene issues, global warming and other factors have been on the rise., the people in Bandar Abbas consumed 39173466 m³ and 41112605 m³ of drinking water in 2011 and 2012, respectively (Counseling Engineers at Padid AAb Sepahan, 2012). These numbers clearly show that drinking water consumed in one year is 1939139 m³. Given the fact that 40% of the provincial population resides in Bandar Abbas and that water supplies are dwindling while demand is on the rise, it is necessary to introduce a management model after investigating the variables in water consumption, available supplies, geographical, cultural and climate features of this city. Such a model would help strike a balance between the available water resources on one hand and the consumed water on the other hand. Considering these conditions, the author seeks to answer the following questions:

1. How is the relationship between existing water consumption and water supplies in Bandar Abbas?
2. Is population of Bandar Abbas in harmony with water supplies?



Study area

The Bandar Abbas County is a coastal township with the central city of the same name and represents the main city in the province of Hormozgan. This county is adjacent to Hajjiabad County in the north, Minab County and Rudan County in the east, Khamir County in the west, Fars Province and Bastak in the north-west, and the Persian Gulf in the south. The study area in Bandar Abbas is 893 km² wide and lies between longitudes of 56°5'25" and 56°20'19" and latitudes of 27°9'53" and 27°16'53". Bandar Abbas County is comprised of 4 township, 4 towns, 11 dehestan and 400 villages (Fig. 1).

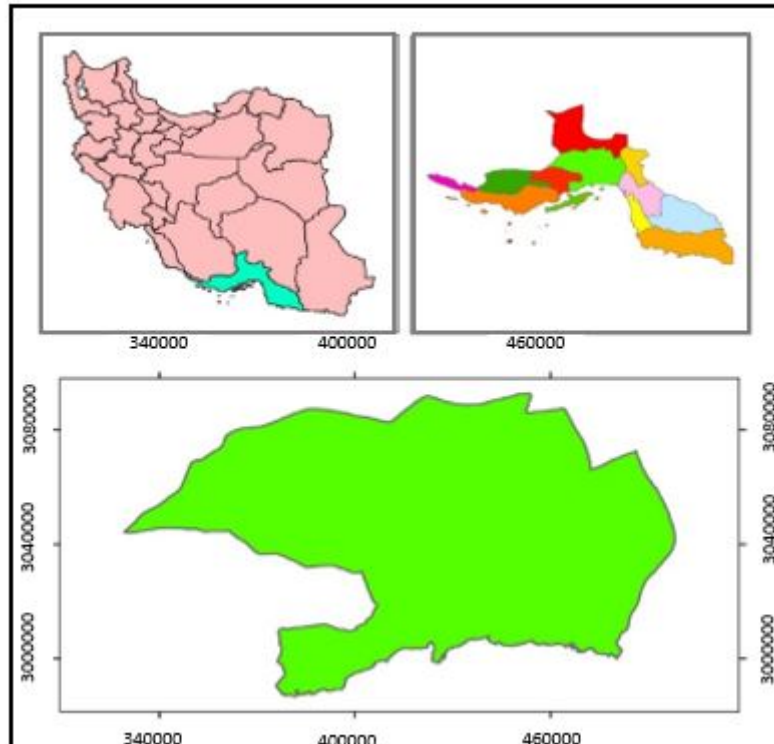


Figure 1: the position of Bandar Abbas County

Literature review

In 'The economic impact of more sustainable water use in agriculture: A computable general equilibrium analysis,' Calzadilla et al. (2010) argue that agriculture is the chief consumer of fresh water resources with about 70% of fresh water resources being used to provide food. In their study titled 'Strategic implementation of integrated water resources management in Mozambique,' Gallego-Ayala, J. and Ju'zo, D. (2011) used SWOT and AHP in order to prioritize, update and determine the chief components of integrated water resources management in Mozambique. They made use of questionnaires which were filled out by a group of water resources experts. They held that SWOT is able to derive the strategies proper for the local conditions and for sustainable development by considering all internal and external factors that affect the area under study. This research revealed that four factors of strength, weakness, threats, and opportunities were prioritized with scores 0.401, 0.252, 0.174, and 0.172, respectively. 11. Yi et al. (2011) conducted a study titled 'An overview of



reclaimed water reuse in China' where they explored the possible ways to reuse the recycled water. This procedure includes the following: 1- the existing condition of reclaimed water, 2- the potential cases of reusing reclaimed water, 3- the laws and regulations for reusing such water, 4- the challenges in reusing reclaimed water, 5- the issues in reusing the reclaimed water. 12. In 'Factors determining residential water demand in north Western Ethiopia, the case of Merawi,' Dagnev explored the factors that determine the demand for water. He gathered the data from 200 families that were then analyzed using SPSS software. The results indicated that family income, the educational level of the parents, the number of members, gender, and the ownership of a house are significantly related with demand for water.

In 2013, Parker and Wilby conducted a research titled 'Quantifying household water demand: A review of theory and practice in the UK' where they explored the water demand among families. This study employed the estimation and forecast method for water demand in terms of two distinct periods: short term (daily and seasonal) and long term (annual and decadal). In addition, the periods of peak consumption were investigated using field measurements and gathered data. The results revealed that weather conditions and family demand for water stand as the most important factor in determining water demand in urban households. In 'Effect of area time horizons in comprehensive and integrated water Resources management,' Yevjevich points out that for over two decades, humans have found that water resource management requires a holistic approach that includes two general policies and one main objective. The policies are: 1- water resources must be treated as an economic, social, cultural, and environmental commodity; 2- the policies and options for water resource management must be analyzed in an integrated holistic framework. The main objective in this approach is to achieve sustainable, efficient and fair development of water resources through integrated water resource management. As such, the fundamentals of such management should be based on the combination of demand and supply management and take into account the environmental, social, and economic aspects. In 'Water crisis and the solutions of reduction of water consumption in agriculture sector,' (2015) Daneshvar Ameri and Jalali Nasab argue that 92% of water resources in Iran is used in agriculture. Since there are no new irrigation technologies in Iran, much of this amount is wasted. This study proposes some suggestions for reducing water consumption in outdoor settings and agriculture: 1- limiting outdoor irrigation, 2- employing new irrigation systems, 3- promoting the journals for optimal water consumption, 4- placing obligatory limits in periods of drought and water shortage, 5- checking for leakages and applying proper fixes, 6- using suitable plant species resistant to drought. In 'Planning Crisis Management of Water Resources in Tehran in the Next Twenty-Five Years,' Ravanshadnia et al. (2015) assert that using rainwater is a valuable solution for water crisis in Tehran given the climate conditions and rising temperatures in this area. They also propose that it is possible to forecast precipitation changes in the next twenty-five years via proper models. In this way, it is possible to collect the future rainwater accumulated on the rooftops and design plans to consume it optimally.

RESEARCH METHODOLOGY

The population of the present study includes all inhabitants of Bandar Abbas. It should be noted that accessing and interviewing all members of this population is too costly and time-consuming. Therefore, sampling is applied.



The sample size is estimated using Cochran formula:

$$n = \frac{\frac{Z^2 pq}{d^2}}{1 + \frac{1}{N} \left(\frac{Z^2 pq}{d^2} - 1 \right)}$$

where n =sample size, N =population size, Z =constant value (1.96), p = a fraction of the population with a certain attribute, q = a fraction of the population without the certain attribute, d = the authorized error (%).

Data collection tools

- *Library research*
- *Field study*
- *Data analysis*

Data analysis tools

- *Population Projection*

We used mathematic method for Population Projection in this study. The following formula was applied:

$$P_t = P_0(1 + r)^t$$

where P_t is the population in year t , P_0 is the population in the first year, r represents the annual rise in population, and t stands for the number of the years between the first year and the year t . the estimation of the population in any given year requires the population of the first year, the annual rise, and the distance between the first year and the year under question.

Forecasting the water demand in Bandar Abbas

In order to forecast the water demand in Bandar Abbas, we made use of the journal published by Planning and Budget Organization (the regulations on designing transfer and distribution systems for urban and country water, 1992, revised in 2013; no. 117-3). Here, the population is calculated using the mathematical method for horizon years and then the water demanded in Bandar Abbas is determined by following a five-part procedure:

1. ***Household consumption:*** we employed two methods in calculating household consumption of water: Coupon method and geometric method. the former is in for of the following formula:

$$Q = K^* . P^{0.125}$$

where Q represents annual consumption (liter per person per day) while P shows the total population of the study area. The coefficient K is determined by local features and in calculated according to the census for the year 2011.

The geometric method is in form of the following formula:

$$Q_t = Q(1 + r)^n$$



where Q_t = the consumed water per household over the years under study, Q = the household consumption of water in the first year, r = the rate of increase in household consumption of water, n = the distance between the first year and the different years under study.

2. **General consumption:** mean consumption per capita is calculated at the end of the period under study with respect to the calculations made during the study and the earlier years and also to composition of various urban and country areas. This amount is forecasted to be 5-15% of household consumption in Iran.
3. **Industrial consumption:** mean consumption for industries and businesses is calculated at the end of the period under study with respect to the calculations made during the study and the earlier years and also to subscribers' profiles and the industrial grade of the study area. This amount is forecasted to be 5-20% of household consumption in the equivalent horizon model for Iran.
4. **Wasted water:** the neglected amounts and resources depend on quality of management and consumption, errors in staff performance and measurements, quality of used materials and the implementation of the grid, water pressure, quality of implementing the grid, lifetime of the facilities, technology, etc. The mean neglected amounts for the horizon of the project must not exceed 15% of the sum of household consumption, general consumption, and industrial consumption.
5. **Water consumed by public green spaces:** includes parks, green spaces in streets and squares, and planted forests. These cases are only considered in case of those cities and villages that continue to use refined water for public green spaces.

Assessing the questionnaire reliability

The reliability of the questionnaire is assessed in many ways of which the most popular is Cronbach's Alpha. This method is used to determine the internal homogeneity of research tools such as questionnaires or of the tests that investigate various characteristics. It shows the extent to which research questions can measure a given characteristic. Cronbach's Alpha varies between 0 and 1: if it equals 1, then it signifies full reliability of the research tool in question; if it equals 0, then the tool lacks reliability (Azkia and Darbaan Astaaneh, 2003). The present study employed Cronbach's Alpha in assessing the reliability of research tools.

Delphi-SWOT model

- *SWOT model*

The more popular method is named SWOT model after combination of S=Strengths, W=weaknesses, O=opportunities, and T=threats. This method is regarded as a novel instrument in analysis of performance and in determining strategies (Nilsson, 2001).

Quantitative Matrix of strategic planning

After specifying the S=Strengths, W=weaknesses, O=opportunities, and T=threats, we design the matrix for internal and external factors. Then, using sum of scores and analysis of the factors, the superior strategies are specified as in the following:

Analysis of internal and external factors

The simultaneous analysis of external and internal factors is feasible in a matrix with the same name. to do this, the values derived from evaluation of external and internal factor are added together and inserted in horizontal and vertical arrangements in the matrix so that the position

of system can be determined. Ordinarily, a matrix with four blocks is used that closely corresponds to the matrix. Based on the final scores, the selected strategies are then sorted out in WT, WO, SO, and ST positions (Eftekhari and Mahdavi, 2006).

S-O strategies or invasive strategies include using strengths in order to implement the prospective opportunities.

W-O strategies or conservative strategies include using advantages within opportunities in order to compensate for weaknesses.

S-T strategies or competitive strategies are designed to identify internal strengths and counter external threats. As such, recommendations mostly include the measure to provide the requirements necessary to meet the prospective threats in a given area.

W-T strategies or defensive strategies seek to minimize the weaknesses and avoid external threats by developing executive strategies.

As mentioned above, this stage includes the prioritization of the strategy type. The general evaluations matrix of external and internal factors is shown in fig. 2.

		The final score of the internal factors evaluation matrix				
		1	2/5	4		
		Conservative		Aggressive		analysis matrix of external factors
		Defensive		Competitive		
						4
						2/5
						1

Figure 2: analysis matrix of external and internal factors

Delphi method

Delphi method is essentially based on a dialectic research, that is, a research comprised of thesis (producing idea or opinion), anti-thesis (the opposing idea or opinion), and finally, synthesis (new agreement or consensus). The synthesis itself can become a new thesis. All participants can modify their current opinions to fit with the new thesis, to support it, or to propose a wholly new opinion. The goal is to constantly change the mind or to reach a consensus. The term Delphi comes from the holy location in ancient Greece where high priests and soothsayers were known to declare predictions and express oracles. This method, however, is a decision-making method.

Application of Delphi method

Survey of experts' opinions (Delphi questionnaire), which includes strengths, weaknesses, opportunities, and threats of the factors, were distributed among the experts. The qualified participants were selected from among those with research and executive experience in water



resource management. In this way, these experts were able to express their opinions on significance of each factor in form of a five-point scale (the least important (1), low importance (2), medium importance (3), important (4), highly important (5)). Then, weighted scores of the expert opinions are calculated. The sum total scores of each opinion signify the times each answer is chosen. The standard weight ranges between 0 and 1. Importance levels are represented by weights: scores 1, 2, 3, 4, and 5 correspond to weights 0.07, 0.13, 0.2, 0.27, and 0.32, respectively. The math formula for percentage, importance and standard weight are as follow.

n: number of people who choose a given importance level;

N: number of all participants;

$$\text{Modulated weight: } (y_i) = \frac{x_i}{\sum x_i}$$

$$\text{Weighted score: } (Z_i) = y_i \times n$$

$$\text{Standard importance (\%):} = \frac{\sum z_i}{N} \times 100$$

$$\text{Standard Importance level: } \frac{\sum (x_i \times n)}{N}$$

R=importance level × percentage

$$\text{Standard weight: } (H_i) = \frac{R_i}{\sum R_i}$$



RESEARCH FINDINGS

Population Projection

The population of Bandar Abbas was 435751 in 2011. With respect to the population in 2006 and 1996, the annual population growth rate is 2.8% and 3.15%, respectively. Thus, the mean population growth rate is 2.98%. Besides, there are some noteworthy reports. Most important, the report on revision of comprehensive plan for Bandar Abbas asserts that annual population growth rate is 3%. The present study follows this authoritative report in this regard. As a result, the final Population Projection for Bandar Abbas until 2041 was calculated (table 1).

Table 1: Population Projection with Mathematic Method for Bandar Abbas Until 2041

BANDAR ABBAS	Year
435751	2011
505154	2016
585612	2021
678884	2026
787012	2031
912362	2036
1057678	2041

Household consumption

- *Calculating the water consumption per household: Coupon method*

After inserting the necessary parameters in the formula, it was possible to calculate the amount of water demanded by families in Bandar Abbas (table 2).

Table 2: the water consumption per household calculated with Coupon Method for Bandar Abbas Until 2041

Mean consumption (liter per day per person)	Population	Year
114	435751	2011
116/2	505154	2016
118/3	585612	2021
120/5	678884	2026
122/8	787012	2031
125/1	912362	2036
127/4	1057678	2041

- *Calculating the water consumption per household: geometric method*

Most books and resources on irrigation suggest that the growth rate of household consumption is 1% of total water consumption in a year. After inserting the necessary parameters in the formula, it was possible to calculate the amount of water demanded by families in Bandar Abbas with geometric method (table 3).

Table 3: The Water Consumption per Household Calculated with Geometric Method for Bandar Abbas Until 2041

Mean consumption (liter per day per person)	Population	Year
114	435751	2011
119/8	505154	2016
125/9	585612	2021
132/4	678884	2026
139/1	787012	2031
146/2	912362	2036
153/7	1057678	2041

After the water consumption per household was calculated with both Coupon and geometric Methods, the recommended consumption per capita was determined using the mean value of these methods. The results show that the household water consumed by a person everyday is 140.5l until 2041. This is 26.5l increase for a person everyday given that the first year (2011) shows 114l for every person each day.

Table 4: Household Water Consumption in Bandar Abbas

Recommended household consumption (liter per day per person)	Mean consumption (liter per day per person): geometric method	Mean consumption (liter per day per person): coupon method	Population	Year
118	119/8	116/2	505154	2016



122	125/9	118/3	585612	2021
126/5	132/4	120/5	678884	2026
131	139/1	122/8	787012	2031
135/5	146/2	125/1	912362	2036
140/5	153/7	127/4	1057678	2041

- **Calculating the general consumption**

With respect to the population growth in Bandar Abbas, distribution of safe drinking water, growth of public welfare level, and increase in number of public institutions and organizations, the general water consumption per capita is 15% of household consumption at most. The general water consumption per capita was calculated for Bandar Abbas (table 5).

Table 5: general Water Consumption in Bandar Abbas

General water consumption (liter per day per person)	Recommended household consumption (liter per day per person)	Year
17/7	118	2016
18/3	122	2021
19	126/5	2026
19/65	131	2031
20/3	135/5	2036
21/1	140/5	2041

- **Industrial consumption**

Mean industrial water consumption is calculated at the end of the period under study with respect to the measurements at the time of the present study and the earlier years. In the horizon of this project, this value is forecasted to be between 5 to 20 % of household consumption in Iran. The existing studies and collected data on one hand and the dire water conditions in the study area on the other hand, the industrial consumption of water is taken to be maximum, i.e. 20% of the household consumption for 2041 horizon in Bandar Abbas (table 6).

Table 6: Industrial Water Consumption in Bandar Abbas until 2041

industrial water consumption (liter per day per person)	Recommended household consumption (liter per day per person)	Year
23/6	118	2016
24/4	122	2021
25/3	126/5	2026
26/2	131	2031
27/1	135/5	2036
28/1	140/5	2041

- **Water Consumed in Public Green Spaces**

Green space refers to gardens and parks, planting along streets, and artificial. This type of consumption is considered for those cities and villages that still use refined water for irrigation purposes. Obviously, these areas must follow the guide for proper water consumption and replace refined water with ordinary for irrigation purposes. In this case, this type of consumption would be zero and should be omitted from our investigations.

Table 7: Total Consumption in Bandar Abbas until 2041

Total (Liter Per Day Per Person)	Water Consumed in Public Green Spaces (Liter Per Day Per Person)	Industrial Water Consumption (Liter Per Day Per Person)	General water consumption (liter per day per person)	Recommended household consumption (liter per day per person)	Year
177/3	18	23/6	17/7	118	2016
164/7	0	24/4	18/3	122	2021
170/8	0	25/3	19	126/5	2026
176/8	0	26/2	19/65	131	2031
182/9	0	27/1	20/3	135/5	2036
189/7	0	28/1	21/1	140/5	2041

- **Wasted water**

The neglected or wasted water in the first year (2011) was calculated to be 521 per person per day in Bandar Abbas. With respect to the total consumption per capita for that year (1941), it is clear that wasted water in 2011 is 27%. Accordingly, 15% waste is forecasted for 2041. This means that every five years is accompanied by 2.5% drop in amount of wasted water. Table no. 8 presents the details of wasted water up until 2041.

Table 8: Neglected or Wasted Water in Bandar Abbas

Wasted Water (Liter Per Day Per Person)	Wasted water (%)	Total (Liter Per Day Per Person)	Year
43/4	24/5	177/3	2016
36/2	22/5	164/7	2021
34/1	20	170/8	2026
31	17/5	176/8	2031
27/4	15	182/9	2036
23/7	12/5	189/7	2041



According to the journal issue no. 117, the areas that use refined water for irrigating public green space must use zero liter of refined water in 2016. However, different interviews and data reveal that this injunction would be fully observed not before 2021. Concurrently, the existing rate of wasted water (521 per person per day) will also be down to 23.71. In other words, the forecasts tell us that by 2041, every person would neglect or waste 28.31 of water per day although this too is hardly negligible. In fact, this volume is equal to 12.5% and can be further reduced by proper planning.

Table 9: total Water demand in Bandar Abbas until 2041

Total (Liter Per Day Per Person)	Wasted Water (Liter Per Day Per Person)	Water Consumed in Public Green Spaces (Liter Per Day Per Person)	Industrial Water Consumption (Liter Per Day Per Person)	General water consumption (liter per day per person)	Recommended household consumption (liter per day per person)	Year
220/7	43/4	18	23/6	17/7	118	2016
200/9	36/2	0	24/4	18/3	122	2021
204/9	34/1	0	25/3	19	126/5	2026
207/8	31	0	26/2	19/65	131	2031
210/3	27/4	0	27/1	20/3	135/5	2036
213/4	23/7	0	28/1	21/1	140/5	2041

Decision-making and management can be regarded as synonymous. Or decision-making can be regarded as the main aspect of management. As such, proper management requires proper making proper decisions. this is not possible without the active participation of citizens as the main consumers in an urban setting. Accordingly, we gathered opinions of both experts and average citizens in bbb so that a better understanding of weaknesses and strengths for better identification and prioritization of strategies could be insured. The research questionnaires were designed in five distinct formats: 1- economic-social 2- educational-cultural-developmental 3- political-institutional 4- technical-executive, and 5- public participation and activities. The sample size was set at 96 using Cochran formula. The questionnaire reliability was calculated at 0.85 using Cronbach's Alpha. Thus, it is safe to say that the research questionnaire has high reliability in evaluating the object of the study. The questionnaire validity was also approved by professors and experts in the field of water resource management. After the questionnaires were collected, the data were analyzed with SPSS²¹. The results showed that the aforementioned five factors are important in water resource management in the following order: technical-executive, public participation and activities, political-institutional, educational-cultural-developmental, and economic-social with mean values of 3.94, 3.63, 3.65, 3.6, and 3.56, respectively. Obviously, the mean values of four factors exceed 3 and thus fall in the importance level of *medium* to *highly important*. Therefore, it is necessary to take all four factors into account while managing urban water resources of bbb.

Characterized by a variety of levels, management and planning has, at the top level, the element of strategy and also, a long-term approach in dedicating resources and making decisions. Strategic approach in water resources management tries to prevent sudden future crises help develop resources in a sustainable manner while taking into account the all the views, policies, structures and systems that bear on this area. Here, the Delphi-SWOT approach will be used to achieve key strategies in Bandar Abbas water resources. In order to implement Delphi-SWOT approach, 7 steps are required in the following order.

Step 1: Identifying the sub-factors

After recording the experts' comments, 39 sub-factors were identified, of which 8 were related to the strengths, 12 to weaknesses, 11 points to opportunity and 8 to threats.

Step Two: Determining the importance level of the factors

In this step, the importance levels of factors i.e. strengths, weaknesses, opportunities, and threats were identified using experts' opinions and a 5-point Likert scale (very little, little, medium, high, and very high). The importance levels of the factors (in greatest-to-least order) correspond to weaknesses (0.4), opportunities (0.26), threats (0.19) and strengths (0.15), respectively.

Step Three: Determining the importance level of the sub-factors

The importance levels of sub-factors (which were specified in step 1) were identified using experts' opinions and a 5-point Likert scale (very little, little, medium, high, and very high). With regard to the weaknesses, lack of a comprehensive, integrated view in decision-making and implementation in water resources management systems was identified as the most important sub-factor. With regard to the opportunities, use of modern technologies in the field of water resources management was identified as the most important sub-factor. With regard to the threats, lack of an expert approach based on the principles of sustainable development in



water resources management was identified as the most important sub-factor. With regard to the strengths, raising public sensitivity to water management was identified as the most important sub-factor.

Step Four: Determining the overall importance level of the sub-factors

In this step, the overall importance of the sub-factors was determined by multiplying the significance of the factors (identified in step 2) by the importance of the sub-factors (identified in step 3). It was possible in this step to prioritize each of the sub-factors in relation to each other: lack of a comprehensive, integrated view in decision-making and implementation in water resources management systems was identified as the most important sub-factor while firm religious ideas and beliefs among people was identified as the least important sub-factor.

Step Five: A Quantitative Matrix for Strategic Planning

In order to formulate a quantitative planning matrix, it was necessary to form a matrix of internal and external factors. As such, it was necessary to use the overall importance level of the sub-factors and the importance level assigned to each sub-factor. Eventually, by multiplying the overall importance level of the sub-factors by the importance level assigned to each sub-factor, the score of the internal factors was specified as 1.89, indicating that the weaknesses overcome the strengths. Moreover, score of the external factors was found to be 2.74, indicating that the opportunities overcome threats.

Step Six: Determining the type of strategy

After the internal and external factors matrix was formed using the analysis matrix of internal and external factors, the type of strategy determined as conservative or WO strategy, given the scores of internal factors and the external factors were 1.89 and 2.74, respectively.

Step 7: Developing Management Strategies

After identifying the type of strategy to be adopted, proper strategies should be set up to minimize the weaknesses and maximize opportunities. Ultimately, 11 strategies for water resources management in city of Bandar Abbas were identified:

1. Developing the modern irrigation systems by tapping into legal-financial resources and through training the users
2. Increasing the efficiency and reducing waste in urban water supply grid by implementing laws and regulations
3. Supervising the exploitation and preventing the over-exploitation of groundwater resources using existing rules and popular participation
4. Establishing a teamwork composed of various specialties and people in order to make right decisions which are comprehensive and far from particularism
5. Raising the culture of proper use of water with a special emphasis on housewives
6. Investing and introducing the private sector into the modernization of the urban water supply system
7. Providing an optimal farming model with respect to regional potential (water, soil, economy, community).
8. Sufficient and timely financing for the completion and implementation of water resource projects and the applying the regulations
9. Artificial nutrition of the bottom of basins and watersheds at the upstream of the basins to reduce evaporation and to store precipitation



10. Raising awareness and culture with respect to using banking services for the modernization and use of modern agricultural equipment
11. Accurate identification of the types of water consumption in green spaces and the possibility of replacing urban drinking water with well water, collected rainwater or wastewater or treated wastewater for irrigation of green space

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