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WATER SECURITY AND SUSTAINABLE DEVELOPMENT*

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Abstract. In the realms of Climate change impact, economic and population growth, and pollution, Water security, and sustainable development are paramount, for addressing the food-water-energy nexus and mitigating the impact of the cited drawbacks. The presented paper in the first part, emphasizes water security and sustainable development notions. In 2015 s the 2030 agenda were approved by 193 members of the United Nation, it consists of 17 goals (SDG) for environmental sustainability, social inclusion, economic development, peace, justice, good governance, and partnership. The 6th target of SDG is dedicated to clean water and sanitation since it is considered as one of the central focuses of Sustainable Development Goals. The second part is focused on Moroccan's water management plans. This latter elaborate a legal framework for water use, the law n° 36-15 that comprises the protection of human health through the regulation of exploitation, and provision of sanction. The green Morocco Plan (PMV) which aims first to develop modern agriculture aligned with the world global market requirement, and second to eliminate poverty by helping smallholder farming. The 140 dam's that Morocco counts provide strong support to economic growth. However, under the actual uncontrollable changing rate, Morocco is still threatened by low "water security", the access of drinkable water and sanitation services are improved but not totally covered, Moreover, the climate change

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influences the precipitation patterns, in long term this will led to the annihilation of water resources. In this light, Morocco should be more realistic, and adopt the appropriate management strategies, which go hand in hand with the sustainable development goals.

Keywords: water security; sustainable development; Green Morocco Plan; SDG6; Moroccan Dam's policy

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JEL Classifications: Q5; Q53

Additional disciplines: ecology and environment, environmental engineering

1. Introduction

From the starting of civilization evolving, water was not only a source of life but also a root of conflict and annihilation, because of extreme flood and drought. Through history, water trigger several wars, back to the world war II, the U.S bombard the North Vietnamese irrigation canals in the 1960s (Jerome 2015), in 1999s, the people protest against the privatization of water in Cochabamba, Bolivia (Card 2005), and the disobedience in Cape Town, because of insufficient water supply in 2012s (Jerome 2015). In the other hand, the water excess may destroy humanity, a heavily unexpected rain may cause human and economic damages. For instance, in 1993s the Mississippi River overflew and inundated more than 9.3 million hectares, (Julie Bosman n.d.). According to Munich Re's natural catastrophe database (NatCatService), in Europe during the last 15 years, flash floods and storms have caused economic damages between 1 and 18 billion US dollars per incident. The Elbe and Danube floods in Germany and other parts of Eastern Europe in 2002 and 2013, caused more than 10 billion US dollars of damages (Kottasova et al. n.d.), and according to a recent estimation, the risk of inundation in China is eight times higher than the global average (Feng et al. 2018).

According to the sixth report of intergovernmental panel of climate change (IPCC, 2014), a decrease of up to 20% in rainfall is predicted by the end of this century, and the increase in temperature is expected to reach 2.5 °C to 5.5 °C under the same scenario.

This paper introduces a broad definition of water security and sustainable development, the interaction between them, in the purpose of providing clear grasping of the concept. The second part is focused on Morocco as one of the countries in development that convoy sustainable development goals. It describes the legal framework of water, the role of the dam's policy and emphasizes the green Morocco plan (PMV). The last section points out the gaps in the cited strategies, and provide a recommendation that could be transposable to every country in development.

2. The hydrologic framework of water security

Only 2.5% of the total amount of water available of Earth is fresh water, 45 000Km3/year flow annually through the stream network to the sea (Oki 2006).

Hydrological cycle assure the conservation of the water stock, the rainfall flows perennial and intermittent rivers, and supply groundwaters, the part that falls on the overland and vegetation forms the intercepted rain (Perrin et al.. 2009), the heat of sun energy, raises the water temperature, breaks the intermolecular links and transform it into a gas form (Likens 2013).

The spatial distribution of precipitation is up to the geography and climate dynamics, there are regions with high water cyclicity, where extremes flood and droughts evoke risks of inundation and water scarcity.

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The flow is the variation of water volume measured in cubic meter through the time, in another term, it is the circulation speed multiplied by the flowing area, this measure is relevant for the estimation of resident time of water molecule in a specific reservoir, by dividing its volume by the mean flux (Oki 2006), in zones unaffected by anthropogenic activities, the residential time in water stream is around two and a half weeks (Institute of Industrial Science, Japan). In contrast, the recharge rate of groundwater is very slow according to the human time scale, the excessive uses lead to the exhausting of the resource (Oki 2006).

Countries located in areas of high climate contrast (unpredictable floods and extensive drought) suffer from water insecurity. Grey and Sadoff (2007) emphasize the relation between hydrologic legacy and poverty rate, the study claims that countries which have an "easy" hydrologic legacy reach water security and have a high economic growth, in contrast, those with "difficult" hydrologic legacy are considered poor. This assumption is supported by Brown & Lall (2006), who claim that high rainfall variability is statistically associated with lower capita incomes.

Certain aquifers or rivers could be shared between two or more countries, the world counts 263 transboundary rivers and 300 transboundary aquifers. For instance, Nile river is shared between Burundi, Central African, Republic, Egypt, Hala'ib triangle, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Abyei, South Sudan, United Republic of Tanzania, Uganda, Dem, and Republic of the Congo (Ntem and Melvin n.d.). The excessive use, the depletion, the pollution, the growing demand for water supply, imperil these shared resources and cause political and social conflict. 1948 Know 37 warfare about water (Thematic et al. n.d.), in the endeavor of resolving this encompassing issue, 295 international water agreement was signed (UNECE water convention, the legal framework for transboundary water cooperation ..) (Analysis n.d.).

3. Water security

Depending on the context and disciplinary perspectives on water use, the definition of "water security" that first emerged in the 1990s differs (Cook and Bakker 2012), it is a coupled human-water system (Srinivasan et al. 2017) and a concept that provides a common language for all parties and components involved in water management (Arriens 2014), In the framework of UNESCO's International Hydrological Program's (IHP) Strategic Plan, Water Security was globally defined as **the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability**(Shrestha S, Aihara Y 2018). This implies that water security is a cycle with the implication of multiple interconnected and interdependent sectors or dimensions (hydrologic, geographic, economic, environmental, social, political, legal, financial…etc.) at local, national, regional, and global scales.

Water security concept is multidimensional, according to Van Beek and Arriens (2016), Falkenmark (2001) in his paper clarify the importance of bridging water security, with food and environmental security, as a major key to reach the sustainable development. Three key ones are to be considered – social equity, environmental sustainability, and economic efficiency (Table 1, Table 2).

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Table 1. Economic, Social, Environmental dimension of water security

Economic dimension	**Social dimension**	**Environmental dimension**
• increasing water productivity and conservation in all water-using sectors • sharing economic, social, and environmental benefits in managing transboundary rivers, lakes, and aquifers.	• ensuring equitable access to water services and resources for all through robust policies and legal frameworks at all levels • building resilience in communities in the face of extreme water events through both hard and soft measures.	• managing water sustainably as part of a green economy • restoring ecosystem services in river basins to improve river health

Source: Thematic, Waters et al. (2013)

To assess water security at regional scale so many indexes were developed, some of them can be described in the table below; while these indicators are helpful, they are limited and don't take in consideration a lot of important dimensions.

Table 2. Economic, Social, Environmental dimension of water security

Index	**Meaning**	**Framework**	**developers**
NWSI	the national water security index (NWSI)	a national framework of water security measure applied to compare nations' water security performance in Asia and the Pacific region, The NWSI has five key dimensions: household, economic, urban, and environmental security and resilience to water-related disaster.	Asian development (ADB, 2016).
WII	water insecurity index	It was applied on a regional scale in India and consisted of six key dimensions: resource, access, consumption, capacity, environment, and climatic stress	Aggarwal, Punhani, and Kher (2014)

The concept of water shortage was quantifying first by Falkenmark in 1989, by developing the water crowding index, using a threshold value of water scarcity level, the critic limit occurs when the index is low to meet people's water needs (<1700 m3 cap−1 yr−1) (Falkenmark et al 1997). The crowding index was the stepping stone of the evolving of water stress indicators, (Raskin et al 1997), (Vörösmarty et al 2000), (Oki et al 2001), and (Alcamo et al 2003) develop other water stress indicator. The critical ratio compares the annual amount of available fresh water to withdrawal water (Alcamo et al 1997, 2000), (Klepper and van Drecht 1998) develop a "water satisfaction ratio', (Douglas et al 2006) worked on the 'relative water stress index". All the above index converges to the same result, water stress is high when the used ration is superior to 0.4.

However, these indicators did not include the interaction between human and ecosystem (Cook and Bakker 2012).

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Water resource faces other pressures, such as mismanagement, depletion, population, economic growth, and climate change impact, thus, the evolving of indicators that express better the relation between human-water-ecosystem is crucial for a better grasp and then management (Gain et al. 2016).

(Vörösmarty & al 2010) work on biophysical indicators to assess water security, (Lautze and Manthrithilake 2012) add the human dimension and assess water security in 46 Asian countries, (Gain et al. 2016) figure out the gap in the listed studies by providing the first global-scale assessment of water security, by the virtue of multi-criteria analysis, the study conceptualize the security term in 4 majors part, each one is assessed by specific index (Fig. 1.), and gather them into one normalized unique index.

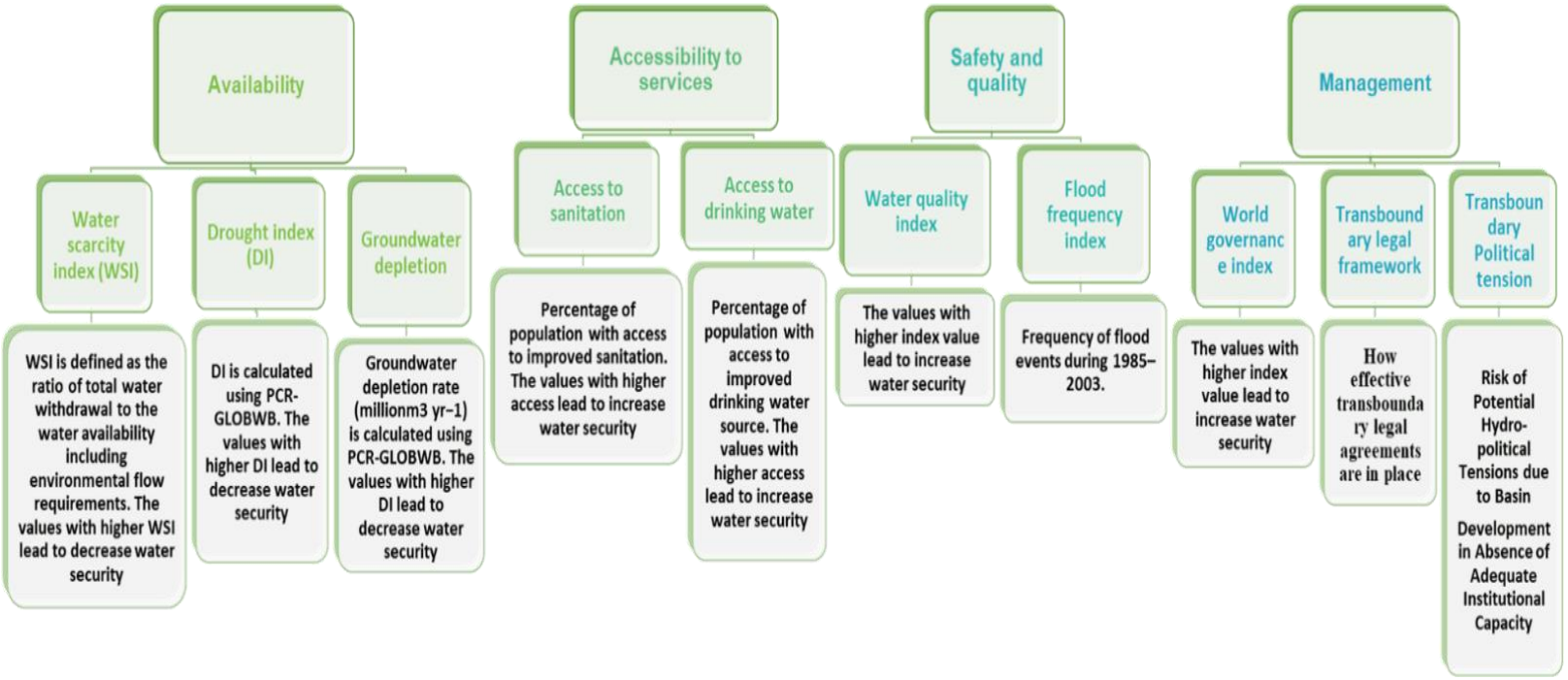

Figure 1. Water security global indicators
Source: Gain et al 2016

5. Sustainable development

The concept of sustainable development was first introduced in 1987 in the Report of the World Commission on Environment and Development called "our common future" as a "d**evelopment that meets the needs of the present without compromising the ability of future generations to meet their own needs**" (UN 1987). Sustainable Development (SD) is usually described as a three-dimension concept; environmental, economic and social (Giddings, Hopwood, & O´Brien, 2002). For a world called "sustainable", this concept must be achieved in all these dimensions.

A sustainable environment can be attained by reserving, improving and valuing the environment and natural resources in the long term, maintaining the major ecological balances, on the risks and on the environmental

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impacts. A sustainable society can be maintained if it satisfies human needs and meet a social goal, by encouraging the participation of all social groups in health, housing, consumption, education, employment, culture…. etc., and finally a sustainable economy that aims for a developing growth and economic efficiency through sustainable production and consumption patterns (UN 1987).

In 2000 the United Nations started the first steps by setting 8 original Millennium Development Goals (MDGs) to be achieved by 2015, to eradicate extreme poverty and hunger, achieve universal primary education, promote gender equality and empower women, reduce child mortality, improve maternal health, combat HIV/AIDS, malaria and other diseases, ensure environmental sustainability, and develop a global partnership for development. In September 2015 The Sustainable Development Goals (SDGs) were approved by the 193 UN Member States and are also known as Agenda 2030 (Transforming our World: the 2030 Agenda for Sustainable Development). The framework consists of 17 goals for environmental sustainability, social inclusion, economic development, peace, justice, good governance and partnership, the main issues for the world population in the 21st century. Each goal has several targets that better define its aims. While the MDGs aimed to reduce the existing issues mostly in under/developing countries by half, the new set of goals were set to eliminate them and has all countries as target (Sustainability Science 2018), and according to the agenda are "**integrated and indivisible and balance the three dimensions of sustainable development: the economic, social and environmental** (UN 2015).

Since water resources are embedded in all forms of development, Water is considered as one of the central focuses of Sustainable Development Goals, as it is at the heart of sustainable development and is critical for socio-economic development, energy and food production, healthy ecosystems and human survival (UN 2018), The UN entirely distinguishes the importance of managing water for sustainable development, and the need for the water and water-using sectors to collaborate and wisely use the world's limited water resources.

The SDG 6 namely sustainable water and sanitation for all, is allocated to water and comprises 11 global indicators, to track the progress.

5. Morocco between water insecurity and management strategies

Morocco is a northwest African country, cover an area of 710,850 km², the agricultural land represents 25 %, 80% of the total surface of the country receive less than 250 mm/year of rain (Africa et al. 2014), 80% evaporated and 0.6% is intercepted or infiltrated, the remained part is used for industry, irrigation and human consumption (Fig. 2.) (AQUASTAT). According to 2017 census, the population is 35 M. The total yield of water is estimated by 22 Md m^3 (Africa et al. 2014), world water problems are downscaled on Moroccan scale, the resource is rare especially in the South and the South-eastern because of arid climate conditions, unequally distributed in space and time, facing a growing demand and climate change impact (Africa et al. 2014).

The historical analysis of the hydrologic series data showed that morocco recorded during the last decencies, more than 20 dry periods (Africa et al. 2014), between 1982-1983 the water deficit in Ziziguir watershed reach minus 80 mm, In 1995 the deficit was almost minus 100 mm in Loukous.

The frequency analysis of the chronologic data point out that the risk of drought is increasing from 5 years in 40 years (1940-1979) to 4 years over 10 (1996-2006) (Africa et al. 2014)

These droughts have a direct impact on water supply and water ued for irrigation, for instance, in Tangier, there was a restriction of nearly 50% between 1993 and 1995, the deficit in the water allocated for irrigation rise from 16% to 90% between 1994-1995 (Africa et al. 2014).

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According to **the UN Intergovernmental Panel on Climate Change** (IPCC), Morocco is a "very vulnerable" country concerning climate change effect, the average temperatures are predicted to increase by 1 to 1,5°, respectively Annual precipitation will decrease (IPCC 2014), In the 2050s, people living in urbanized area will face problem with access to water and food (Global Nexus 2017).

The three major sources of water pollution in Morocco are; municipal wastewater discharge, industrial effluents, and agricultural activities, urban area generate around 500 m^3/year of wastewater, and it may reach 900 m^3 in 2020. The high salinity and nitrate concentration affect the underground water, streams are generally contaminated by phosphorus, ammonia, organic matters, and high coliform counts. This polluted water is directly discharged to a natural water body, for example, Sebou watershed which constitutes 29% of Moroccan water resources is heavily polluted by nitrates, phosphorus and pesticide residues (World Bank group, 2012), see Fig. 2.

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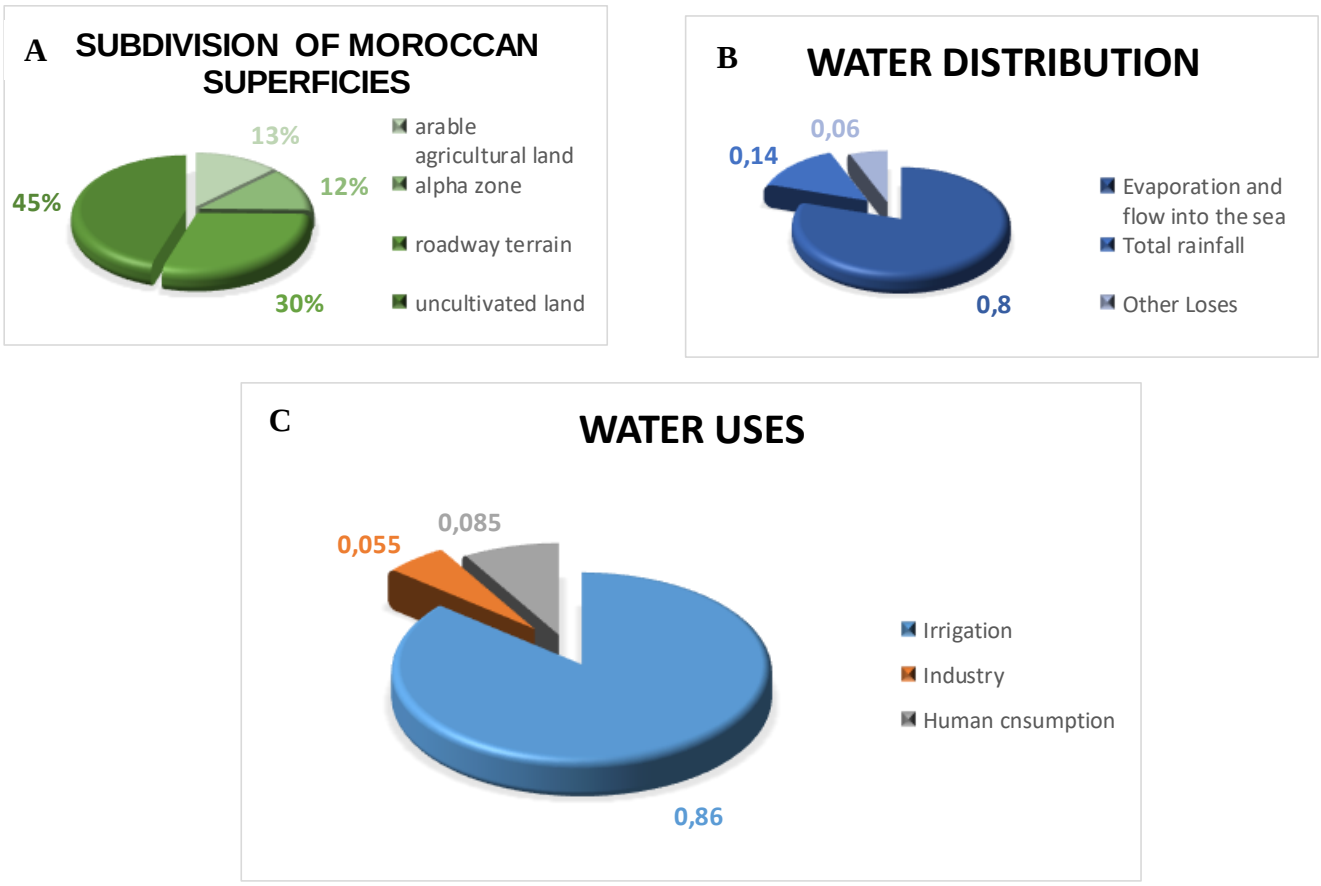

Figure 2. A subdivision of the Moroccan area, B: percentage of water loses from the total rainfall, C: Moroccan water uses.
Source A: (Africa et al. 2014), B C: AQUAQTAT

5. Water law in Morocco and the policy of dams

The water legislation framework in the country starts first with the Islamic laws, which incite rational management and the equitable sharing of the resource. During the French protectorate, the government put all the resources under the government authority, and in 1925, they adopt a law that defines the public ownership of water and defines the conditions of water use for irrigation and other purposes (A. Laamari, M. Boughlala, A. Herzenni et al. 2011). The independence era marks the green revolution when Morocco oriented the economic growth toward the evolvement of the agricultural sector, by adopting the revolutionary **dam's policy**. In the1995s the government passed the Water Law of 1995 (Law 10/95), which, integrate and coordinate the allocation and management of all water sources, also create 6 river basin agencies in order to decentralize water institutional reforms(A. Laamari, M. Boughlala, A. Herzenni et al. 2011). The law 10-95 of 1995 was promulgated in October 2016, and become 36-15 this later has 12 chapter and 163 articles (Fig. 3).

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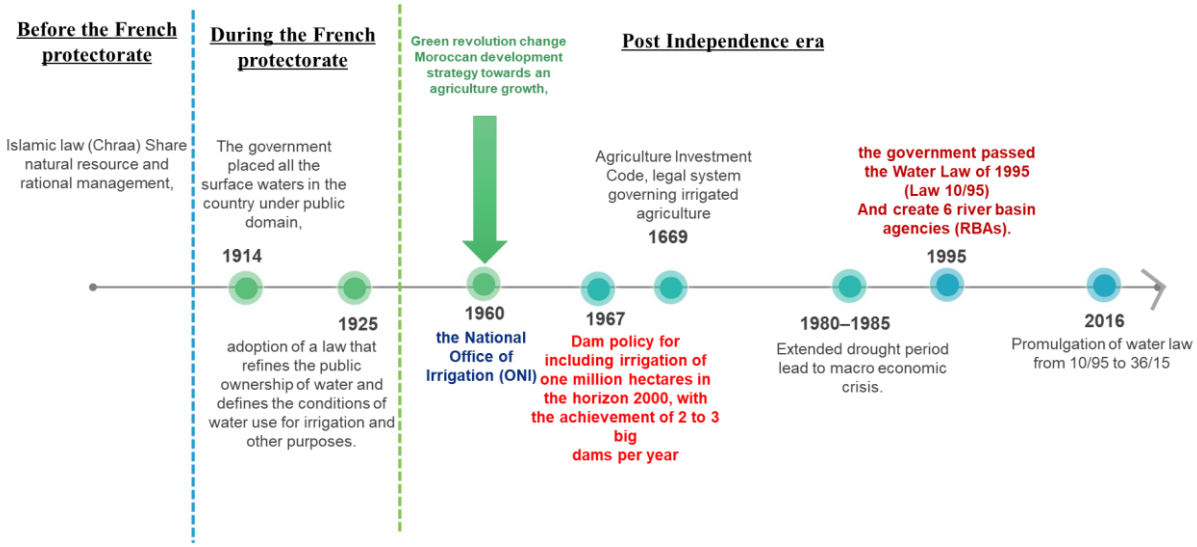

Figure 3. Water law timeline
Source: all the information in the scheme are in the following reference (A. Laamari, M. Boughlala, A. Herzenni et al. 2011) &(Dahir n°1-16-113 du 6 kaada 1437 portant promulgation de la loi n°36-15 relative à l'eau. 2016)

The law 36-15 includes cooperation between users and the public authorities, aims to protect human health through the regulation of exploitation, distribution and sale of drinkable waters, provision for sanctions and the regulation of activities that may pollute water resources (Dahir n°1-16-113 du 6 kaada 1437 portant promulgation de la Loi n°36-15 relative à l'eau. 2016).

In addition to water laws, the policy of dams is one of the most effective and decent management strategies that Morocco adopt, it includes solutions for a set of critical drawbacks, and gives strong support to the economic growth. Now, Morocco counts 140 large dams, with a global capacity higher than milliards cubic meters, 13 are used for water transfer with a capacity of 200m3 /s, length 1100 km and a volume of 2.5 billion m3 / year (El and Directeur 2016), see Fig 4 and Fig. 5.

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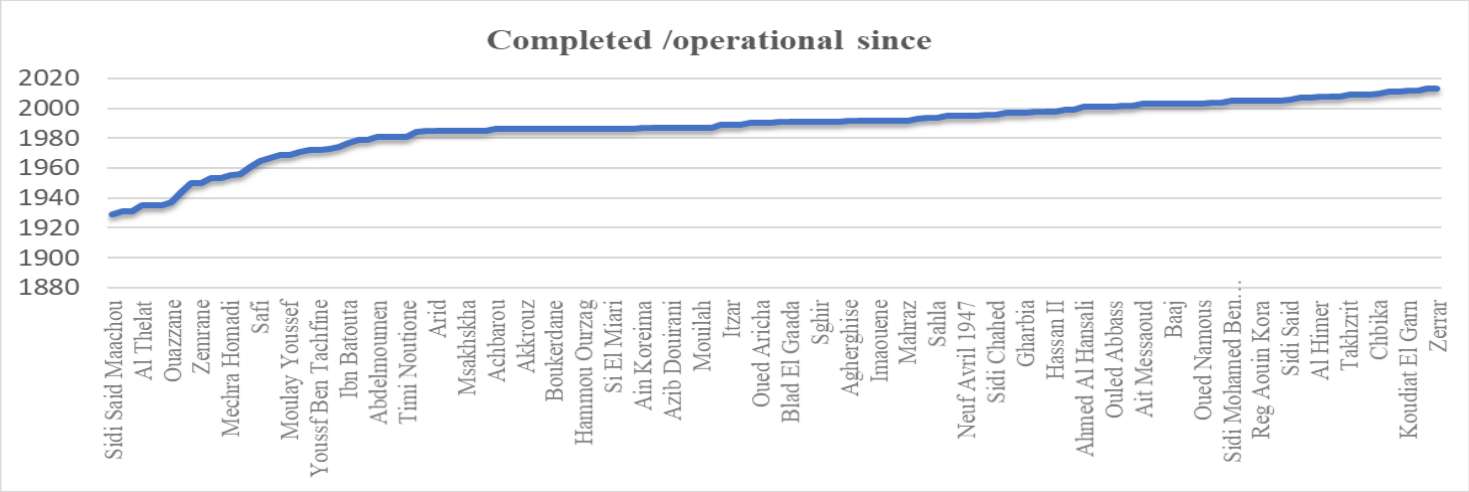

Figure 4. Operational date of large dams in Morocco
Source: Aquastat

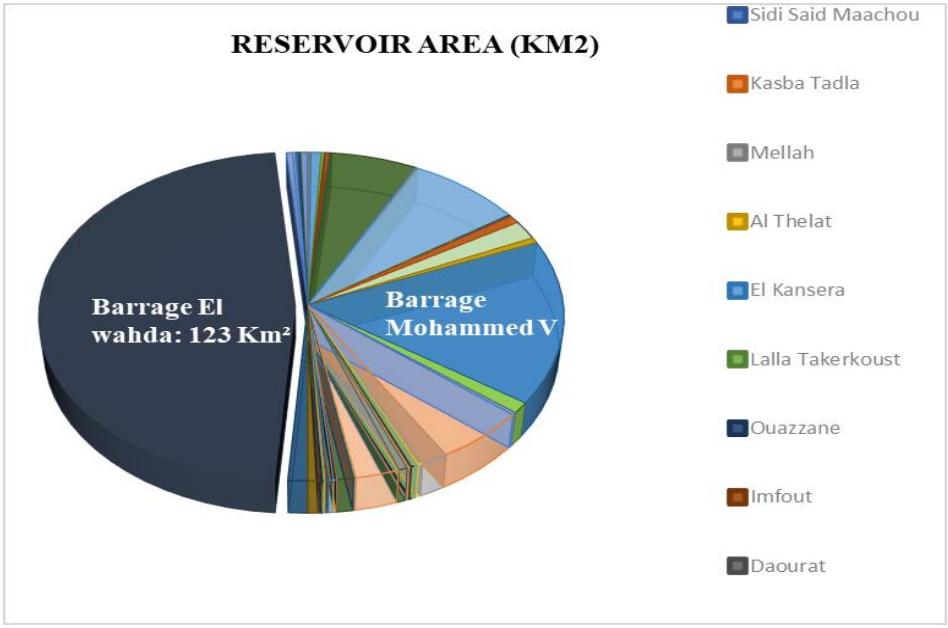

Figure 5. Reservoir area in km²
Source: Aquastat

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Table 3. Dams' benefices in drinkable water, irrigation, energy, drought and flood mitigation.

Drinkable water	**Irrigation**	**Energy**	**Drought and flood mitigation**
Dams satisfy 66% of the drinkable and industrial agglomerations water needs, this rate is predicted to reach 80% in 2020.	1500,000 hectares are irrigated from dams.	Current hydroelectric productivity is around 2.750 GWh / year, Hydroelectric power represents 10% of total electricity production and will have to reach 14% by the year 2020	the management of 160 sites vulnerable to flooding by dam construction. The lamination rate is high (100% in Abdelmoumen dam, 90.5 for Youssef ben each fin)

Source: (El and Directeur 2016)

The policy has a significant result concerning the above beneficiary sectors, the drinkable water and sanitation services in both rural and urban areas have increased, more than 50% of the total population have access to drinkable water and safely managed to basic sanitation service, (Fig. 6. and Fig. 7.). In the 2030s it is predicted to provide drinkable water and good sanitation services to the total population, which aligned with the 6th sustainable development goal.

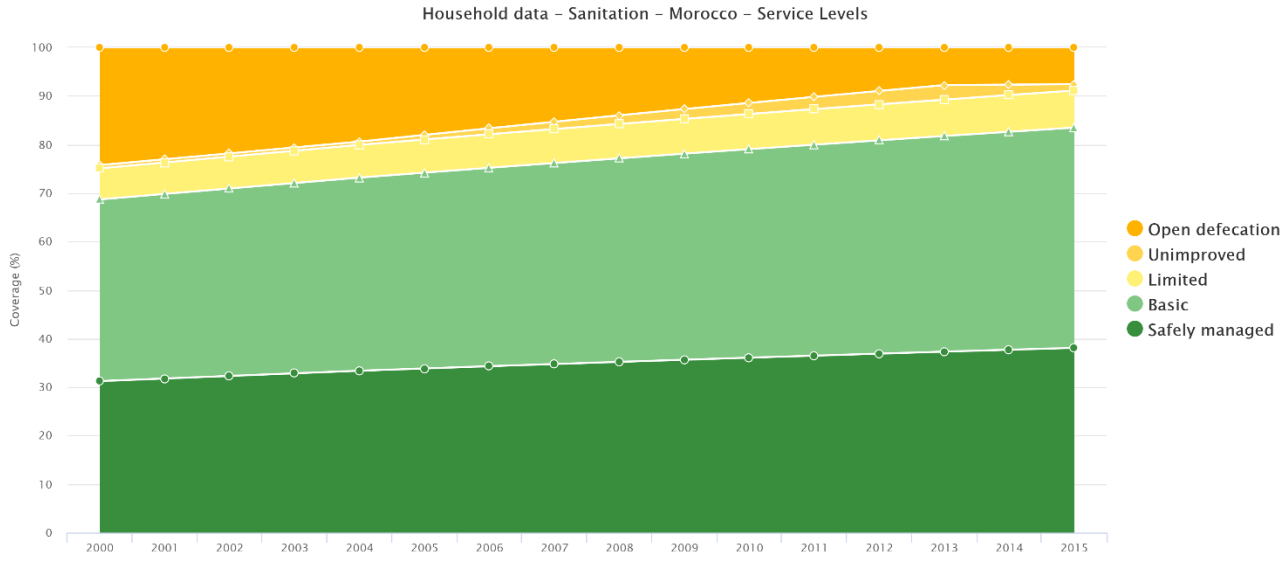

Figure 6. The variation of sanitation rate in Morocco from 200 to 2015
Source: Household data

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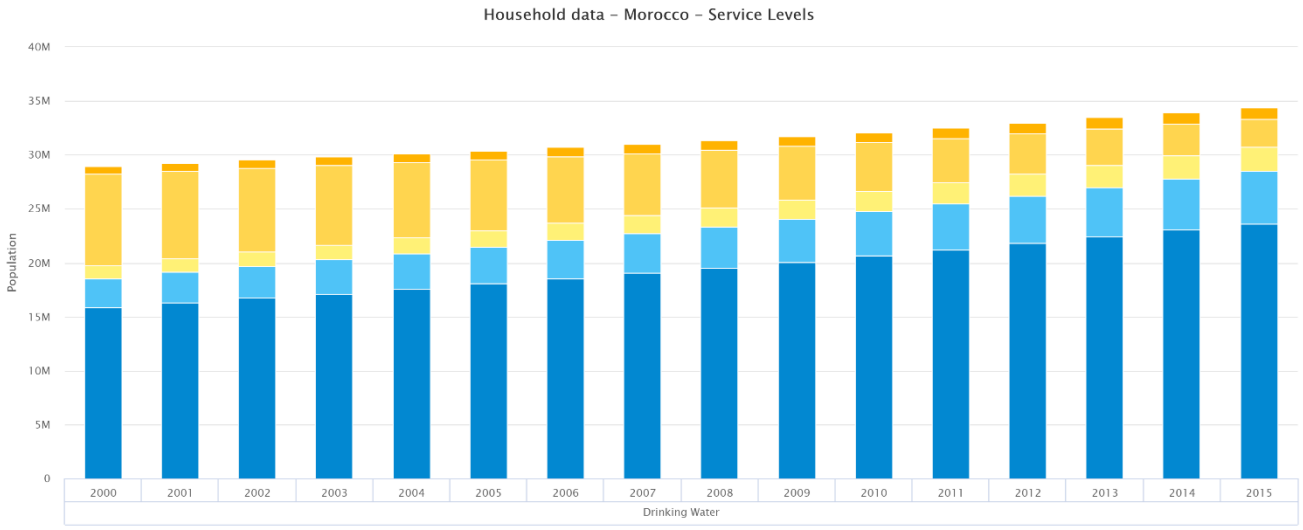

Figure 7. The variation of drinkable water in Morocco from 2000 to 2015
Source: Household data

6. Green Morocco Plan (PMV)

The Green Morocco Plan (PMV) aims to accelerate growth, reduce poverty and ensure the long-term sustainability of agriculture (Ministry of Agriculture and Maritime Fisheries 2016).
The plan has to pillar (Ministry of Agriculture and Maritime Fisheries 2016):

Pillar I

Aims to develop modern agriculture, market-oriented, with strong competitiveness, develop a new market in the USA, Russia, Asia, and encourage private investment through aggregation. This latter form is based on a double contracting, the aggregators should sign a contract with Morocco and with operators, this strategies mobilize 75 billion dirhams3 of investments over ten years, and benefit 540.000 farmers (Aksebi 2012).

Pillar II:

The targets of this approach are the elimination of poverty by improving the performance of smallholder farming (around 560,000 farmers), specifically those living in the marginalized area, and this through three social projects (Aksebi 2012);

-Reconversion projects that aim to switch from cereals to higher value products and less sensitive to water deficit, such as olive trees, almond trees, carob trees, cacti…

-Diversification project and augmentation of territory product.

-Intensification project is concentrated on the supervising of farmers and providing the decent in order to enhance the yield and raise the production rate.

The National Irrigation water saving program (PNEEI) aims to reduce water stress since it is the main limiting factor to the improvement of agricultural productivity. This program consists of conversion to localized irrigation over an area of nearly 550,000 hectares; an average equipment rate of nearly 55,000 ha/year (Ministry of Agriculture and Maritime Fisheries 2016).

In addition to drip irrigation, Morocco adopt other strategies for dealing with water stress issues, for example

-The rainwater harvesting method based on the collection of water rain using different technics (Hasnaoui 2011), this later is legally managed by the decrees number 2-97-224 of 24/10/1997.

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Soil composting help protecting the environment and especially water from the toxic substances impact, improving soil fertility and then agricultural productivity, reduce plant's pelt, the liquid extracted from the composting is used in drip irrigation (LABIDI 2016) and (Azin khalid, INRA d'agadir).

Conclusions

The water, food, energy, and ecosystems complex are a dynamic system in which there is plenty of interactions. Water is the source of life and energy, which are crucial for food production, the food is the basic element that maintains the ecosystem equilibrium. In contemporary society, energy is used for the water treatment process, groundwater extraction, and food production…

Regarding the environmental problems that the world face, the United Nation define 17 sustainable. Water is included in all forms of development, since it is the central focuses of Sustainable Development Goals, as it is at the heart of sustainable development and is crucial for socio-economic development, energy, and food production, healthy ecosystems and human survival (UN 2018).

Morocco is one of the countries the most threatened by climate change impact (IPCC) and water stress scarcity (Gain et al. 2016). Dam's policy and green morocco plan help the country to overlap issues related to water supply, increase the food security, decrease intern and extern migration, avoid the population centralization in big Cities, reduce social problems such as ignorance and poverty, provide a good life quality, However, it still facing problems, since the stress is still increasing, also the drip irrigation does not assure a strong production growth (Tanouti 2017), (Alonso et al. 2019).

In addition, the pesticide used to eliminate plant pelts help the growth of the agriculture productivity, but in other hand is not aligned with the ecosystem protection notion, the excessive uses of such product, halt the biodiversity and has a harmful sequel on human health, such as the deployment of cancers. The agricultural policy should be oriented toward a biologic production which respects the compromise between human benefice and ecosystems requirement since humankind is a part of the ecosystems and not the master of it.

Also, Morocco should integrate all dimension of sustainability and combine the economic progress with environment protection, by involving public and semi-public authorities (National office of drinkable water), privates companies for the elaboration of technical studies, International development institution (World Bank) and the most important invest in the scientific research which help providing advanced tools in terms of water management. For instance, build a national database including all the necessary information about soil, land use and land cover, hydrology…, these data could be introduced in mathematical tools for modeling, the obtaining results serve the decision makers to define the appropriate management strategies and help ecosystems to build a strong resilience capacity against climate change and natural hazard risks.

References

Africa, North, Royaume Maroc, Implementing Mitigation, and Of Water Scarcity. (2014). "Drought Management in Morocco."

Aksebi, Najib. (2012). Une Nouvelle Stratégie Pour l ' Agriculture Marocaine : Le « Plan Maroc Vert ». NEW MEDIT: 12–24.

Alcamo, J., Henrichs, T. and Rsch, T. (2000). World water in 2025-global modeling and scenario analysis for the world commission on water for the 21st centuryKassel World Water Series 2 Kassel, Germany, Center for Environmental Systems Research, University of Kassel www.usf.uni-kassel.de/usf/archiv/ dokumente/kwws/kwws.2.pdf

Alcamo, J., P. Döll, Kaspar, F., and Siebert, S. (1997). Global change and global scenarios of water use and availability: An application of Water- GAP 1.0, Rep. A9701, Center for Environmental Systems Research., University of Kassel, Kassel, Germany www.usf.uni kassel.de/usf/archiv/dokumente/projekte/ watergap.teill.pdf

Alcamo, J., P. Döll, T. Henrichs, F. Kaspar, B. Lehner, T. Rösch, T. and Siebert, S. (2003b). Global estimation of water withdrawals and availability under current and "business as usual" conditions. *Hydrological Sciences Journal*, 48, 339–348. https://doi.org/10.1623/hysj.48.3.339.45278

Alonso, A. et al. (2019). Comparative Assessment of Irrigation Systems' Performance: Case Study in the Tri Ff a Agricultural District, NE Morocco. *Agricultural Water Management* 212 (August 2018): 338–48. https://doi.org/10.1016/j.agwat.2018.08.033.

Analysis, Crosscutting. 6 Transboundary Waters Systems – Status and Trends Crosscutting Analysis. https://uneplive.unep.org/media/docs/assessments/transboundary_waters_systems_status_and_trends_crosscutting_analysis.pdf

Azin Khalid (INRA d'agadir), Soudi Brahim (IAV). Compostage et Bio Méthanisation Pour La Valorisation Agronomique et Énérgitique Des Déchets Agricoles Organiques Dans Le Sous Massa. http://www.agri-mag.com/2017/06/compostage-et-bio-methanisation-souss-massa/.

Bosman, J., Turkewitz, J. and Williams, T. (2019). In the Midwest, Relentless Floods Dredge Up 'Shadow' of 1993."
Brown, C., Lall, U. (2006). Water and economic development: The role of variability and a framework for resilience. *Natural Resources Forum*, 30(4) https://doi.org/10.1111/j.1477-8947.2006.00118.x

Card, Dallas. (2005). The Case of Privatization in Cochabamba, Bolivia Prepared for Julia Sagebien INTD 5003 Water Wars: The Case of Privatization in Cochabamba, Bolivia. http://my2.ewb.ca/site_media/static/attachments/group_topics_grouptopic/15584/Bolivian_Water War.pdf.

Cook, Ch., and Bakker, K. (2012). Water Security: Debating an Emerging Paradigm. *Global Environmental Change*, 22(1), 94–102. http://dx.doi.org/10.1016/j.gloenvcha.2011.10.011

Dahir N°1-16-113 Du 6 Kaada 1437 Portant Promulgation de La Loi N°36-15 Relative à l'eau. 2016. http://www.onssa.gov.ma/fr/images/reglementation/reglementation_connexe/LOI.36-15.FR.pdf

Douglas, E. M., Githui, F., Mtafya, A., Green, P., Glidden, S. and Vörösmarty, C. J. (2006). Characterizing water scarcity in Africa at different scales. *Journal of Environmental Management*, 10, 1–10.

El, Khalid, and Ghomari Directeur. (2016). La Politique et Les Bienfaits Des Barrages Au Maroc.

Falkenmark, M. (2001). The greatest water problem: the inability to link environmental security, water security and food security. *International Journal of Water Resources Development*, 17(4), 539–54.

Falkenmark, M., Kijne, J. W., Taron, B., Murdoch, G., Sivakumar, M. V. K. and Craswell. E. (1997). Meeting water requirements of an expanding world population [a discussion] Phil. Trans. R. Soc. B 352 929–36

Feng, A., Gao, J., Wu, Sh., Liu, L., Li, Y., Yue, X. (2018). Assessing the Inundation Risk Resulting from Extreme Water Levels under Sea-Level Rise: A Case Study of Rongcheng, China. *Geomatics, Natural Hazards and Risk*, 9(1), 456–70. https://doi.org/10.1080/19475705.2018.1447026

Gain, Animesh K, Giupponi, C. and Wada, Y. (2016). Measuring Global Water Security towards Sustainable Development Goals Measuring Global Water Security towards Sustainable Development Goals.

Giddings, B., Hopwood, B., O'Brien, G. (2002). Environment, economy and society: fitting them together into sustainable development. Sustainable Development, 10(4), 187-196. https://doi.org/10.1002/sd.199

Global Nexus. (2017). Morocco's Water Security: Productivity, Efficiency, Integrity. https://www.policycenter.ma/publications/morocco%E2%80%99s-water-security-productivity-efficiency-integrity

Goal, Sustainable Development, and Synthesis Report. (2018). Sustainable Development Goal 6 Synthesis Report on Water and Sanitation

Grey, David, and Sadoff, C.W. (2007). Sink or Swim? Water Security for Growth and Development. *Water Policy*, 9(6), 545–71.

Hasnaoui, Moulay Driss. (2011). Plan de La Collecte Des Eaux Pluviales Plan de l ' Exposé :

Institute of Industrial Science, The University of Tokyo, 4-6-1 Komaba, Meguro-Ku, Tokyo 153-8505, Japan. Japan Science and Technology Agency, 4-1-8 Honcho, Kawaguchi- Shi, Saitama 332-0012, Japan. 3Frontier Research Center for Global Change, Japan Agence.

IPCC, 2014: Climate Change. (2014). Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp

Jerome, Sara. (2015). A Brief History of Water Conflict. https://www.wateronline.com/doc/a-brief-history-of-water-conflict-0001

Klepper, O. and Van Drecht, G. (1998). WARiBaS, water assessment on a river basin scale; a computer program for calculating water demand and water satisfaction on a catchment basin level for global-scale analysis of water stress Report 402001009 National Institute of Public Health and the Environment (RIVM)

Kottasova, I. Pleitgen, F. and Smith-Spark, L. CNN. (2013). Floods Bring Misery to Central Europe. http://edition.cnn.com/2013/06/04/world/europe/europe-flood/index.html

Laamari, A., Boughlala, M., Herzenni, A., Karrou, M. and Bahri, A. (2011). Irrigation in the Mediterranean: Technologies, Institutions and Policies "Chapter 7: Water Policies in Morocco – Current Situation and Future Perspectives 101, 101–17.

Labidi, Aya. (2016). Le Compost et Ses Bienfaits Biologiques. http://www.agrimaroc.ma/le-compost-et-ses-bienfaits-biologiques/.

Lautze, J. and Manthrithilake, H. (2012). Water security: old concepts, new package, what value? *Natural Resource Forum*, 36, 76–87.

Likens, G. E. (2013). Biogeochemistry of a Forested Ecosystem. Springer Science & Business Media.

Ministry of Agriculture and Maritime Fisheries. (2016). Strategie Du Plan Maroc Vert: Environnement Economique Et Social Du Secteur Agricole.

Ntem, B., and Melvin, L. Table of Transboundary River Basins and Countries: 211–15.

Oki, T. (2006). Global Hydrological Cycles and World Water. *Science*, (August): 1068–73. http://research.bpcrc.osu.edu/hydro/publications/OkiKanae_GlobalHydro_Science.pdf

Oki, T., Agata, Y., Kanae, S., Saruhashi, T., Yang, D. and Musiake, K. (2001). Global assessment of current water resources using total runoff-integrating pathways, *Hydrol. Sci. J.*, 46, 983–95

Perrin, C., Samie, R., & Hendrickx. (2009). Les Outils Du Projet : Modélisation Hydrologique et Représentation Des Usages. Journée de Restitution Du Projet. EDF (Toulouse) Cemagref,

Raskin, P., Gleick, P., Kirshen, P., Pontius, G. and Strzepek, K. (1997). Water Futures: Assessment of Long-range Patterns and Prospects (Stockholm: Stockholm Environment Institute)

Shrestha, S., Aihara, Y., Bhattarai. A.P. (2018). Development of an Objective Water Security Index and Assessment of Its Association with Quality of Life in Urban Areas of Developing Countries. *SSM Popul Health*, 6, 276–285.

Srinivasan, V., Konar, M., and Sivapalan, M. (2017). A Dynamic Framework for Water Security. *Water Security*, 1, 12–20. http://dx.doi.org/10.1016/j.wasec.2017.03.001

Sustainability Science. Edited by Ken E. Giller, Ira Martina Drupady, Lorenza B. Fontana, Johan A. Oldekop. Volume 34, Pages A1-A2, 1-62 (October 2018)

Tanouti, Oumaima. (2017). Squaring the Circle: Agricultural Intensification vs. Water Conservation in Morocco. 192: 170–79.

Thematic, Waters et al. "WATERS THEMATIC PRIORITY AREA PRACTICES in Transboundary Water."

UN [United Nations]. (1987). https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf

UN [United Nations]. (2015). The 2030 Agenda for Sustainable Development, A/RES/70/1. 16301(October), 13–14

UN [United Nations]. (2018). 2018 YEAR IN REVIEW https://www.un.org/en/year-in-review/

UN-Water. (2013). Water Security & the Global Water Agenda: A UN-Water Analytical Brief. In Citeseer. Retrieved from http://www.unwater.org/publications/publications detail/en/c/197890/%5Cnhttp://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.360.9258&rep=rep1&type=pdf

Van Beek, E. and Arriens, W.L, (2016). Water Security: Putting the Concept into Practice. (TEC background papers; No. 20). Stockholm: Global Water Partnership (GWP). https://www.gwp.org/globalassets/global/toolbox/publications/background-papers/gwp_tec20_web.pdf

Vörösmarty, C. J. et al. (2010). Global threats to human water security and river biodiversity. *Nature*, 467, 555–61

Vörösmarty, C. J., P. Green, J. Salisbury, and R. B. Lammers. (2000). Global water resources: Vulnerability from climate change and population growth. *Science*, 289, 284–288, https://doi.org/10.1126/science.289.5477.284

World Bank. 2012. Water quality management Morocco, prepared Mediterranean Environmental Technical Assistance Program., Washington, D.C.

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