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# Determining Agricultural Water Poverty Index in Kermanshah Province: The Case of Mahidasht Basin, Iran

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## ABSTRACT

**As an assessment method of the water resources, Water Poverty Index (WPI) has become an available tool in water resources management. In particular, Agricultural Water Poverty Index (AWPI) is an assessment tool for agricultural water in rural areas. During the past decades, Mahidasht Basin in Kermanshah Province has been declared by water policy makers as "forbidden" basin in terms of water exploitation. Therefore, effective water resource management in the basin is deemed important. *AWPI* provides an appropriate tool in managing water resources more effectively. *AWPI* is an extension of Water Poverty Index (WPI) with five components including resources, access, use, capacity, and environment. This study sought to investigate the Agricultural Water Poverty Index in Mahidasht Basin in Kermanshah Province. Results revealed that Mahidasht Basin is faced with severe Agricultural Water Poverty (AWP= 49.06). Moreover, although farmers had limited water resources (R= 27.4) but these limited resources were highly accessible (A= 74.9). The result of this study has practical implications for water policy makers in Kermanshah Province. For example, agricultural policy makers can use the result of this study to devise better policies to alleviate agricultural water poverty in Mahidasht Basin where it is faced with water crisis.**

**Keywords**: Agricultural Water Poverty Index, Normalization, Indicators, Water crisis.

## INTRODUCTION

The concept of Water Poverty Index (WPI) was first introduced by Sullivan (2002) and Lawrence *et al.* (2003) indicating the degree to which water scarcity impacts human population. It was also intended to "produce an integrated assessment of water stress and scarcity, linking physical estimates of water availability with socioeconomic variables that reflect poverty" (Sullivan, 2002).

Although the definition of water poverty index is still being disputed, it is designed to contribute to more effective water management at different scales. Agricultural Water Poverty (AWPI) is an extension of *WPI* that aims to improve agricultural water use across rural areas (Forouzani *et al.*, 2013). Moreover, the index was designed to aid national decision markers, at community and central government level, as well as donor agencies, to determine priority needs for interventions in the water sector. The index is based on five components: resources, access, capacity, use, and environment (Mlote *et al.,* 2002; Lawrence *et al.,* 2003; Sullivan and Meigh, 2003, Sullivan *et al.,* 2003; 2006). Each of the components, carry weights in the calculation of the final number representing the index.

Interestingly, some scholars in the agricultural discipline have paid particular attention to the water poverty index in terms

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of food production. For example, Forouzani and Karami, (2010), Forouzani *et al.* (2012) and Forouzani *et al.* (2013) proposed Agricultural Water Poverty Index (AWPI) to assess water scarcity in Southern Iran. They used *WPI* components (resources, access, use, capacity, and environment) to draw the agricultural water poverty map for Marvdasht County in Fars Province in Southern Iran. Finally, Agricultural Water Poverty Index (AWPI) was proposed by Forouzani *et al.* (2013) using the modified version of water poverty index originally suggested by Lawrence *et al.* (2003). However, during normalization process a statistical error occurred which tends to hinder comparability of the results.

This study argues that our new approach in assessing *AWPI* is more robust and it further seeks to improve the statistical procedure used to calculate *AWPI*.

## MATERIALS AND METHODS

This study utilized a survey research design in Kermanshah Province in Western Iran. Iran is a country of over 1.6 million km$^2$ with a population of around 78.8 million in 2015. Its economy is characterized by a large hydrocarbon sector, small scale agriculture and services sectors, and a noticeable state presence in manufacturing and financial services (World Bank, 2015). Iran is currently experiencing climate variability due to its range of geographical regimes. Its long-term average annual rainfall is in the range of 224–275 mm year$^{-1}$, making Iran one of the most arid regions of the world. When comparing Iran with various parts of the world, annual precipitation in Iran is less than one third of the world average (CA 990 mm) (SemsarYazdi and LabbafKhaneiki, 2007). This study has focused on Kermanshah Province, which is located in the west part of Iran and is distinguished as one of the main cereal-growing regions. The total area is 24,980 km$^2$ with annual precipitation ranging from 375 to 500 mm. The total cropped area is about 820,000 hectares of which the rain-fed area constitutes more than 75 percent (Zarafshani *et al.*, 2012).

We measured *AWPI* across Mahidasht Basin due to high water exploitation in the basin. Mahidasht basin with an approximate area of 839.59 km is located in west and southwest of Kermanshah. There are 1593 wells across the basin which makes it one of the regions in the Province with the highest number of wells. Mahidasht basin is divided into four different sub-basins based on water exploitation (Sarfirouz-abad, Mahidasht, Central, Kouzaran). Therefore, we selected these four sub-basins in our study. Farmers in Mahidasht Basin are generally irrigated farmers engaged in the production of maize, wheat, barley and sugar beet. Currently, this region is declared by the Regional Water Company (RWC) as one of the forbidden basins in the province to have access to well digging license due to water scarcity in the region. In other words, irrigated farmers as well as rain-fed farmers are not allowed to deepen their current well or dig a new well.

### General Description of AWPI Components

The Agricultural Water Poverty Index (AWPI) framework adopted here consists of five components and 34 indicators (Table 1). Their conceptual description, calculation and normalization are developed in detail as follows:

#### Resources

The resource component deals with the physical availability of water resources in the study (Mahidasht Plain). If a given farmer receives a higher value of this component, this reflects better water situation (an abundant water supply with less vulnerability) and vice versa. Since the only source of water resources in Mahidasht Basin is well, this component was measured by one indicator measuring the level of

**Table1.** Components and indicators of *AWPI* in Mahidasht Basin.

| Components | Subcomponent | Indicator |
|---|---|---|
| Resources | | R : Level of water in farmers' well |
| Access | | $A_1$: Distance from water source |
| | | $A_2$:Type of water distribution |
| | | $A_3$: Area uncultivated due to water scarcity |
| | | $A_4$:Common well |
| | | $A_5$: Farm soil type |
| | | $A_6$: Fallow |
| | | $A_7$: Use of subsoiler |
| | | $A_8$: Deep planting machinery |
| | | $A_9$: Use of macro fertilizer |
| | | $A_{10}$: Use of animal manure |
| | | $A_{11}$: Using cover crop |
| Use | | $U_{1:}$ Crop yield |
| | | $U_{2:}$ Compliance with date of planting in order to take advantage of water conservation |
| | | $U_{3:}$ Coping strategies towards water scarcity |
| Capacity | Human capital | $C_{11}$: Education |
| | | $C_{12}$: Water management knowledge |
| | | $C_{13}$: Being an innovative farmer |
| | Social capital | $C_{21}$:Willingness to put collateral for friends during tough times |
| | | $C_{22}$: Lending money |
| | | $C_{23}$: Interaction with others |
| | | $C_{24}$: Solving problems in the neighborhood |
| | | $C_{25:}$ Participating in extension classes related to water management |
| | Physical capital | $C_{31}$: Building water reservoir pool |
| | | $C_{32}$: Using pressurized sprinkler |
| | | $C_{33}$: Farming on leveled land |
| | | $C_{34}$: Having drainage system |
| | | $C_{35}$: Using concrete ditch |
| | | $C_{36}$: Using pipes to transfer water |
| | | $C_{37}$: Having smart water meter |
| | | $C_{38}$: Crop insurance |
| Environment | | $E_1$: Water quality (EC) |
| | | $E_2$: Rate of Fertilizer |
| | | $E_3$: Rate of Pesticide |

water in farmers' well as shown in Equation (1):

$$R = \frac{\Sum(W_{Ri} X_{nRi})}{\Sum W_{Ri}} \quad (1)$$

Where, $R$ is water discharge from well; $W_{Ri}$ is the weight of the indicator, $X_{nRi}$ is the normalized value.

Access

This component refers to regular and adequate access to improved agricultural water for plant growth. Inadequate access to agricultural water will eventually lead to loss of time spent collecting water that could be used for productive activities. Farmers' access to water was measured by 11 indicators: distance from water source, type of water distribution, Area uncultivated due to water scarcity, common well, farm soil type, fallow, use of subsoiler, deep planting machinery, use of macro fertilizer, use of animal manure, using cover crop.

$$A = \frac{\sum(W_{Ai} X_{nAi})}{\sum W_{Ai}} \quad (2)$$

Where, $A$ is access to water and $X_{nAi}$ reflects the normalized value of each indicator and $W_{Ai}$ is the weight of the indicator.

## Use

The use component aims to capture the use farmers make of water resources and its contribution to the wider rural economy because water use is basic prerequisite of plant growth and it tends to increase with rural development. Efficient use of available water was measured by three indicators: crop yield, compliance with date of planting in order to take advantage of water conservation, coping strategies towards water scarcity.

$$U = \frac{\sum(W_{Ui} X_{nUi})}{\sum W_{Ui}} \quad (3)$$

Where, $U$ is the efficient use of water and $X_{nUi}$ reflects the normalized value of each indicator and $W_{Ui}$ is the weight of the indicator.

## Capacity

The capacity component comprises a set of socio-economic indicators which can show the effectiveness of farmers' ability to supply and manage water. In this study, the capacity was measured with three subcomponents and 16 indicators. The subcomponents were: human capital (C1), social capital (C2), and physical capital (C3). The indicators for all the three subcomponents were: education, water management knowledge, being an innovative farmer, willingness to put collateral for friends during tough times, lending money, interaction with others, solving problems in the neighborhood, participating in extension classes related to water management, building water reservoir pool, using pressurized sprinkler, farming on leveled land, having a drainage system, using concrete ditch, using pipes to transfer water, having smart water meter, and crop insurance.

$$C1 = \frac{\sum(W_{C1i} X_{nC1i})}{\sum W_{C1i}} \quad (4)$$

$$C2 = \frac{\sum(W_{C2i} X_{nC2i})}{\sum W_{C2i}} \quad (5)$$

$$C3 = \frac{\sum(W_{C3i} X_{nC3i})}{\sum W_{C3i}} \quad (6)$$

Where, $C$ is the capacity and $X_{nCi}$ reflects the normalized value of each indicator and $W_{Ci}$ is the weight of the indicator.

$$C = \frac{(W_{C1} \times C1) + (W_{C2} \times C2) + (W_{C3} + C3)}{W_{C1} + W_{C2} + W_{C3}} \quad (7)$$

Environment

Finally, the environment component comprised a number of indicators which not only cover water quality but also variables linked to fertilizer and pesticide use.

$$E = \frac{\sum(W_{Ei} X_{nEi})}{\sum W_{Ei}} \quad (8)$$

Where, $E$ is the environment and $X_{nEi}$ reflects the normalized value of each indicator and $W_{Ei}$ is the weight of the indicator.

## Weighting of *AWPI* indicators

For the purpose of weighting *AWPI* indicators, we used suggestions provided by Jemmali and Matoussi (2013) and Jemmali and Sullivan (2014) in that objective weighting scheme was used through Multiple Criteria Decision Making (MCDM). Agricultural water poverty indicators were weighted using Analytical Hierarchy Process (AHP). This technique is among several techniques in Multiple Criteria Decision Making (MCDM). AHP is a method to determine the relative importance of a set of activities in a multi-criteria decision problem. In the literature, AHP has been widely used for solving many complicated decision-making problems (Su





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*et al.*, 2012; Begicevic, 2009; Cited in Fabac and Zver, 2011). We used the following steps in AHP technique:

**Step 1.** A hierarchy structure was built with three levels: *AWPI* components at the top of the hierarchy, subcomponents in the middle, and indicators at the bottom.

**Step 2.** We set up a comparison matrix. The elements of the matrix are results of the pairwise comparison based on a standardized comparison scale of nine levels (see Table 2).

**Step 3**. We finally determined the relative weights for each matrix using experts in Water Organization and Agricultural organization. Table 3 illustrates weights of each component, subcomponent and indicators.

At the final step, Consistency Ratio (CR) was determined. According to Su *et al.* (2012), a consistency ratio of 0.10 or less is considered acceptable. However, if the value is higher, the judgments may not be reliable and have to be elicited again (Ramanathan, 2001).

## Normalization of *AWPI* Indicators

In order to ease comparison, we aggregated and interpreted indicators by normalizing the values of each variable into a uniform and unidirectional scale. In the normalization step, various methods are developed so far; in this study we selected the simplest and commonly used, the minimum–maximum method as suggested by Komnenic *et al.* (2009) and Lawrence *et al.* (2003). In the minimum-maximum method, two versions of normalization are proposed (Formula 9, 10). However, one of the major limitations of normalization is the problem of small sample size (Lewis, 2001). In order to overcome this limitation, 110 irrigated farmers were interviewed and thus the problem of overestimation of *p* is not a concern.

$$Xn = \frac{x_i - x_{min}}{x_{max} - x_{min}} \quad (9)$$

$$Xn = \frac{x_{max} - x_i}{x_{max} - x_{min}} \quad (10)$$

The first formula is used when an increase in one indicator causes a decrease in agricultural water poverty. However, in the second formula, an increase in one indicator causes an increase in agricultural water poverty.

## Calculation of *AWPI*

There are two modes in calculating *AWPI*: The conventional method used by Forouzani *et al.* (2013) and a new approach provided in this study. In the conventional method and the new approach, the following formula was used to assess *AWPI*:

$$AWPI = \left(\frac{(W_R \times R)+(W_A \times A)+(W_U \times U)+(W_C \times C)+(W_E \times E)}{W_R + W_A + W_U + W_C + W_E}\right) \times 100 \quad (11)$$

In the conventional approach Forouzani *et al.* (2013) used $X_n$ as a normal value for measuring every component, but a statistical error occurred when $X_n$ was multiplied by value of each subcomponent. For example, in the component A, $X_n$ is multiplied by $A_i$ but when the normalized value of any subcomponent is used, there is no need to multiply the value of each subcomponent by normalized value. In other words, the normalized value of each subcomponent

**Table 2.** Nine-point intensity of importance scale.

| Definition | Intensely of importance |
|---|---|
| Equally important | 1 |
| Moderately more important | 3 |
| Strongly more important | 5 |
| Very strongly more important | 7 |
| Extremely more important | 9 |
| Intermediately more important | 2, 4, 6, 8 |

**Table 3.** Weights of Components, subcomponent, and indicators of *AWPI* in Mahidasht Basin.

| Components | Subcomponent | Indicator | Weigh |
|---|---|---|---|
| Resources (0.424) | | R : Level of water in farmers' well | |
| Access (0.321) | | $A_1$: Distance from water source | 0.126 |
| | | $A_2$: Type of water distribution | 0.160 |
| | | $A_3$: Area uncultivated due to water scarcity | 0.098 |
| | | $A_4$: Common well | 0.146 |
| | | $A_5$: Farm soil type | 0.071 |
| | | $A_6$: Fallow | 0.158 |
| | | $A_7$: Use of subsoiler | 0.157 |
| | | $A_8$: Deep planting machinery | 0.042 |
| | | $A_9$: Use of macro fertilizer | 0.029 |
| | | $A_{10}$: Use of animal manure | 0.018 |
| | | $A_{11}$: Using cover crop | 0.015 |
| | | | 0.612 |
| Use (0.129) | | $U_1$: Crop yield | |
| | | $U_2$: Compliance with date of planting in order to take advantage of water conservation | 0.262 |
| | | $U_3$: Coping strategies towards water scarcity | 0.126 |
| | | | 0.537 |
| Capacity (0.078) | Human capital | $C_{11}$: Education | |
| | | $C_{12}$: Water management knowledge | 0.306 |
| | (0.549) | $C_{13}$: Being an innovative farmer | 0.157 |
| | | | 0.547 |
| | Social capital | $C_{21}$: Willingness to put collateral for friends during tough times | |
| | (0.322) | $C_{22}$: Lending money | 0.225 |
| | | $C_{23}$: Interaction with others | 0.138 |
| | | $C_{24}$: Solving problems in the neighborhood | 0.057 |
| | | $C_{25}$: Participating in extension classes related to water management | 0.031 |
| | | | 0.196 |
| | Physical capital | $C_{31}$: Building water reservoir pool | |
| | | $C_{32}$: Using pressurized sprinkler | 0.311 |
| | (0.129) | $C_{33}$: Farming on leveled land | 0.035 |
| | | $C_{34}$: Having drainage system | 0.034 |
| | | $C_{35}$: Using concrete ditch | 0.170 |
| | | $C_{36}$: Using pipes to transfer water | 0.117 |
| | | $C_{37}$: Having smart water meter | 0.099 |
| | | $C_{38}$: Crop insurance | 0.038 |
| | | | 0.497 |
| Environment (0.038) | | $E_1$: Water quality (EC) | |
| | | $E_2$: Rate of Fertilizer | 0.245 |
| | | $E_3$: Rate of Pesticide | 0.258 |

usually takes the place of the subcomponent's real value. Table 4 summarizes the conventional and new approach used in assessing *AWPI*.

## RESULTS AND DISCUSSION

Exploring different weaknesses of the *AWPI* initially, a revision is presented here



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**Table 4.** Conventional and new approach in assessing *AWPI*.

| Steps | Conventional approach | New approach |
|---|---|---|
| 1 | Determining components (R, A, U, C, and E)[a] | Determining components (R, A, U, C, and E )[a] |
| 2 | Normalizing data (due to different scale) | Normalizing data (due to different scale) |
| 3 | Weighting components and subcomponents (using AHP technique) | Weighting components and subcomponents (using AHP technique) |
| 4 | Calculating each component; e.g. component (A) was calculated by the following formula $A = \frac{\sum(W_{Ai} X_n A_i)}{\sum W_{Ai}}$ | Calculating each component; e.g. component (A) was calculated by the following formula[b] $A = \frac{\sum(W_{Ai} X_{nAi})}{\sum W_{Ai}}$ |
| 5 | Calculating AWPI using following formula: AWPI= $\left[\frac{w_r R + w_a A + w_c C + w_u U + w_e E}{w_r + w_a + w_c + w_u + w_e}\right] \times 100$ | Calculating *AWPI* using following formula: AWPI= $\left[\frac{w_r R + w_a A + w_c C + w_u U + w_e E}{w_r + w_a + w_c + w_u + w_e}\right] \times 100$ |

[a] R= Resources; A= Access; U= Use; C= Capacity, E= Environment. [b] The normalized value is NOT multiplied by $A_i$.

in response to the statistical assessment addressed recently by Forouzani *et al.* (2013). Based on new statistical analysis, *AWPI* across Mahidasht Basin revealed a score of 49.06. However, when we used the conventional analysis *AWPI* reduced to 41.52, our new approach is considered to be more realistic provided that Mahidasht Basin has been declared as the forbidden zone in terms of resources. For example, as shown in Figure 1, resource component in the new approach was 27.4 whereas in the conventional method it reached as high as 71.7. This clearly indicates that resources are low in Mahidasht Basin and that more water conservation strategies are needed. Moreover, access component was 74.9 in the new approach showing that farmers are trying hard to gain access to the limited water resources. However, this value in conventional method is 19.38 indicating that farmers in Mahidasht Basin are somewhat passive in exploiting access to more water resources. Interestingly, the value for water

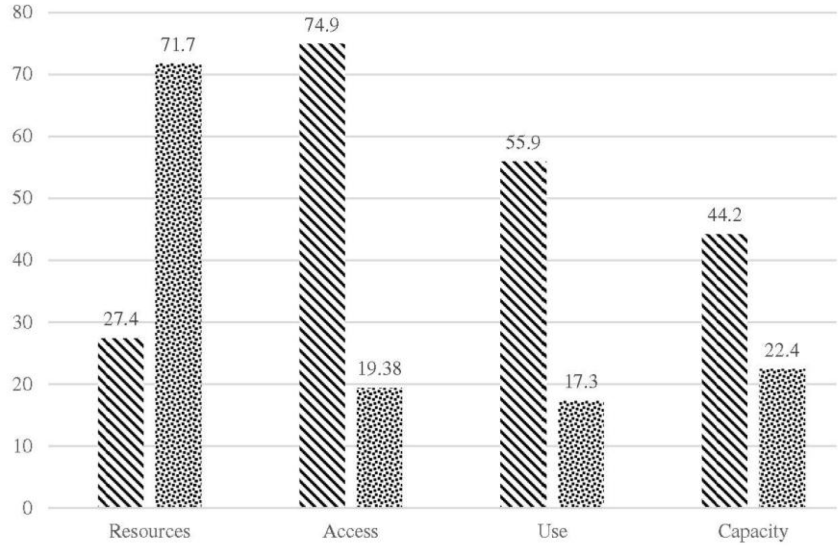


**Figure 1**. A comparison of the Agricultural Water Poverty Components in Mahidasht Basin based on two types of statistical methods




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use component in the new approach was 55.9 whereas in the conventional method, this value was 17.3. This value in our new approach is more realistic in the fact that farmers gained more access to water resources and consequently used these resources to their benefit. Capacity to manage water at both community and government level is needed to manage water effectively. The result of capacity component in the new approach showed that farmers managed water somewhat effectively because the majority of farmers in Mahidasht Basin (85%) had medium to high agricultural water management knowledge. However, based on conventional approach, capacity component was 22.4. This value may seem more unrealistic in our context in that farmers in Mahidasht Basin gained more access to water resources due to their somewhat higher capacity (44.2). In regards to environmental components, result of the new *AWPI* approach revealed a value of 51.2 whereas the conventional approach showed a value of 23.6. Again, result from the new approach is more consistent with other components. In other words, when access to water resources is high and farmers are using water faster than it can replenish, we do not expect a better water quality and a more environmental integrity among water and the ecosystem. The electrical conductivity of water in Mahidasht Basin was 0.89 ppm which is considered as low quality water according to Alikhan and Adil Abbasi (2013). In terms of pesticide and chemical fertilizer, Mahidasht Basin farmers are overusing pesticide and chemical fertilizer. This clearly demonstrates that Mahidasht Basin is not faring well on environmental issues.

Overall, the resource, access, use, capacity and environment received a score of 27.4, 74.9, 55.9, 44.2, and 51.2 respectively. These values are highly deviated when we consider *AWPI* based on Forouzani *et al.* (2013).

Furthermore, as shown in Figure 2, agricultural water poverty score for each sub-basin (Sarfirouz-abad, Mahidasht, Central, Kouzaran) revealed that Central sub-basin received the highest AWP (44.00) and Kouzaran sub-basin with the lowest AWP (52.00).

Although Central sub-basin and Kouzaran are geographically close, they received a different *AWPI* score. This is due to the fact that although Central and Kouzaran sub-basin are low in resources but Kouzaran sub-basin scored the highest in capacity to

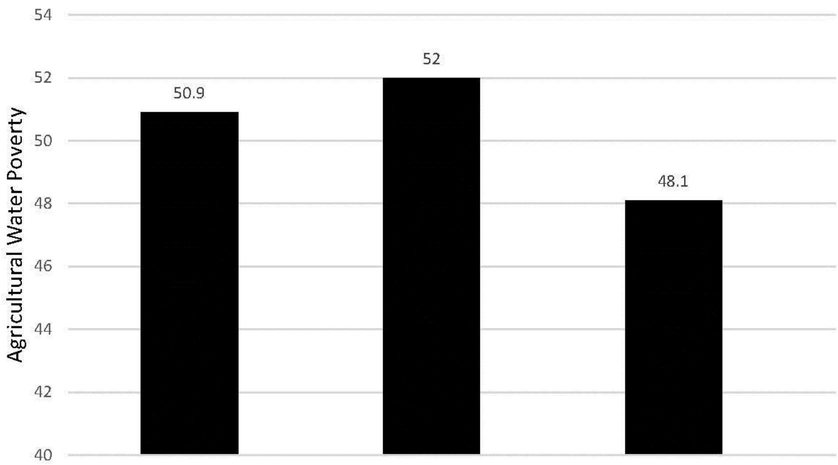


**Figure 2.** Agricultural Water Poverty Score across four different sub-basin in Mahidasht Basin.





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manage water. This clearly indicates that farmers in Kouzaran sub-basin are more skillful in managing water effectively and have the capacity to lobby for improvements. This in turn has made farmers have high access to water (Table 5). *AWP* for Mahidasht and Sarfirouz-abad revealed that Mahidasht scored 48.1 and Sarfirouz-abad scored 50.9. Although geographically close, their *AWP* scores are different. One justification for different *AWP* score among these two sub-basins is that Sarfirouz-abad farmers had more water resources and that they used water more efficiently.

To visualize *AWP* across four sub-basins, a pentagram is illustrated in Figure 3. As shown in Figure 3, central sub-basin is faced with high *AWP* in terms of resource, use and capacity. Thus more water management intervention is needed in Central sub-basin. Kouzaran sub-basin has the lowest water poverty in terms of resources, access and capacity. This means that Kouzaran farmers have more water resources and that they have better access to these resources. This may be justified by the fact that farmers in Kouzaran sub-basin are well equipped with human capital such as education and knowledge on water management. Interestingly, farmers in Kouzaran sub-basin have higher physical capital which in turn has helped them in managing water resources more effectively.

**Table 5.** The value of each component across study area.

| Sub-basin<br>*AWP* Component | Central | Mahidasht | Kouzaran | Sarfirouz-abad |
|---|---|---|---|---|
| Resources | 18.6 | 25.8 | 31.2 | 31.6 |
| Access | 74.8 | 73.9 | 81.3 | 71.4 |
| Use | 44.9 | 56.2 | 52.6 | 59.9 |
| Capacity | 39.4 | 44.2 | 49.2 | 43 |
| Environment | 65.4 | 53.5 | 32.7 | 50.89 |

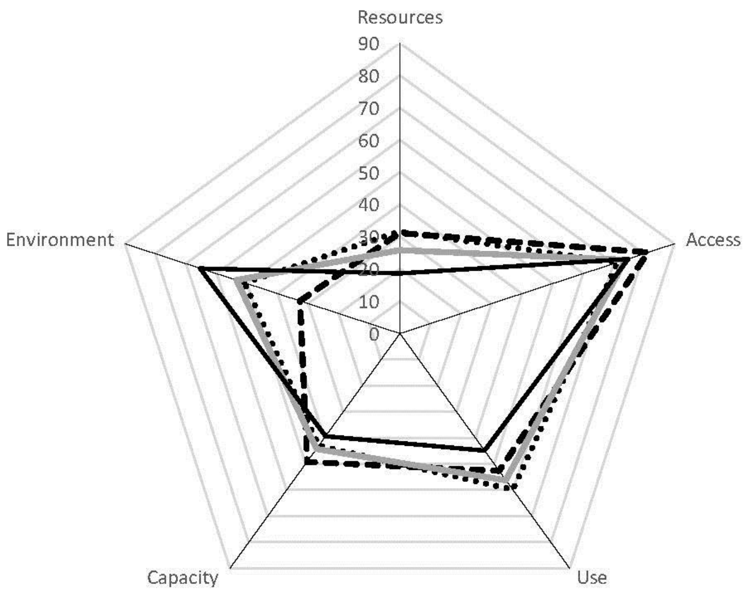


**Figure 3**. A comparison of the AWPI across four regions in Mahidasht basin.





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## CONCLUSIONS

The main results of our application of *AWPI* show clearly that Mahidasht Basin, are characterized by a high *AWPI*. The very poor results for sub-basins (Central and Mahidaht) which illustrated the lack of water resources joined with low capacity of farmers to effectively manage water resources encouraging the water decision makers to design appropriate policy to meet the challenges. Although limited effort has been made to develop *AWPI*, the refinements proposed in this paper are intended to increase the statistical soundness of the *AWPI*. To exploit the performance of the *AWPI* completely, the components are examined individually and the indicators are normalized. For the calculation of *AWPI*, it is essential to normalize indicators with different scales. We showed that during normalization process, there is no need to use the real value. Instead, we can use the normalized value of each indicator. The usefulness, of our procedure in calculating *AWPI* lie in its realistic value of *AWPI* which takes into account five component indices (R, C, A, U, and E). We therefore, recommended focusing on normalized value of each indicator when calculating *AWPI*. The advantage being that normalized value is used instead of real value. This in turn adds statistical rigor in calculating *AWPI*.

The *AWPI* presented in this study is a powerful tool for determining priorities, it empowers decision-makers to act impartially by allowing them to justify their choices. For example, water policy-makers can prioritize limited resources in sub-basins that are in urgent need for attention. At the same time, it gives local communities an opportunity to express their needs in a systematic way, and helps them to lobby for action. Because of the simplicity inherent *IN AWPI*, it appeals to policy-makers as a single number that can be used to represent the water situation at a particular sub-basin. At the same time, underlying complexities need not be lost. For the ease of understanding, a pentagram was developed to show the values of all five components in a visually clear way in all sub-basins. This pentagram may direct attention to those water sectors requiring urgent policy attention.

The *AWPI* provides a transparent framework on which decisions in water planning and management can be based. However, it should be used with caution when calculating the final value of *AWPI*. The *AWPI* can provide an assessment that helps to determine need priorities. This is an important step, but beyond this other tools would be needed to carry out more detailed planning and study the impacts of water development projects across Mahidasht Basin. The *AWPI* can be useful in many ways. It needs to be emphasized, however, that the normalization of any indicator, and its deployment, may be subject to statistical error. This may jeopardize the reliability and therefore the comparability of results.

The *AWPI* is directed towards communities and is especially relevant for poorer areas, but it does not neglect the issues of environment. Our study revealed that Mahidasht Basin suffers mostly from water resources, farmers' capacity and environmental issues. For example, the overuse of chemicals and fertilizers by farmers in Mahidasht Basin has made the policy-makers announce the area as a "Forbidden Basin" meaning that farmers are not allowed to dig any further wells or deepen their current well. We finally recommend that *AWPI* be updated at reasonable intervals so that it could be used to monitor progress. However, one major concern in using *AWPI* is selecting indicators for each subcomponent. For example, although over 50 indicators of sustainable water management have been identified, and globally indicators of all types are in use, "*one size fit all*" may not be as effective when selecting indicators across rural population.

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**بررسی شاخص فقرآبی کشاورزی در استان کرمانشاه (مورد مطالعه: دشت ماهیدشت، ایران)**

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## چکیده

شاخص فقر آبی به عنوان یک ابزار ارزیابی در مدیریت منابع آب کاربرد دارد. بطور ویژه، فقرآبی کشاورزی یک ابزار ارزیابی آب در مناطق روستایی است. شرکت آب منطقه‌ای استان کرمانشاه، دشت ماهیدشت را به عنوان «دشت ممنوعه» اعلام کرده است بدان معنا که استخراج آب در این دشت در وضعیت بحرانی قرار دارد. بنابراین مدیریت اثر بخش منابع آب در این دشت حائز اهمیت است. شاخص فقرآبی کشاورزی یک ابزار مناسب در مدیریت منابع آبی کشاورزی است. این شاخص حاصل توسعه شاخص فقرآبی با پنج مولفه است شامل منابع آبی، دسترسی به منابع آب، استفاده از منابع آب، توانمندی و اقدامات زیست محیطی. این مطالعه با هدف سنجش فقرآبی کشاورزی در دشت ماهیدشت انجام شد. نتایج نشان داد که این دشت با فقرآبی کشاورزی شدید مواجه است (AWP= 49.06) نتایج همچنین نشان داد که کشاورزان در دشت ماهیدشت با کمبود منبع آبی مواجه هستند (R= 27.4) اما این منابع محدود تا حد قابل توجهی در دسترس کشاورزان قرار دارد (A= 74.9) این مطالعه دستاوردهایی برای سیاست‌گزاران آب در استان کرمانشاه دارد. به عنوان مثال سیاست‌گزاران بخش کشاورزی می‌توانند از نتایج این مطالعه برای کاهش فقرآبی کشاورزی در دشت ماهیدشت استفاده کنند.





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