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The hydropolitical challenges of domestic water conservation. Palestine and Tunisia case studies

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ABSTRACT

Southern Mediterranean area, particularly the Middle East and North Africa (MENA), has been facing social, economic, environmental and political challenges related to the water scarcity and quality. Within the European SWMED project, a socio-economic survey was conducted in Palestine and Tunisia, in order to explore the water conditions, and the social and economic situations of local families. The article illustrates the research design and implementation, as well as the main results that were used to select the appropriate sustainable water management solutions to respond to the hydropolitical issues. Due to the huge use of water in agriculture and the difficulty of reducing the water consumption in this sector, fostering tools for domestic water saving may be a winning strategy for facing water scarcity in MENA region.

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1. Introduction: controversial water-related issues

Water is a strategic asset used in public and private activities, both with domestic and productive purposes. It is the basis for all societal activities – e.g., food and energy production, transportation, waste disposal, industrial development – and ecological ones – e.g., habitat for fish species, human health. As freshwater is unevenly and irregularly distributed, some regions of the world extremely suffer from water scarcity. This is the most urgent problem to be faced by many countries as it affects their development: water scarcity obstructs private and public life, and gets down agriculture, manufacturing and tourism. Following Harrington and Fisher (2014), we can agree in defining water scarcity as a failure to achieve the right amount of the right quality of water for the right purpose at the right time for the right people. The 'right amount' depends on the specific needs guiding water use; 'right quality and purpose' are mutually balanced and depend each other; the 'right time' depends on seasonal patterns change; the 'right people' means equitable water allocation between different users' communities. Water scarcity precisely occurs when water demand nears or exceeds the available water supply.

As the International Water Management Institute estimated (2007), at a global level 1.2 billion people live in areas of physical water scarcity, where water withdrawals for

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agriculture, industry and domestic purposes exceed 75% of river flows; an additional 500 million people live in areas approaching physical scarcity; another 1.6 billion people live in areas of economic water scarcity, where water is available but human capacity or financial resources limit access. But the water depletion index (Richter 2014) depicting the water scarcity status of each water basin shows quite clearly that water scarcity is not solely a natural phenomenon. Numerous human activities – e.g., untimely water use, pollution, insufficient infrastructure, inadequate management systems – can exacerbate water scarcity. The over-exploitation of the soils alters the water cycle and initiates a vicious circle where precipitations decrease, water demand increases and pumping is intensified even more. Furthermore, many key phenomena intervene on the water crisis both locally and globally. We refer to environmental problems – e.g., climate change, desertification –, economic processes – e.g., the fate of the food industry, globalization – and socio-cultural phenomena – e.g., population growth, urbanization.

If people living in urban areas by 2030 will really rise to 60% (UN-DESA 2008), in addition to discharges of wastewater, we will face further problems, such as an increase of the runoff from roads and the flows of numerous pollutants into waterways and streams. Also climate change has a huge impact on water quality and management (Bates *et al.* 2008). Higher temperatures of the surface water will accelerate biological productivity, increase the amount of bacteria and fungi in the water, and promote algal blooms (Kundzewicz *et al.* 2007). Many regions may see an increase in the intensity of precipitation events and, thus, in the sedimentation and leaching of solid mine wastes. Pollutants may flow into surface water faster and with less time for natural water filtration and groundwater infiltration (Ibidem). A rise in sea level will further accelerate seawater intrusion into coastal aquifers and affect coastal ecosystems and drinking water supplies.

Moreover, water quality and quantity will be affected also by the water management decisions adopted at local, national and international level. The scarce water supplies combined with increased human use will lead to a trans-boundary management (Gleick *et al.* 2012). In fact, political boundaries rarely coincide with watersheds' borders and the increasing needs to extract water often generate geo-political disputes between two or more states, especially when some of them import water from other areas. Water may also activate internal conflicts due to policies aimed at the water service privatization (Shiva 2002, Bakker 2007). Even real 'water wars' may arise, especially when hydric resources are used by states or non-state actors as a weapon or as a target of a military action (Gleick and Heberger 2014). Consequently, politics intrude on water policy and water plays a strategic role in international conflicts or – especially in recent years – in local and sub-national disputes (Gleick *et al.* 2012).

Overall, the failure of water resources to meet the basic requirements of society has several social, economic, environmental and political impacts. Human activities heavily contribute by accelerating water consumption and, at the same time, producing increasing amounts of waste that contaminates water bodies. Agricultural production, industrial and mining activities, as well as water infrastructure and disposal of untreated human wastes affect the physical, chemical and biological characteristics of water bodies (Carr and Neary 2008).

At the global level, irrigated agriculture accounts for 70% of total freshwater withdrawals (Molden 2007) while industry and energy production accounts for nearly 20% (UN WWAP 2009). This water is often returned to its source in a degraded condition. Also

mining activities have long been known to cause significant water-quality impacts, as they bring to the surface materials long buried in the earth, and they also generate large-scale waste disposal – some of which are directly dumped into streams. Infrastructure, including irrigation systems and dams, affects water quality as well, by modifying the natural characteristics of water bodies, the biological productivity and characteristics of riverine ecosystems and downstream habitats (WCD 2000). But widespread water-quality problems are determined also by the disposal of human waste, such as fecal contamination that often results from the discharge of raw sewage into natural waters and concerns 18% of the world's population (UNICEF and WHO 2008).

Nevertheless, agriculture is the activity that mainly consumes and pollutes water. A comparison of domestic, industrial and agricultural sources of pollution from the coastal zone of Mediterranean countries found that agriculture was the leading source of phosphorus compounds and sediment. Furthermore, nitrate is the most common chemical contaminant found in the world's groundwater and aquifers and its concentrations have increased in the last decade in the Americas, Europe, Australasia, and most significantly, in Africa and the eastern Mediterranean (UNEP 2008). Agricultural activities are also linked to the salinization of surface water, eutrophication, pesticides in runoff, altered erosion and sedimentation patterns (Gleick *et al.* 2012). As agriculture has a lower level of utilization's efficiency (Young 2005), United Nations calls for crop water productivity increases with the aim of reducing pressure to develop new supply sources or increasing water allocation to agriculture (Scheierling *et al.* 2014). FAO (2012) considers demand management as an important option to cope with water scarcity: increasing agricultural water productivity – i.e., improving the value or benefit derived from the use of water in this sector – could be an important strategy for managing water demand. Otherwise, without further improvements in water productivity or major shifts in production patterns, the amount of water consumed by evapotranspiration in agriculture will increase by 70–90% by 2050 (Molden 2007).

This approach to the problem of water scarcity and agricultural productivity requires defining public policies and instruments aimed at changing consumption patterns. Water saving and, thus, a better management of domestic sewage can effectively contribute to a better sustainable water governance, if we consider water scarcity and quality as preliminary problems to be resolved. Generally, water conservation is the cheapest strategy to face water scarcity and allow living in healthy ecosystems (Richter 2014). Specific tools and activities, such as recycling industries or farms' water, reducing losses and leaky pipes or planting less-water-intensive or drought-tolerant vegetation, may help to limit water consumption. Consequently, investing in water conservation helps also to avoid other environmentally damaging options.

2. The Mediterranean basin and its 'tipping points'

Mediterranean is a wide basin which gathers several countries with specific features. But both developed and developing countries need of water availability to face the increasing populations and living standards as well as the development of irrigated agriculture, industry and tourism activities (Cudennec *et al.* 2007). Water availability mainly depends on runoff from mountains (De Jong *et al.* 2009), as these supply 20−50% of the total discharge and in semi-arid areas can contribute 50−90% of the total supply (Viviroli *et al.* 2007).

Overall, in the Mediterranean countries, water resources are limited and very unequally distributed. Southern countries receive only 10% of the total precipitation and 20 million of local people do not have access to drinking water, particularly in the South and East (Thibault 2009). In fact, water scarcity is particularly intense in the Maghreb countries, in the Middle East area and also in some sectors of northern Mediterranean countries, such as South Italy and South Spain. This diverse degree of water availability is contributing to increasing political tensions, and now a high level of investment and complex long-term solutions are required. Moreover, in the Mediterranean basin precipitation can be subject to high variability, with long and intense dry periods (Nicault *et al.* 2008), or extreme rainfall and floods (Beguería *et al.* 2009). There is mounting evidence of long-term climatic trends (Giorgi *et al.* 2004), and changes in land cover have produced alterations in hydrological responses at the basin scale.

Definitively, Mediterranean is a 'hot-spot' (García-Ruiz *et al.* 2011) in terms of climate variability and change as well as in the rate of land transformation processes, mainly due to the increasing water demand and land cover and other harmful human activities – e.g., new urbanizations, deforestation. Temperature is projected to increase about 3.5°C on an annual basis by the end of this century, and precipitation could be reduced more than 10% (Calbò 2010). Thus, water availability will be reduced in the Mediterranean. Moreover, human impacts on river hydrology, such as those that derive from regulating their flow, has been affecting the water availability as well, by impacting the functional organization of streams and the pertinent ecosystem services, and by impoverishing the therein ecosystems (Sabater and Tockner 2010).

Desertification is another relevant phenomenon in the Mediterranean area. In the African lands, drier than the European ones, desertification is driven by encroachment of cultivation on rangelands, which are determined by population growth and national policies. In the northern Mediterranean, desertification is due to the irrigation developments driven by markets and regional agricultural policies. There is also a difference between the western and the eastern Mediterranean basin, as the latter is drier than the former. Overall, we observe that an extensive use of the land is usually associated with an intensive use, both leading to the land's degradation. Of course, climate change can affect drylands as well, thus transforming semiarid into arid drylands, or non-drylands into drylands (Safriel 2009).

Mostly, Mediterranean area is a context of increasing shortages and it is urgent to adopt water management policies aimed at ensuring a sustainable and efficient use of water. Indeed in the last years the amount of water abstraction have reached 95% of total withdrawal; losses during transport and use have risen to 40% of total water demand; agriculture have accounted for 64%, especially in the South and East (Thibault 2009). In many Mediterranean countries water withdrawals already near or even exceed the limit threshold of renewable resources, and by 2025 pressures on water resources will increase, mainly in the South (Benoit and Comeau 2005). The huge water demand is met by an unsustainable water production: 16 km^3/year are produced and 66% of them come from fossil water withdrawals while 34% from over-exploitation of renewable water. Furthermore, the combination of climate change and demographic growth will bring the Mediterranean regions to be particularly exposed to a dangerous reduction of their water resource (Thibault 2009). According to the projections of the Blue Plan (Benoit and Comeau 2005), water demand may increase by 18% within 2025, mainly in the

Southern countries (+28%) and even more in the Eastern ones (+33%). Agriculture is expected to remain the main sector for water consumption, especially in the South and East: irrigated surfaces could increase by 38% in the South and by 58% in the East, whereas in the North water demand for agriculture could remain stable or even decline.

The traditionally strategy aimed at satisfying the increasing water demand has been the extension of water supply and waterworks. But this supply-based approach has been increasing withdrawal of renewable resources, exploitation of underground water and water transfers. Consequently, such policies may deteriorate natural resources and produce severe damages in the long-term – e.g., the fossil resources' depletion or the coastal aquifers' destruction through seawater intrusion. Moreover, production costs, conflicts and sanitary risks could be exacerbated, thus reaching physical, socioeconomic and environmental limits (Thibault 2009). On the contrary, betting on a water-demand approach, through policies aimed at fostering water saving, should be a better strategy in order to slow down or even avoid all these harmful effects. Moreover, such approach integrates also the water demand of the natural systems to preserve ecosystems.

3. From the SWM approach to the SWMED project: the water management in the Mediterranean area

The per-unit cost of either supplying or saving water is almost always the most influent factor in addressing water shortages (Richter 2014). Some plans only aim at increasing water supply for managing the hydrologic uncertainty but they are no longer considered as an appropriate solution because of the construction costs, environmental and social impacts, and inefficient use (Anzera and Marniga 2003). Conversely, water saving can be affected by other important factors, such as environmental conditions or users' cultural background, etc. Overall, technology and infrastructure alone are not sufficient to address water issues. These deal with governance processes making water management sustainable and equitable (Cooley *et al.* 2013). Such processes require interaction and dialog among key players and stakeholders for setting standards and objectives as well as resolving disputes over water resources. More sustainable funds and stronger mandates should be assigned to the organizations engaged in water governance, and new standards, codes and best practices should be adopted as well, by engaging local entities and civil society. Ongoing operations and maintenance need proper financing mechanisms and communication activities on risks should be implemented.

All these activities may lead to adopt a 'Sustainable Water Management' (SWM) addressing the several and different water issues by managing water resources in an integrate way, by taking into account the needs of present and future users, as well as by considering all cultural, educational, communication and scientific aspects. In fact, according to the famous Brundtland Report, sustainable activities imply an equitable resources' distribution among users not only in a given location, but also over time. Sustainability deals with the basic needs and corresponding strategic assets ('commons') and rights we share as humans (Mattei *et al.* 2010). The most relevant challenge is to define how such commons should be managed in order to comply with the sustainability criterion.

In recent years there has been a shift from the traditional top-down approach to a participatory management system as users' communities may elaborate endogenous norms and institutions that regulate and manage commons according to both sustainability

and efficiency criteria (Ostrom 1990). If properly done, this system ensures that users' needs are addressed. Managing water through a participatory process, for example, may help to understand communities' claims and to take into account the resource's possibilities or limitations. More in general, water resources should be managed in an equitable and sustainable manner by providing all interested and affected parties with the opportunity to express their values and needs (Richter 2014). This approach requires sharing lay and scientific knowledge, as well as involving citizens in the decision-making processes through concrete forms of institutionalized participation.

Definitively, SWM attempts to consider water management in a holistic perspective, by taking into account various sectors affecting its use and by including political, economic, social, technological and environmental considerations (Richter 2014). Since the Mar del Plata Water Conference (1977), SWM has been high on the international agenda and later conferences have refined the concept. The current meaning of SWM is primarily based upon the principle that water is a finite and valuable resource that is essential to sustain life, environment and development. Consequently, water management should be based on a participatory approach involving users, planners and policy makers at all levels and fostering water saving/reuse and preventative policies. Precisely this perspective has been adopted by the European project 'Sustainable domestic water use in Mediterranean Regions' (SWMED) submitted with the first call of the ENPI CBCMED (2007–2013) – Priority 2, Promotion of environmental common heritage sustainability at the basin level.

The project aimed at reducing water abstraction while improving the quality of water in each of the participating countries – Italy, Malta, Tunisia and Palestine – through new solutions providing specific services reducing water use and enhancing wastewater reuse. The SWMED hypothesis is that reduction of water abstraction can be achieved in the frame of local water management by optimizing the per capita water need through a pool of tools and technologies – i.e., water-saving devices, reuse of treated wastewater, rainwater harvesting, storage and use –, thus complying with the above-mentioned guidelines that require supporting crop water productivity.

4. Palestine and Tunisia: two revelatory case studies in the MENA region

In the Mediterranean basin the Middle East and North Africa (MENA) are the regions experiencing the most serious social, economic and environmental issues related to water management. Water scarcity, climate change, water governance and rapid population growth are the most critical problems. It is estimated that the region's population will reach 255 million inhabitants by 2025 (UN 2007), out of which 64% will live in urban areas. Within the same year, temperatures will rise between 3°C and 5°C and precipitation will be reduced by 20% (Bates *et al.* 2008), so that about 80–100 million people will be exposed to higher water stress (Warren *et al.* 2006). Meanwhile, by 2050 water availability per capita will decrease by 50% and groundwater will drop by 10% (Bates *et al.* 2008). As MENA is an arid region whose agricultural activities draw large amounts of water, the increasing pressure on groundwater resources may threaten the groundwater recharge. Agricultural yields will suffer larger fluctuations (World Bank 2010, Verner 2012), affecting nutrition, income and employment. Moreover, heat waves may deteriorate more and more water and air quality, thus affecting public health and quality of life. The increase in water level – 30–100 cm (Bates *et al.* 2008) – could cause

flooding in urban and coastal areas. Changes in temperature and precipitation can also damage the strategic economic sectors, such as agriculture or tourism, and even further inflame local conflicts among states already competing for water (Nordås and Gleditsch 2007). In fact, in this area of the Mediterranean, the water's control enables industrial and agricultural development and, at the same time, ensures a strong negotiating power with neighbors. The combined effect of all these factors, together with water pollution, accelerated urbanization, agricultural pesticides and fragile wastewater facilities (Anzera and Marniga 2003) makes it essential to solve the problem of water supply and sanitation services in the MENA region by focusing on the water demand reduction. The main challenge in the region has always been matching demand with supply: ensuring the availability of sufficient water quantity and adequate quality at the right location and the right time and at a price that people can afford and are willing to pay. In this context the use of appropriate technologies plays an important role. The social and economic conditions of local people and governments combined with the political context of these areas are key factors to assess which strategies should be adopted. For this reason, the SWMED project previously carried out both a feasibility study and a socio-economic survey in order to propose 'tailor-made' solutions for a sustainable water management (SWM). Tunisia and Palestine – specifically, the West Bank – have been selected as revelatory case studies because, despite their specific features, they can be considered sufficiently representative of the water-related issues in the MENA region in terms environmental and social aspects.

4.1. The hydrological and hydropolitical situation in Tunisia

In Tunisia, over 40% of the population is located in a desert climate where the average rainfall is only 50 mm. The depressions in the arid plains in the north of the Sahara are highly saline and cannot be a source of water supply. Moreover, the most dense river network is in the northern part of the country where river basins account for 81% of the surface water potential at the national level. The south, on the contrary, is characterized by networks of non-renewable aquifers. Temperatures are rising and precipitation is decreasing, resulting in more frequent and intense dry years (King *et al.* 2007). The combination of these elements, together with the excessive use of groundwater resources, makes the storage capacity a vital necessity for Tunisia (UN 2009). This is all the more evident if we consider the importance of agriculture and industrial activities: they consume large amounts of water bodies with limited efficient incentives for fostering water conservation and recycling, thus endangering the coverage of drinking water in urban and rural areas (Ibidem). Also the sewer system is inadequate: although it is improving in urban areas, in rural areas nearly half of the users dispose of the waste through traditional and unsanitary methods.

Tunisia has amortized water scarcity by transferring large amounts of water from the wet north to the central areas and installed desalination plants to treat brackish water areas to the south. Such interventions are not economically sustainable and the environmental impact has to be considered. Moreover, despite access to drinking water has expanded and coverage for the whole country has been advancing (WHO and UNICEF 2008), the growing water demand from various sectors requires the application of an integrated management through policies aimed at matching user needs with the social and

environmental value of water. While the past policies encouraged a water use through preferential tariffs or subsidies with public campaigns to make population aware more about water saving necessity than the water use's implications and exhaustion, the over-exploitation of water resources, especially groundwater one, and, more generally, the water demand increased. Thus, since the early nineties, a number of reforms have been fostering the transition from a supply-based management to a demand-based one.

4.2. The hydrological and hydropolitical situation in the West Bank

In Palestine, the hydrological situation (water scarcity, pollution, salinization, variability of rainfall) is exacerbated by the particular political situation. A full 80% of the Jordan River basin, in fact, falls on the borders of several countries: Israel, Palestine, Jordan, Syria and residually Lebanon. Thus, over time these states have tried to divert the river or to build dams in order to concentrate the Jordan and its tributaries into their own territories. Moreover, the renewable aquifer is under Gaza, Israel and the West Bank but is exploited mainly by Israel through a system of deep wells (Anzera and Marniga 2003): such transboundary nature of the water resources results in geopolitical conflicts. A real water war in the Palestinian territories began since the birth of Israel, when the first Jewish settlers began to develop strategies to divert Jordan and to define the new state's borders by considering the location of water resources (Weizman 2003). Attempts to divert the Jordan continued over the years, thus affecting the political relations with Syria and Lebanon and fueling internal frictions among the involved Arab regimes (Anzera and Marniga 2003). With the victory of the Six Day War (1967) the Jewish state gained a considerable territorial expansion and, consequently, complete control of the Jordan, as well as a vantage point on the river Yarmuk and the access to the aquifer in the West Bank. With the agreement of Cairo (1994), the Israeli authorities nationalized water resources through a licensing system that gave them a monopoly over infrastructure. Despite the fact that Palestinians were formally allowed to administer water and dig wells, Israel retains and continues to retain effective control over water resources.

According to the World Bank report (2009), Palestinians living in the West Bank have access to only a fifth of the water resources offered by the mountain aquifer, while Israel often exceeds the limits imposed by Oslo Agreement (1995) without the approval of the Joint Water Committee (JWC). Aquifers are thus in danger with a ripple effect affecting populations. Both the water lowering and the limits imposed by the Israeli government to the construction and rehabilitation of wells are determining a progressive decline in per capita water withdrawals of Palestinians. Although access to the water supply has increased, almost half of the water is still provided by Mekorot (an Israeli company), through a variable and discontinuous supply: a quarter of the connected population receives less than 50 liters per capita per day (LPCD) and in some cases, even just 10–15 LPCD. Half of the households experience problems with drinking water quality. Little progress in the treatment of waste water is under way, which meanwhile has a negative environmental impact. Not many investments in sanitation have been made as well, and only a third of the West Bank population is connected to a sewerage system. Disastrous consequences are also recorded both on the households' balance sheets and health conditions: the payment of water fees covers 8% of the average family spending and up to a sixth of the poorest families' income; water quality standards are not assured, and

public health costs associated with water-borne diseases are increasing. Also agriculture, which is the basic activity contributing to 12% of GDP and employing over 115.000 people, is affected by the decline in water availability, with obvious repercussions on employment.

The described situation is due to the lack of a proper water management in all the Palestinian territories, and to the low rates of investment in infrastructure and technology. Water is a commodity within a political congested context and many Palestinians local authorities are indebted due to the non-payment of bills by citizens. Israel transferred the debts to the PWA, which threatens to freeze development projects for a number of villages unless local governments repay their debts. Consequently, in 2009, the Prepaid Water Meter (PWM) was adopted in many areas. This equipment assigns a pre-determined and pre-paid quantity of water to the households and, when the available credit corresponding to a certain amount of water runs out, the PWM automatically breaks off the supply. Local governments in the West Bank are thus recovering 120% of the bill payments, thus making the supply of water a truly profitable activity (McClune 2004) and creating great disparities in water consumption between rich and poor. The main problem, however, is the lack of autonomy of the Palestinian authorities: the growing dependence on Mekorot for utility water supply makes them vulnerable and exposed to the Israeli decisions and actions. Furthermore, all Palestinian territories lack a plan of efficient use of water resources. In the West Bank, high rates of losses in transport systems and supply reduce the available water by one third; and the reuse of wastewater in agriculture is currently limited. Investment in infrastructure used for the water provision and sanitation are inadequate, due to the poor planning abilities, political and security problems, and high costs.

5. Research design and implementation

In such a scenario, the value and importance of SWMED arises. The project moved from the idea that a reduction in the water withdrawals could be achieved by optimizing the per capita water consumption through different tools to be installed in different types of settlements: compact urban areas, with a prevalence of multi-store buildings; peri-urban areas, with a prevalence of semi-detached houses with gardens; rural villages and/or refugee camps.

In both Tunisia and in Palestine three case studies representing different types of settlement were selected, and for each of them the socio-economic feasibility of the intervention was assessed on the basis of a multi-criteria analysis considering economic, social and environmental aspects. Meanwhile a survey was conducted in the same target areas in order to explore the families' water conditions as well as the social and economic ones. The goal was to better understand the problems associated with the water consumption and sanitation in order to better intervene through the SWMED tailored tools and suggest lines of action to the national and international institutions.

In Tunisia, target areas were identified jointly by the *Centre de Recherche et des technologies des eaux* (CERTE), the *Office National de l'Assainissement* (ONAS) and the *National Water Distribution Utility* (SONEDE). The three locations were representative of the various types of settlement actually present in the country so as to replicate the study and experimentation in other contexts:

- *Chorfech 24 (East part)*: rural settlements where houses are connected to the water distribution system, but not to the sewer system;
- *Zaouiet El Mgaiez (ZEM)*: rural villages with a partial domestic water connection to the distribution system, a partial sewage system but without treatment plants;
- *Bardo Center*: multi-store buildings in urban area, where houses are equipped with a system of water supply and sewerage network connected to treatment plants.

In Palestine, similarly, the Palestinian Hydrology Group (PHG) and PWA selected three places representing the different conditions of water supply and wastewater management in the country:

- *Bani Zeid*: rural settlement with a partial purification system, several percolation wells and rainwater harvesting systems;
- *Faria Refugee Camp (Tubas)*: a refugee camp whose families are mainly connected to the water supply but can effectively count just on a reservoir for collecting water and a sewer system through which disposal takes place in special pits;
- *Jenin*: agricultural center that, like many other northern governorates, is poorly served by the municipal water network (a quarter of the population buys water from tankers or collects rainwater), sewage and wastewater system (disposal is mainly channeled into special pits).

In their respective countries CERTE and PHG interviewed the householders – the most suitable spokespersons representing families' needs and problems – through a structured and semi-standardized questionnaire. The householders as key informants were selected according to a purposive sampling strategy and following a snowball procedure. The adopted research strategy is thus quantitative but non-probabilistic, coherently with the exploratory objectives of the survey that did not aimed at statistical conclusions, but rather at highlighting the main problems in water and sanitation services, according to the general objectives of SWMED.

In the presence of interviewers, questionnaires were filled out by 132 householders in Palestine (40 in Bani Zaid, 43 in Jenin and 49 in Tubas) and by 84 in Tunisia (27 in Chorfech, 39 in ZEM and 18 in Bardo). The questionnaire aimed at satisfying the following research questions: who is addressed by the tools of water conservation and water recycling that the project intends to support? Can the families effectively purchase, use and sponsor these instruments, and reap their benefits? Which are their current living conditions and do the SWMED tools improve the quality of their lives?

6. Main results: a comparative overview

The questionnaire was composed of 49 questions related to: respondents' general information; demographic and socio-economic conditions of the families; information about water conditions of the house (water supply, sewage, usage and costs); water culture and values; interest and awareness on environmental issues and policies related to the use and management of water. The main results allow comparing data regarding the families of both countries.

6.1. Family socio-economic status, house characteristics and water conditions

In Tunisia, the sample is composed exclusively of men, coherently with the choice of interviewing householders. Data reveal that 85.7% of respondents are house-owners (only 12 live in a rented or family house) and most of the families involved in the research (69%) are small or medium-sized (1–5 members). The socio-economic status tends toward a low level: most of families (86.4%) has only one member working and this explains why almost three quarters of the families involved in the survey have a monthly income of less than 1200 TND (about 500 euros), as well as why almost the same percentage does not own a private car. In this state of indigence, Bardo is an exception: there 83.3% of respondents live in a more comfortable condition, and due to the arid climate, they rely on air conditioners.

Overall the houses are mainly characterized by three (20.2% of house) or four rooms (32.2%); only 50% of the kitchens of ZEM are not connected to the water supply network, but in more than 90% of the homes there is a dishwasher and an automatic (29.8%) or semi-automatic (63.1%) washing machine. Finally, three-quarters of the houses have only one bathroom, all with a toilet; but only 65.5% of them have on a dual flushing toilet.

Similar data are recorded in the West Bank. The sample is mainly composed of men (87.1%), mostly between 40 and 60 years, and once again the majority of respondents (81.8%) are the owner of the house in which they live. About 60% of the families involved in the research are of small or medium-sized, but there are also couples without children. The socio-economic status indicates a low level income also in Palestine, where most families rely on one or two salaries at most (86.4%), and where almost half of these has a monthly income between 1200 and 2000 Shekels (about 250–400 Euro) and does not own a private car.

With regard to the characteristics and conditions of Palestinian houses, most of them have average dimensions, with two or three rooms (82%), all the kitchens are connected to the waternet. Over 90% of households have an automatic or semi-automatic washing machine, while many do not have dishwasher (89.4%). More than half of households have only one bathroom (54.5%) but a good 42.4% of them has two: however, only half of the bathrooms has a toilet (57.3% of households), while others use squat toilets (41.7%). In any case, 96.2% have flush toilets.

In Tunisia, the majority of house are connected to the network and has a supply of water 24 hours a day (89.3%), except for respondents ZEM that instead rely on a well. The evaluation on the water service provided by SONEDE is ambivalent: the majority of household (55.6%) express a negative assessment about water quality, but a large percentage of them (81%) give a positive evaluation of the pressure flows. Overall Tunisians seem sensitive about information needs on water consumption: 84.6% of respondents said that it is important to receive information about the cost of wastewater discharge, the water supply in general, the methods of supply and water treatment, the criteria for placement of septic systems, the frequency of use of wells and aquifers, and finally, on the composition of drinking water. With respect to the payment, just over half of the sample believe that it is right to pay for water but 61% believe that the price is not adequate (because 72.6% of them do not know how to calculate the water bill), although the majority (81.3%) pay no more than 50 TND per quarter (about 20 €).

In Palestine, respondents demonstrate significant satisfaction with the water service: most of the houses (84.1%) have a water supply 24 hours a day and interviewees have expressed a good assessment of water quality and pressure (respectively, 87.9% and 93.2%). Regarding the payment issues, over 90% of the sample claims that it is right to pay for water and 68.9% of respondents believe that the current price of water is appropriate: in particular, 42.5% of households pay less than 60 Shekels, while 22.7% pay over 100 ILS (about 12–10 €). However, many of the respondents (83.3%) do not know how the water bill is calculated and would like to learn more. In fact, many of them (48.5%) believe that it is important to receive more information on how to make a better use of water resources, on what is the price of water at the source and how rates are estimated.

6.2. Saving water and wastewater treatment: problems and attitude

In Tunisia, the majority of respondents (86.9%) clearly perceive water conservation as a very urgent issue, and 82.2% are aware of the importance of undertaking concrete action to solve the water scarcity through water saving. Although half of respondents (47.6%) are aware of the existence of water conservation devices, a large part of the sample (80.9%) say it is ready to install this type of instruments in their own home and, when possible, also to financially contribute (65.6% of respondents say to be willing to pay for the installation) (Figure 1).

Also the lack of adequate treatment has emerged as an acute and severe difficulty to be faced for the Tunisians' quality of life, mainly in ZEM and Chorfech: as much as 70.3% of shelters or homes are not connected to a sewage system and 86.4% of respondents say they use septic tanks to dispose of sewage, while 11.9% use percolation wells as an alternative means of purification; not without a quota, albeit residual, of people (1.7% of cases) turning to the free flowing in the adjacent area. All Bardo respondents are connected to the sewage system.

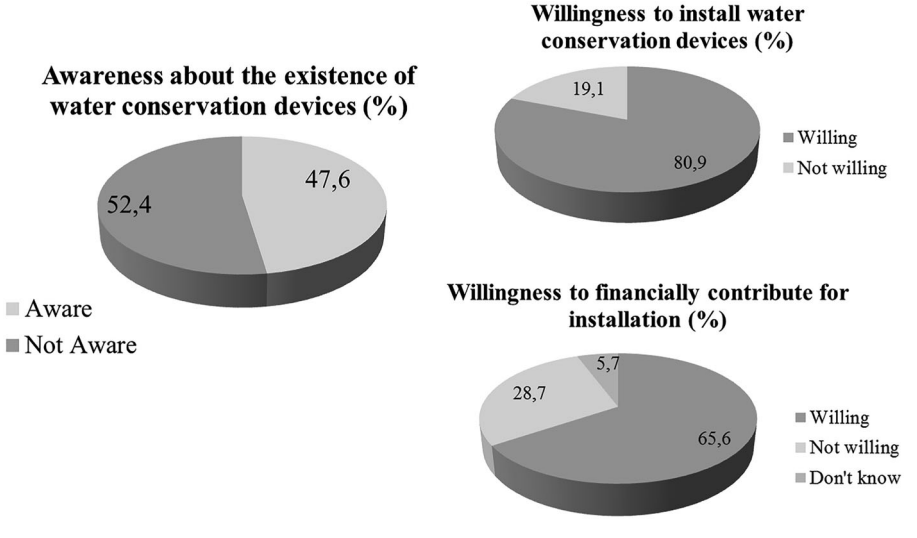

Figure 1. Indicators of the inclination of the Tunisians towards water conservation devices.

Generally speaking, the Tunisian interviewees were aware of the water problems the country is facing. In Bardo water consumption is perceived as the more urgent issue, while Chorfech is most concerned with the question of the discharge of wastewater and pollution; the inhabitants of ZEM report other issues as well, such as the lack and poor quality of drinking water, the decrease in the groundwater level, the low flows in altitude and the reduced amount of fresh water. Consequently, the attitude of the Tunisian respondents towards the installation of dry sanitation systems is fairly uniform: more than half of the sample believes that this setup is useful both in private homes as in public buildings. A similar attitude is also recorded about the graywater treatment systems: 64.3% of respondents are willing to install them. Despite this positive approach of Tunisians to the mentioned solutions, it is important to note that almost all (94%) do not receive any related training , which means that they do not know whether and how dry toilets and graywater treatment systems operate, but in any case they perceive an advantage from the mere existence of such facilities that allow water saving and recycling. Almost all respondents (97.6%), in fact, demonstrate a high sense of responsibility for water protection in favor of future generations, deeming them useful assets to meet basic needs and human rights. Precisely for this reason, Tunisians prefer a public-private management of the water system (over 47% of respondents) or a only public one (40.5% of respondents).

In Palestine, the situation is completely different. In fact, 61.4% of the sample does not perceive the problems of water scarcity in the region. The most aware households refer water problems to sovereignty and access issues – i.e., Israeli control on the sources or imposed restrictions. A significant percentage of respondents (62.9%) claims to give importance to the water conservation but, in practice, not all (only 43.9% of the sample) are aware of the existence of water-saving devices, and even fewer (only 37.9%) are willing to install them. This reluctance to adopt solutions (Figure 2) to save water at home is usually due to the lack of awareness about the usefulness and the real costs of these devices, as well as to the poor economic conditions of families.

In order to better 'portray' our Palestinian respondents, we classified respondents in terms of preparedness and aptitude towards hydro-technological innovation, based on

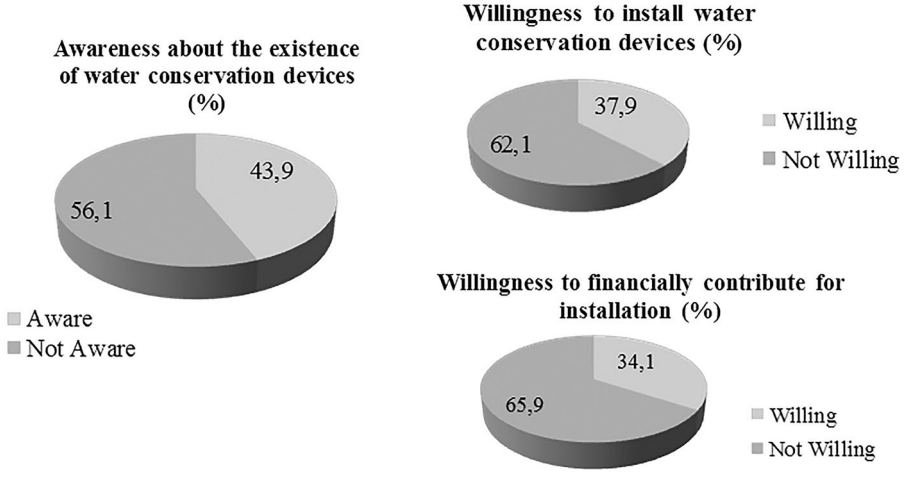

Figure 2. Indicators of the inclination of the Palestinians about water conservation devices.

their knowledge and attitude toward these tools. The majority of our respondents (43.9%) are not prepared users because unaware of the existence of the devices and still reluctant to install them at home; 25.8% of them are really aware of the technology solutions and willing to use them. Not a few (18.2%) those who know that water-saving devices exist, but are not interested in installing them in the house; viceversa (12.1%) few people, although unaware of the solutions offered by such technology, would be willing to use them.

Moreover, alongside the problems concerning domestic water-saving, another related issue emerges clearly: the lack of adequate sewer system. In fact, 92% of shelters or houses are not connected to any sewer system: thus, 67,7% of them use percolation pits to dispose of sewage, 23,3% adopt free-flowing and only 8% use septic tanks.

Overall, the approach of the interviewed Palestinians towards water-saving devices that use dry sanitation systems is rather ambivalent: the majority of the sample (78%) thinks that it is useful to install them in public buildings but not in private homes. Only a third of respondents (35.6%) could tolerate dry sanitation tools in their own bathrooms, probably because many persons are not fully aware of what such systems are or how they work. A similar attitude is recorded about graywater treatment systems, because not all respondents are aware of the benefits that these devices are able to provide, and only half of them are willing to install them. The main reasons why people are quite skeptical are traced, even here, in the low awareness of water issues and existing solutions, as well as in the poor economic situation in which many families live. However there are respondents who cite as justification of their reticence the belief that graywater treatment systems could produce bad odors or create pollution around the house. Fortunately, most of the sample (86.4%) would like to receive more and better information on issues related to water and environmental problems, and almost all (98.5%) still feel a strong sense of responsibility for protecting water in favor of future generations. Unlike Tunisians, however, our respondents do not refer the equal access to water or the quality management to the nature (public or private) of the provider. Indeed, most of them prefer a public-private partnership (49%) or even a private operator (32%) for water supply, and only 19% of the sample prefers a public management. This apparent contradiction is explained, however, taking into account the particular hydropolitical situation of the West Bank: the lack of sovereignty on water resources within their territory means that the public sector is the Israeli one; therefore, it is not difficult to imagine that the Palestinians prefer to entrust the management to a private provider, although in conditions of natural monopoly, rather than perpetuate the occupation model.

7. Conclusions

It can be concluded that both simple and advanced solutions (such as tools for regulating the water flow, shower diffusers, WC 'Water Saving', wastewater and graywater treatment and reuse systems, rainwater harvesting at household level, etc.) sufficiently respond to the multiple and diverse needs of the different settlement typologies in the region and can help them to improve adaptive capacity toward any potential climate and other changes. It is clear that the type of solutions need to be appropriate to each settlement typology in order to respond to the specific problems they face with.

In Palestine, for example, the proposed solution for Bani Zaid, that aimed at upgrading the households' connection to the existing treatment systems through new sewage systems or at refurbishing the existing wetlands, is more appropriate because it can eliminate the frequent disposal of wastewater in the nearby land. A similar approach can be adopted also in Jenin area, even if the therein water consumption per capita is low (43 l per capita per day) and simple saving water methods (such as tools for regulating the water flow, shower diffusers, WC 'Water Saving') can improve water availability as well. Instead, Tubas (with Faria refugee camp) as a particularly problematic area with a good sewage system but without any wastewater treatment plant, can benefit from the proposed WWTP solution. Furthermore, it can take advantage of the existing sewage system by adopting low technology treatment system thus reducing maintenance costs (with a low impact on a population that is still worried for water tariffs). It is important to remark that gray water treatment systems are perceived as costly and polluting by a part of the population that underrates these devices even if they can be really proficient in those areas.

On the other hand, in Tunisia, the situation is quite different. In ZEM, for example, 92% of the respondents are aware about the necessity of water conservation strategies and are willing to implement water saving devices. The main problem in this area is sanitation and the fitting treatment solution is the Constructed Wetlands (CW) as it has a low environmental impact and low energy consumption. The implementation of the CW can also lead to potential reuse of treated water in the forest area. In Chorfech24 – where the survey concerned only that area that is not connected to the existing CW plant due to a highway splitting the village into two parts – one of the studied options is the realization of a sewer connecting the northern part to the CW in the southern part, thus rehabilitating the final pumping station and relieving one of the most troublesome issues about water – i.e., the absence of a sewage plant. This kind of installation can also reduce the dependence of local inhabitants by percolation pits or septic tanks, with a positive impact on environment and water consumption. However, a local CW for the studied area appears even more useful as treated wastewater could be available for reuse in agriculture. Moreover, data show that respondents are also interested in rainwater harvesting in order to decrease the pressure in water supply and use it for livestock watering. Instead, Bardo (an urban area with a good sewage system) essentially needs to be familiarized with water-saving kits, such as the underground segregation of gray water for the urban irrigation reuse, demonstrative green roofs with the purpose of rainwater harvesting and storm water peak reduction, or the application of water conservation devices (WCD) All these treatment systems can reduce water costs, with a positive impact on a population still concerned about water tariffs. While the widespread trust in WCD's effects in ZEM and Chorfech24 seems to make a public promotion of the tools unnecessary, in Bardo it is important to highlight the importance of gray water treatment systems as it is not accepted by a large part of the population (72%).

In such a scenario, innovating public policies are needed. Here we try to suggest some guidelines that can orient the water management in West Bank and Tunisia by adopting the multilevel governance approach. This method envisages a continuous feedback among the actors involved in the water governance – i.e., local government, state governance, international institutions, NGOs – in order to save water, monitor the resources and find new solutions to avoid water shortages (Fedele *et al.* 2014).

On one hand, the main recommendations aimed at addressing the Palestinian problems regarding water and wastewater management, can be categorized as follows:

(a) At a policy level, it is important to properly inform policy makers about water problems and challenges. Politicians should keep the water issue high in the political agenda as first priority in order to obtain Palestinians' full sovereignty over water resources.
(b) At a governance and regulatory level, it is important to implement the 2014 Water Law in order to foster water resources protection, pollution prevention, water tariff regulation, water resources development and monitoring, etc.. Moreover, it is needed to distinguish authorities among governmental bodies and ministries in order to ensure a more coordinated and integrated water management. Finally, a clear regulation on the stakeholders' participation in the decision making processes related to water management should be adopted and institutionalize.
(c) At a technical and technology level, water saving devices and tools need to be promoted and national campaign should be carried out to in order provide all public buildings with these devices. In addition an incentive program must be launched in order to encourage people to adopt and install these devices rationalizing water use. Decentralized wastewater treatment plants for rural and pre-urban areas should be promoted with a focus on natural and biological treatment technologies with improved wetlands. Gray water treatment and reuse need to be encouraged; this can also be coupled with modified percolation pit ensuring localized sanitation solutions. Furthermore, guidelines and manuals need to be produced, thus assisting people in better understanding and managing the technological solution.

(d) At a social and cultural level, national campaigns need to be implemented in order to strengthen public knowledge and awareness about the advantages of water saving practices and devices. For example, local mass media can highly contribute by informing people on water issues as well as by encouraging them to engage in national campaigns for water savings. Moreover, it is important to organize information sessions and to arrange visits for pilot locations, in order to change public perception on the reuse of treated effluent.

On the other hand, in Tunisia the problems regarding water and wastewater management can be faced by the following initiatives.

(a) The institutionalization of a Regulation Authority with decision-making autonomy, in order to control the whole water management system according to a coherent and holistic approach and to penalize all breach of the regulations. Such authority could work with the Water National Council that is responsible of the setting national strategies, and could also supervise projects aimed at implementing the water system.
(b) The translation of the sustainable development instance planned by the Tunisian Constitution in regional councils including those specific groups that closely deal with local resources such as water. It can enable the integration of inter-sectors issues and local needs.

(c) The promotion of treated wastewater reuse by enhancing the dialogue between the ministries of agriculture, health and environment and implementing institutional system dedicated to recycling water.

Definitively, both Tunisian and Palestinian case studies demonstrate that it could be useful to adopt public policies aimed at clarifying the benefits resulting from the use of water saving systems and from adopting more sustainable solutions to the water and sanitation problems. Nevertheless, as social policy innovations as well as technological development are long-term and non-linear processes, it is important to be flexible and to adapt management plans if the circumstances require it. Such adaptive approach to the assets' governance can ensure tailor-made and targeted solutions. Moreover, involving citizens in the decision-making processes can contribute to make the innovations and decisions more attractive.

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No potential conflict of interest was reported by the authors.

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