Water-food security nexus in Middle East and North Africa Region: an exploratory assessment

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Abstract

The multifaceted relationships between water resources and food security (FS) are at the core of sustainable development challenge in Middle East and North Africa (MENA). This paper proposes a multidimensional analysis of two indices related to water security and FS. The five components of the Water Poverty Index (mWPI) – Resources, Access, Use, Capacity and Environment – and the three components of the Global Food Security Index (GFSI) – Availability, Affordability and Food quality and safety – have been analysed and correlated. Results indicate a positive correlation between mWPI and GFSI, while correlation is higher when considering only Capacity and Access components. The correlation between mWPI with the different dimensions of the GFSI shows a higher correlation with food availability and food quality/safety. Integrating water security metrics into FS indices could be a useful step to operationalize water-food -nexus and to design effective actions and strategies to achieve FS in the MENA region.

Keywords: *water security, food security, water-food nexus, Middle East and North Africa.*

Résumé

Les relations multidimensionnelles entre ressources hydriques et sécurité alimentaire sont au cœur du défi du développement durable dans la région du Moyen-Orient et de l'Afrique du Nord (MENA). Dans ce travail, nous allons proposer une analyse multidimensionnelle de deux indices corrélés à la sécurité hydrique et à la sécurité alimentaire. Les cinq composantes de l'Indice de pauvreté en eau (IPE) – ressources, accès, utilisation, capacité et environnement – et les trois composantes de l'Indice global de sécurité alimentaire (ISA) – disponibilité, abordabilité, et qualité et sûreté alimentaires – ont été analysées et mises en corrélation. Les résultats indiquent une corrélation positive entre l'IPE et l'ISA alors que la corrélation est plus élevée si on considère seulement les composantes capacité et accès. La corrélation entre l'IPE et les différentes dimensions de l'ISA met en évidence une corrélation plus élevée avec la disponibilité et la qualité/sûreté alimentaires. Intégrer la mesure de la pénurie d'eau aux indices de sécurité alimentaire pourrait être utile en vue de déterminer le Nexus eau-alimentation et mettre au point des actions et des stratégies efficaces pour atteindre l'objectif de la sécurité alimentaire dans la région MENA.

***Mots-clés*:** sécurité hydrique, sécurité alimentaire, Nexus eau-alimentation, Moyen-Orient et Afrique du Nord.

1. Introduction

The relationships between water resources and food security are at the core of the challenge of a sustainable development in Middle East and North Africa (MENA). Recent events around the globe in general, and in the MENA region in particular (cf. the Arab Spring), have put more attention and pressure onto food security (Hassan-Wassef, 2012) and stressed how water-food nexus is indeed shaped by physical (hydrological) conditions as well as by economic resources, institutional assets and social dynamics regarding water resources (FAO/RNE, 2015). The multidimensionality of both water and food ask for going beyond simplistic approaches toward analytical frameworks able to take into account social, political and economic issues.

The MENA region is one of the most water scarce regions in the world (Hamdy, 2008) with an average water availability per person only around 1,200 m^3/person/year (FAO/RNE, 2013). Almost 80 percent of total renewable resources is withdrawn while half of the countries located in the region withdraw more than 100%. Currently, nearly 75% of the water resources in the MENA region is allocated to agriculture (FAO/RNE, 2015).

Water shortage in the MENA region will be further enormous in the next decades and shortages will be driven primarily by demand: 80% of future shortage has been attributed to a steep increase in demand owing to strong population growth and fast economic development (including the rising demand of a wealthier middle-class, with different dietary habits) (FAO/RNE, 2013).

This situation will cause an increase of sectorial conflicts in which environmental water requirement, intended as the water needed by the ecosystem to sustain its integrity, could be seriously at risk (Smakhtin *et al*., 2004). In addition to demand-side there are also supply-side pressures, with an estimated 20% of future shortage being attributable to climate change (FAO/RNE, 2015).

In this context, the ability of MENA countries to feed their growing population is severely challenged by competition over increasingly limited water resources.

Food security is built on four pillars (CFS, 2012; UN-HLTF, 2011): food availability (sufficient quantities of food available on a consistent basis); food access (having sufficient resources to obtain appropriate foods for a nutritious diet); food use (appropriate use based on knowledge of basic nutrition and care); and stability in food availability, access and utilization. Three elements contribute to food availability: production, distribution, and exchange. Accessibility of

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food can be described by three elements: affordability, allocation, and preference. The three elements of food utilization are nutritional value, social value and food safety (Ericksen, 2008).

Despite high average calorie intakes, MENA continue to suffer from various malnutrition problems (FAO/RNE, 2014). There are significant differences across countries and gender, with consistently higher rates of obesity in women. Micronutrient deficiencies are common in both affluent and less affluent countries. Food availability in the MENA region has witnessed remarkable improvements in the last 20 years. Nonetheless, nutrition has not registered comparable improvements in the majority of the countries. Countries in the region have been passing through a difficult transition in their agriculture and food systems as well as in the nutritional and health status of the population. The result is the “triple burden of malnutrition”, where undernutrition coexists with overnutrition and micronutrient deficiencies (FAO, 2015). The MENA region faces a unique set of intertwined and complex challenges to achieve food and nutrition security. Over and above the traditional challenges of resource scarcity and rapid population growth, the region is confronted with unique nutrition challenges and a growing number of conflicts, political instability and crises, resulting in large refugee populations and taking a huge toll on the region’s overall food security (IFPRI and WFP, 2013; FAO, 2015).

The region’s rapidly shrinking freshwater resources, exacerbated by climate change, pose major constraints for all dimensions of food security, notably for availability and stability but even for food utilization and safety (FAO/RNE, 2011; Kubursi, 2012; Zdruli *et al*., 2013; Lacirignola *et al*., 2014; Antonelli and Tamea 2015; FAO/RNE, 2015). Water scarcity has also driven up the region’s cereal import needs and heightened its exposure to the volatility of international markets. With a limited and fragile natural resource base, high population growth and an increasing demand for food, the Near East and North Africa (NENA) region is structurally unable to feed itself that’s to say to achieve food self-sufficiency. In addition, both the prevalence of high poverty rates in some countries and inadequate food consumption patterns are major causes of food insecurity and malnutrition (FAO/RNE, 2011).

Several indicators have been proposed to measure the interdependency among the different dimensions of water and food security (Brown and Matlock, 2011).

Human needs have been firstly considered by the Falkenmark index (Falkenmark, 1989) and by Gleick index (Gleick, 1996) that, giving priority to the satisfaction of all human needs, consider the capability of water resources to sustain food self-sufficiency. Many attempts have also been made to focus on the needs of poor and vulnerable individuals and on institutional capacity to manage competition and conflicts among different users and uses (UN-Water TF-IMR, 2009).

Pangaribowo *et al.* (2013) carried out a review of existing food and nutrition security indicators and indices namely: the FAO Indicator of Undernourishment (FAOIU); the Global Hunger Index (GHI); the Global Food Security Index (GFSI); the Poverty and Hunger Index (PHI); the Hunger Reduction Commitment Index (HRCI); anthropometric indicators; the Diet Diversity Scores, and medical and biomarker indicators. They also classified them taking into consideration the food dimensions of food security i.e. availability, accessibility, utilization, and stability. It is worth highlighting that in no one of these food security indices water security is considered as a standalone component or indicator. Nevertheless, access to drinking water is one of the 22 indicators of political commitment considered in the calculation of HRCI (Hunger and Nutrition Commitment Index, 2016).

Water security (e.g. UNESCO-IHE, 2009; Cook and Bakker, 2012) is often framed as a component or subset of food security (cf. Biswas, 1999; FAO, 2000; White *et al*., 2007). According to FAO, water security is the ability to provide adequate and reliable water supplies for populations to meet agricultural production needs (Clarke, 1993). In many countries, especially those with arid or semi-arid climate such as the MENA ones, irrigation water is the salient feature of food. Despite the fact that food security and water security have been recently often used jointly in many contexts, the challenge of linking water security and food security (cf. Falkenmark, 2001) still exists both in research and policy arenas, which is particularly problematic in the climate change era (Hanjra and Qureshi, 2010).

The paper explores the multifaceted linkages between water security and food security in the MENA region by analysing relations between Water Poverty Index (WPI) and Global Food Security Index (GFSI). In the first part, the paper describes the two indices considered as the most appropriate to describe the multidimensionality of the issues under analysis. In the second part, through a combined analysis of the two indices, the relations between water poverty and food security are investigated in the MENA region and some factors and drivers are identified.

2. Material and Methods

In this paper, we use the Water Poverty Index as proposed by Sullivan (2002), and revised by Sullivan and Jemmali (2014). It is an index ranging from 0 to 100 that combines five core components – *Resources, Capacity, Access, Use* and *Environment* – where each component is given by an arithmetic weighted mean of different subcomponents (Tab. 1) identified to capture a wide range of water resources aspects.

The component *Resources* includes amount and variability of groundwater and surface water resources, distinguished in internal and external. The *Access* component includes access to drinking water and water for domestic use and hygiene, as well as access to irrigation. The *Capacity* component focuses on water institutional capacity by combining a set of human development indicators of a country, like gross domestic product (GDP), health and education.

Table 1. *Components and subcomponents considered in the mWPI.*

Components	Subcomponents
Resources (RES)	RES1: Internal water resources
	RES2: External water resources
Access (ACC)	ACC1: Access to safe water
	ACC2: Access to improved sanitation
Capacity (CAP)	CAP1: Economic capacity
	CAP2:Under-five mortality rate
	CAP3: Education enrolment rate
Use (USE)	USE1: Domestic water consumption rate
Environment (ENV)	ENV1: Water quality
	ENV2: Water stress

Source: Adapted from Sullivan and Jemmali (2014).

Table 2. *Components and indicators considered in the GFSI.*

Availability (AVA)	1. Sufficiency of supply
	2. Public expenditure on agricultural research and development (R&D)
	3. Agricultural infrastructure (crop storage facilities, ports and roads)
	4. Volatility of agricultural production
	5. Political stability risk
Affordability and financial access (AFF)	1. Food consumption as a proportion of total household expenditure
	2. Proportion of population living under or close to the global poverty line
	3. GDP per capita (at purchasing power parity, or PPP, exchange rates)
	4. Agricultural import tariffs
	5. Presence of food safety net programmes
	6. Access to financing for farmers
Food quality and safety (QUAL)	1. Diet diversification
	2. Government commitment to increasing nutritional standards
	3. Micronutrient availability
	4. Protein quality
	5. Food safety

Source: The Economist Intelligence Unit, 2015.

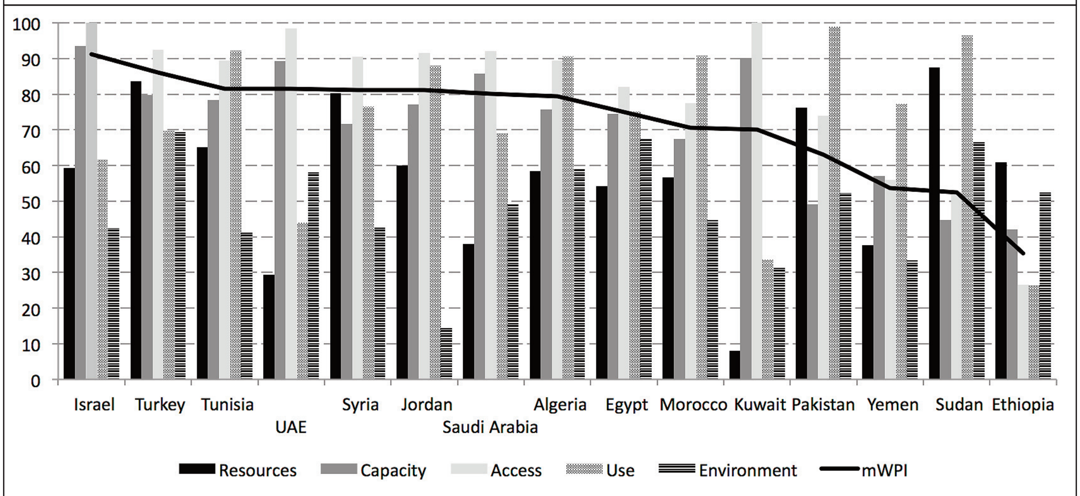
The *Use* component combines domestic water use and consumption of water in different productive sectors, such as industry and agriculture against the value generated by each sector. The last component *Environment*, which aims to capture the degree of maintenance of ecological integrity, uses as proxies index of water quality and water stress.

Taking into account the availability of the data, in the present work a set of 10 subcomponents has been considered and included in the calculation of a modified WPI (mWPI) (Tab. 1).

The Global Food Security Index considers the core issues of affordability, availability, and quality across a set of 109 countries. The index is a dynamic quantitative and qualitative benchmarking model, constructed from 28 unique indicators (Tab. 2), that measures these drivers of food security across both developing and developed countries (The Economist Intelligence Unit, 2015). It is the first index to examine food security comprehensively across three of its internationally established dimensions (*i.e.* availability, access and utilisation). Moreover, the index looks beyond hunger to the underlying factors affecting food insecurity (The Economist Intelligence Unit, 2012). The index is a score ranging from 0 to 100 (where 100 is the most favourable situation) (The Economist Intelligence Unit, 2012, 2015). Beginning in October 2012, the Economist Intelligence Unit (EIU) updates the index on a quarterly basis to adjust for the impact of fluctuating food prices (The Economist Intelligence Unit, 2012). In the last report of the Economist Intelligence Unit (2015) data are available for the following 15 MENA Countries: Algeria, Egypt, Ethiopia, Israel, Jordan, Kuwait, Morocco, Pakistan, Saudi Arabia, Sudan, Syria, Tunisia, Turkey, UAE and Yemen.

mWPI and GFSI have been correlated to measure the strength of the linear relationship between indices as a whole and between single components. Given the explorative nature of the work and the absence of any hypothesis about cause-effect relation between the variables, we consider correlation as the most appropriate measure of association. Starting from the construction and the subsequent examination of the scatter plot, Pearson correlation coefficient, *r*, the associated value of significance and confidence interval have then been estimated in order to value the robustness of the statistical evidence. Using the guide of Evans (1996), the absolute value of r has been considered "very weak" for values from .00 to .19; "weak" for values from .20 to .39; "moderate" for values from .40 to .59; "strong" for values from .60 to .79 and "very strong" for values from .80 to 1.0. All analyses were performed using IBM® SPSS® Statistics 20. MENA countries considered are those for which data for both indices are

Figure 1 - *mWPI in MENA countries-*



Source: Adapted from Sullivan and Jemmali (2014).

Table 3 - *mWPI in selected MENA countries.*

Country	mWPI	Resources	Capacity	Access	Use	Environment
Israel	91.21	59.25	93.46	100	61.55	42.37
Turkey	86.06	83.68	79.69	92.5	69.65	69.32
Tunisia	81.55	65.04	78.34	89.5	92.32	41.2
UAE	81.48	29.32	89.26	98.5	43.93	58.27
Syria	81.2	80.25	71.65	90.5	76.64	42.53
Jordan	81.09	60.0	77.12	91.5	87.98	14.57
Saudi Arabia	80.12	37.94	85.68	92	69.02	49.06
Algeria	79.37	58.41	75.68	89.5	90.6	59.15
Egypt	74.94	54.21	74.45	82.0	75.21	67.64
Morocco	70.5	56.65	67.43	77.5	90.85	44.67
Kuwait	70.11	7.95	90.2	100	33.55	31.2
Pakistan	62.99	76.16	49.07	74.0	98.9	52.22
Yemen	53.68	37.69	56.95	56.0	77.32	33.32
Sudan	52.45	87.41	44.74	52.5	96.51	66.7
Ethiopia	35.32	60.9	41.97	26.5	26.42	52.77

Source: Adapted from Sullivan and Jemmali (2014).

available namely Algeria, Egypt, Ethiopia, Israel, Jordan, Kuwait, Morocco, Pakistan, Saudi Arabia, Sudan, Syria, Tunisia, Turkey, UAE and Yemen. The main strength of the methodological approach adopted is that it allows a quantitative analysis of the water-food nexus. The weaknesses of the approach are related to those of the two indices used (Lawrence *et al*., 2002; Komnenic *et al*., 2009). Although attractive for their multidimensionality, both mWPI and GFSI have several drawbacks mainly linked to the arbitrariness of the weighting process and to their incapacity to take into account spatial differences of different components. Moreover, data for both mWPI and GFSI are not available for different years and for all MENA countries, thus negatively affecting the regression quality.

3. Results and Discussion

The modified Water Poverty Index (mWPI) (Fig.1) shows that MENA countries considered in the analysis can be divided in three main groups: the first one including the top rank countries; the second one is the most numerous and includes Algeria, Egypt, Jordan, Kuwait, Libya, Morocco, Oman, Palestine, Saudi Arabia, Syria, Tunisia, UAE; the third group includes all the countries in the Horn of Africa plus Mauritania and the Southern Asia countries of Pakistan and Afghanistan.

Moving to the analysis of the components (Tab. 3), it can be noticed that all the countries in the top, with the only exception of Armenia, are either high-income or upper middle income countries and can push the indicator by acting on *CAP* and *ACC* subcomponents; Lebanon and Turkey have also good performance for the *ENV* subcomponent while all the countries are in lower part of the ranking for the *USE* subcomponent.

As for water poor countries of the last group, they suffer from weak institutional capacity that determines low level of *ACC* to water resources that - in some cases such as Iraq, Sudan and Pakistan - could be enough and efficiently used to satisfy populations' requirement.

Food security – including food availability, food affordability and food quality and safety - is still a challenge in many MENA countries. The countries that make up the MENA region in the GFSI are extremely diverse in terms of both food supply and consumption (Table 4). These differences have a significant impact on the food and agricultural policies that countries have in place across the region. Several states - including Turkey, Morocco and Israel - are major food exporters and are self-sufficient in most agricultural products. Conversely, the arid Gulf Arab states are heavily dependent on food imports. Despite these intraregional differences, the MENA region performs rather well in the GFSI, ranking third regionally behind North America and Europe in over one-half of the indicators that contribute to the overall food security score (The Economist Intelligence Unit, 2015).

The 2012-2015 trends of the GFSI show that over the past four years most countries have achieved steady, incremental

Table 4 - *GFSI in selected MENA countries.*

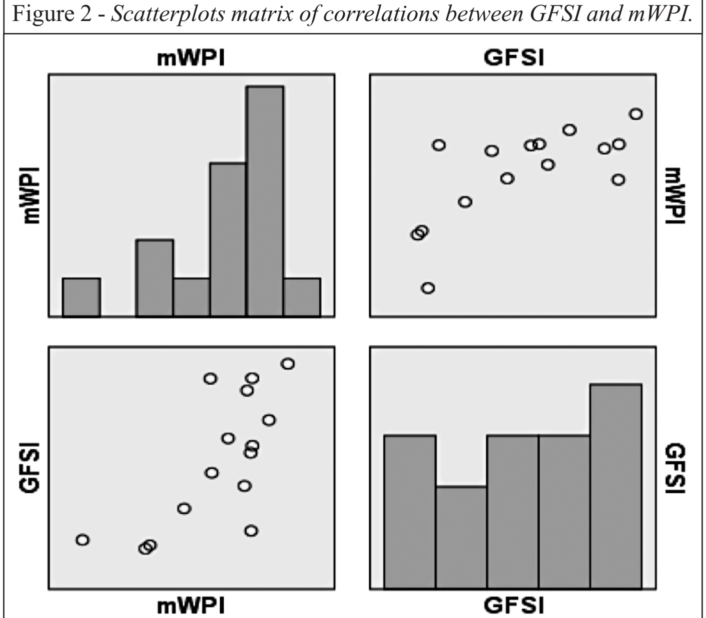
Country	GFSI (2015)	GFSI-Rank (109 world countries)	Change 2014-2015	Availability score	Affordability score	Quality and safety score
Israel	78.9	19	-1.6	74.0	81.8	85.4
UAE	75.6	23	+2.5	63.0	88.9	77.0
Kuwait	75.5	24	+1.8	64.3	88.7	73.4
Saudi Arabia	72.8	30	+2.7	67.7	80.6	67.3
Turkey	66.0	39	+1.8	67.7	62.9	69.1
Egypt	61.8	47	+12.4	67.9	55.6	60.9
Tunisia	60.1	51	+2.0	62.6	56.1	62.9
Jordan	58.5	55	+4.4	61.4	58.4	50.6
Morocco	53.9	62	+1.3	57.9	49.6	53.9
Algeria	50.9	68	+1.5	55.0	47.5	47.8
Pakistan	45.7	77	+1.7	50.9	37.1	53.0
Syria	40.6	84	-0.5	41.8	36.6	47.2
	38.5	86	+2.2	45.5	32.6	34.0
Yemen	37.3	90	+1.5	38.7	37.7	32.4
Sudan	36.5	92	+2.9	38.7	30.8	45.0

Source: Adapted from The Economist Intelligence Unit, 2015, 2016.

improvement in food security, but a few countries have made dramatic progress. Low- and lower-middle income populations in regions such as MENA remain the most vulnerable to food price shocks. However, MENA experienced the greatest improvement in food security between 2014 and 2015. In fact, the best improvement at global level was recorded in Egypt (+12.4 points). Increase in the region's average overall score was driven primarily by gains in affordability. Lower levels of food loss and increased access to high-quality protein resulted in marked improvements in the two other categories, availability and quality and safety, as well. Nevertheless, the score deteriorated in Israel and Syria (The Economist Intelligence Unit, 2015).

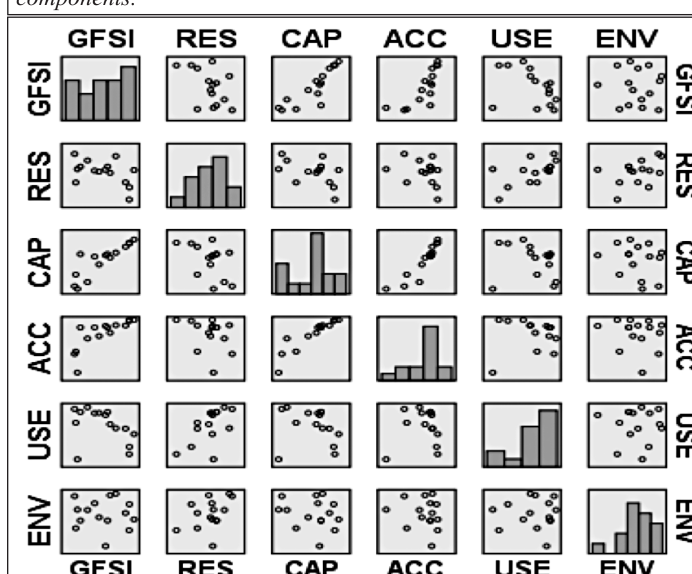
As far as the MENA region is concerned, the best GFSI score was recorded in 2015 in Israel while the lowest was recorded in Sudan (The Economist Intelligence Unit, 2015). Israel is ranked 19 at global level. Its strengths are mainly related to quality and safety (category rank 10/109) and to a certain extent also availability (rank 17/109) while it has some challenges related to affordability (rank 23/109). It has a full score (*i.e.* 100) in relation to many indicators such as proportion of population under global poverty line, presence of food safety net programmes, access to financing for farmers, nutritional standards and food safety. Meanwhile the lowest indicator score regards public expenditure on agricultural R&D (score 12.5). Sudan (rank 92/109) faces relevant challenges in relation to all the three categories of the index. However, it performs better in quality and safety (rank 81/109) with respect to availability (rank 102/109). The strengths of the country regards food loss (score 87.5) and volatility of agricultural production (score 79.1) while the main challenges are public expenditure on agricultural R&D (score 0), corruption (score 0), gross domestic product per capita (score 4) and agricultural infrastructure (score 9.3) (The Economist Intelligence Unit, 2016).

Figure 2 - *Scatterplots matrix of correlations between GFSI and mWPI.*



Source: Authors' elaboration based on data from Sullivan and Jemmali (2014) and The Economist Intelligence Unit (2015, 2016).

Figure 3 - *Scatterplots matrix of correlations among GFSI and mWPI's components.*



Source: Authors' elaboration based on data from Sullivan and Jemmali (2014) and The Economist Intelligence Unit (2015, 2016).

Table 5 - *Correlation matrix between mWPI and GFSI.*

		mWPI	GFSI
mWPI	Pearson Correlation	1	.704**
	Sig. (2-code)		.003
	N	15	15
GFSI	Pearson correlation	.704**	1
	Sig. (2-code)	.003	
	N	15	15

Source: Authors' elaboration based on data from Sullivan and Jemmali (2014) and The Economist Intelligence Unit (2015, 2016).

The analysis (Tab. 3) shows that there is a positive correlation between mWPI and GFSI ($r= .704, N=15, p < .01$) that's to say that countries with high mWPI, so water rich countries, have also high level of food security. Scatterplots suggest a definite relationship between mWPI and GFSI with larger values of mWPI tending to be associated with larger values of GFSI (Fig.2). This result is perfectly in line with reports of many international and regional organizations (e.g. FAO/RNE, 2011; Kubursi, 2012; FAO/RNE, 2013; FAO/RNE, 2015; FAO 2015; ESCWA, 2015) that highlight the strong nexus between water security and food security in the MENA region. Correlation among the GFSI and the subcomponents linked to availability of water resources and to their efficient and sustainable use are moderate and not statistically significant (Tab. 5).

Our results downsize the emphasis on the role that water availability can have in achieving food security level (de Fraiture *et al*., 2007; Molden *et al*., 2007; Hanjra and Qureshi, 2010); on the contrary, they confirm the crucial role of access to water resources and the capacity to manage them (HLPE, 2015). The moderate correlation between GFSI and the water resource efficiency, that is often advocated as one of the key strategies to achieve food security, is probably due to the fact that in the version of mWPI utilized in this work, only the domestic use is considered. That being said, it should be highlighted that these results, as well as following implications and considerations, are context-specific so one should be cautious before generalizing them to other world regions.

Correlation among mWPI and GFSI' components, displayed in the scatterplot matrix (Fig. 4), is significant for all the dimensions of food security; higher when considering the quality score ($r = .732, N=15, p <.01$) and availability category ($r = .718, N=15, p < .01$) and lower in the case of food affordability component ($r = .623, N=15, p <.05$), (Tab. 6).

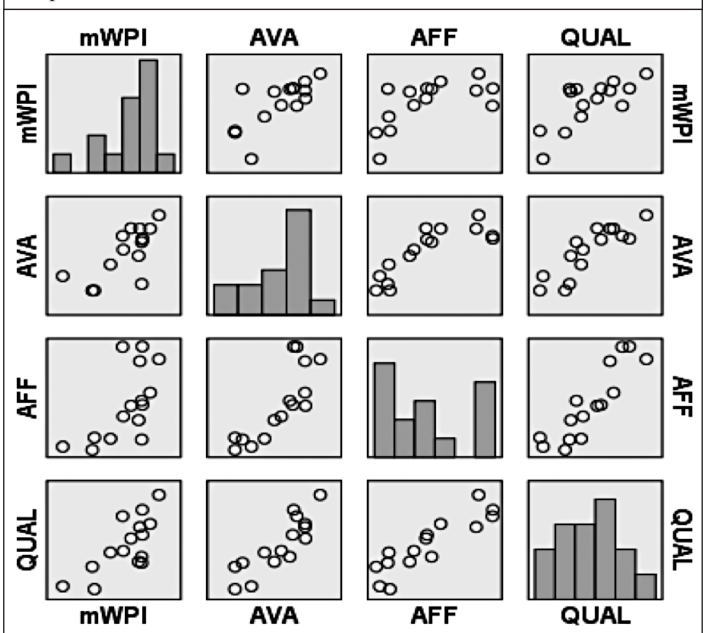
Last but not least, it should be highlighted that where linear regression model did not allow to have significant correlations, other regression models (e.g. quadratic, cubic) could represent better the relations among the mWPI and GFSI and their respective components. Nevertheless, using those regression models goes beyond the scope of the present paper.

Table 6 - *Correlation matrix among mWPI's components and GFSI.*

		GFSI	RES	CAP	ACC	USE	ENV
GFSI	Pearson correlation	1	-.480	.864**	.780**	-0.410	-.059
	Sig. (2-code)		.070	.000	.001	.128	.834
	N	15	15	15	15	15	15
RES	Pearson correlation	-.480	1	-.485	-0.302	.594*	0.404
	Sig. (2-code)	.070		,067	.274	.019	.135
	N	15	15	15	15	15	15
CAP	Pearson correlation	.864**	-.485	1	.918**	-0.210	-0.213
	Sig. (2-code)	.000	0.067		.000	.452	.445
	N	15	15	15	15	15	15
ACC	Pearson correlation	.780**	-0.302	.918**	1	.088	-.178
	Sig. (2-code)	0.001	.274	.000		.754	.526
	N	15	15	15	15	15	15
USE	Pearson correlation	.410	.594*	-0.210	.088	1	.006
	Sig. (2-code)	0.128	0.019	0.452	.754		.983
	N	15	15	15	15	15	15
ENV	Pearson correlation	-.059	.404	-0.213	-.178	.006	1
	Sig. (2-code)	.834	.135	.445	.526	.983	
	N	15	15	15	15	15	15

Source: Authors' elaboration based on data from Sullivan and Jemmali (2014) and The Economist Intelligence Unit (2015, 2016).

Figure 4 - *Scatterplots matrix of correlations among mWPI and GFSI's components.*



Source: Authors' elaboration based on data from Sullivan and Jemmali (2014) and The Economist Intelligence Unit (2015, 2016).

Table 7. *Correlation matrix among mWPI and GFSI's components.*

		mWPI	AVA	AFF	QUAL
mWPI	Pearson correlation	1	.718**	.623*	.732**
	Sig. (2-code)		.003	.013	.002
	N	15	15	15	15
AVA	Pearson correlation	.718**	1	.823**	.862**
	Sig. (2-code)	.003		.000	.000
	N	15	15	15	15
AFF	Pearson correlation	.623*	.823**	1	.888**
	Sig. (2-code)	.013	.000		.000
	N	15	15	15	15
QUAL	Pearson correlation	.732**	.862**	.888**	1
	Sig. (2-code)	.002	.000	.000	
	N	15	15	15	15

Source: Authors' elaboration based on data from Sullivan and Jemmali (2014) and The Economist Intelligence Unit (2015, 2016).

Table 7. *Correlation matrix among mWPI and GFSI's components.*

		mWPI	AVA	AFF	QUAL
mWPI	Pearson correlation	1	.718**	.623*	.732**
	Sig. (2-code)		.003	.013	.002
	N	15	15	15	15
AVA	Pearson correlation	.718**	1	.823**	.862**
	Sig. (2-code)	.003		.000	.000
	N	15	15	15	15
AFF	Pearson correlation	.623*	.823**	1	.888**
	Sig. (2-code)	.013	.000		.000
	N	15	15	15	15
QUAL	Pearson correlation	.732**	.862**	.888**	1
	Sig. (2-code)	.002	.000	.000	
	N	15	15	15	15

Source: Authors' elaboration based on data from Sullivan and Jemmali (2014) and The Economist Intelligence Unit (2015, 2016).

4. Conclusions

The risks inherent in water-food nexus interconnections are likely to intensify in the coming decades as a result of growing demand, tightening resource constraints, and intensifying impacts of climate change. This is particularly true in the MENA region that is characterized by water resources scarcity exacerbated by climate change. Treating water and food systems independently of each other can result in critical system linkages and vulnerabilities being overlooked or, at least, underappreciated and can possibly lead to the formulation and implementation of ineffective policies and measures.

On the other side, a new nexus oriented approach in science as well as policy arenas is highly needed to better understand interlinkages between water and food sectors and to address unsustainable patterns of growth and impending resource constraints. Different development pathways to food security such as domestic production, commercial imports, food aid and food requirements from overseas can embody different agricultural and water management implications for national natural resources as well as different priorities in water policy can affect level of food security.

Water-food nexus should be operationalized when dealing with food security in the MENA region so water security metrics should be integrated in food security indices. This is of paramount importance to design effective actions and strategies to achieve sustainable food security in the region.

A water-food nexus approach can support a transition to sustainability in the MENA region. Nevertheless, adopting the nexus approach in a large-scale, system-wide manner may be challenging because of limited knowledge of how water and food systems operate and interact. Far-reaching changes can only happen if policy makers, enterprises/industries and consumers alike better understand these interconnections. However, it is widely assumed that adopting a nexus approach will help reducing trade-offs and generating additional benefits that outweigh costs associated with stronger integration across water and food sectors.

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