NAWAMED

Nature Based Solutions for Domestic Water Reuse in Mediterranean Countries

Thematic objective: B.4 Environmental protection, climate change adaptation and mitigation

Priority: B.4.1 Water efficiency

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1. Introduction

1.1 Context

The management of water resources in the southern Mediterranean Region invariably starts from a context of unavailability of sufficient water resources to meet the existent and future water demands generated by people, their economic activities and agriculture. This situation generally arises due to the characteristic semi-arid climate of the region, with long dry summers and a short, mild rainy season which drastically limits the availability of freshwater resources at the intra- and inter-annual level.

The development of the water sector in the region has invariably had to evolve throughout the years, to address this important challenge which places a severe limitation on the social and economic development of the region. In fact, the water culture of the Mediterranean is based on the development of alternative water resources, rainwater harvesting in particular; as well as water management techniques aimed at managing and retaining rainwater runoff within catchments – such as the retention of water in valleys through the construction of masonry dams across the main valley (wadi) systems.

Similarly, the traditional agricultural sector in the Mediterranean region has developed important water conservation techniques such as the utilisation of low water requiring crops (or cultivars) as well as measures aimed at the retention of water in the soil such as through the construction of rubble walls which act to slow the movement of rainwater in agricultural areas enhancing its catchment and infiltration. In fact, agricultural rubble walls are a key characteristic, even today, of the Mediterranean agricultural landscape.

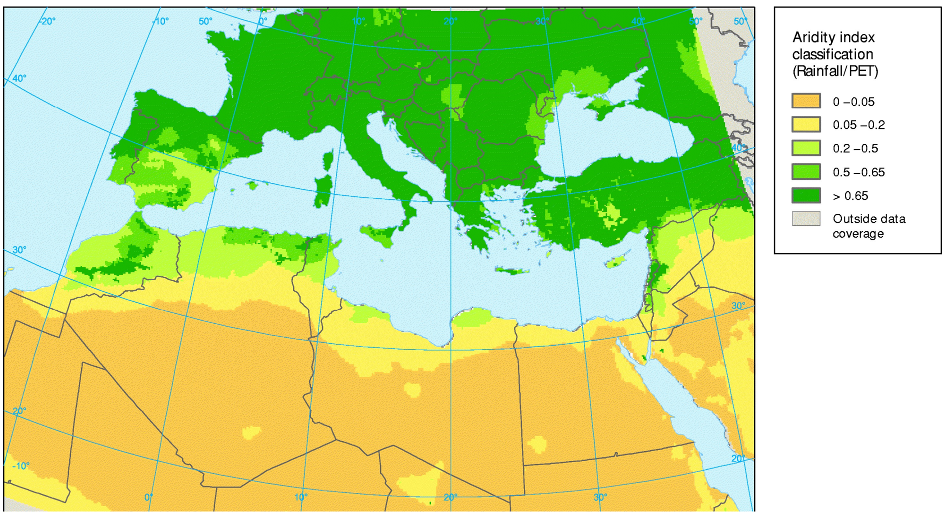

Figure 1: Semi-Arid and Arid climatic characteristics prevail in Southern and Eastern Mediterranean countries

The situation has been further exacerbated in recent years decades due to population growth. Studies from Plan Bleu[1] illustrate that the total population of the Mediterranean countries grew from 281 million in 1970 to 419 million in 2000 and to 472 million in 2010. The same studies predict that the population of the Mediterranean region will reach 572 million by 2030, almost double that in 1970. Invariably an increase in population results in an increase in water demand, creating increased stress on the limited natural freshwater resources of the region.

The Mediterranean region has also experienced significant demographic shifts, where internal migration from rural areas to urban areas has resulted in a significant increase in the population living in urban centres resulting in the spread of the main urban centres (cities). This demographic change has also resulted in the creation of hotspots of water demand, increasing the pressures associated with water demand on specific regions of the Mediterranean countries. This situation is leading cities to increasingly depend on the transfer of water from other regions, increasing vulnerability to water scarcity in particular during prolonged droughts. Invariably such situations can potentially lead to conflict, should the access to water of local populations be restricted due to the need of water transfers for cities.

Additionally, the Mediterranean is without any doubt one of the major hubs of tourism worldwide, attracting around 300 million tourists annually, around a third of the total tourism flow worldwide. Tourists go to the Mediterranean to enjoy its history and culture, but also its natural coastal landscapes and therefore peaks in tourist arrivals are generally registered during the summer period. This creates further pressures on water supply resources in the region, given that peak demand from tourism occurs during the drier period of the year, and therefore where natural freshwater resources are at their lowest capacity.

Furthermore, a generally increasing standard of living and a shift to service-oriented economies in Mediterranean countries is creating a higher demand for water – not just for direct consumption but also for indirect uses such as public amenities. In particular, moves to enhance the quality of urban areas through greening initiatives is in itself resulting in an increasing water demand for urban embellishment. Such demand is expected to increase in the coming years as the economic value of urban greening initiatives becomes more important to address the liveable context of our cities.

Therefore, most countries in the Mediterranean are facing conditions where limited natural freshwater resources characteristic of the semi-arid climatic conditions of the region, are confronted by an increasingly high-water demand due to increasing populations and associated economic activities. These two conditions reinforce each other in increasing stress on the region's water supply resources, thereby increasing risks to water supply security.

[1] National regulations, plans & strategies in Mediterranean countries regarding non-conventional water use - Plan-bleu : Environnement et développement en Méditerranée (planbleu.org)

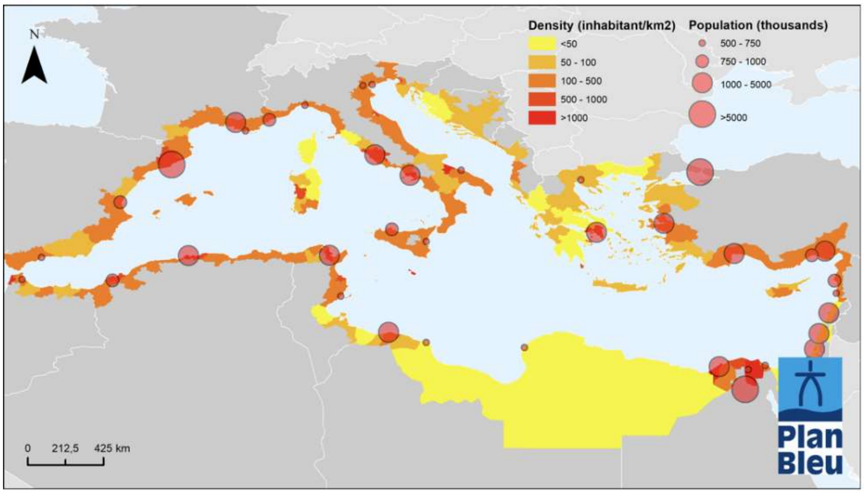

Figure 2: Population hotspots in the Mediterranean Region (source Plan Bleu)

1.2 Non-Conventional Water Resources

Within this context, Non-Conventional Water Resources (NCWR) can provide significant opportunities for optimising the management of water resources by diversifying the available freshwater resource-base. In this away NCWR enable security of water supply to be achieved whilst ensuring the sustainable use of natural freshwater resources.

The role of NCWR within a comprehensive water management framework can have two different (but complementary) aspects:
(i) that of carrying over water capacity from the wet season to the dry season – and hence primarily rainwater harvesting techniques, and
(ii) that of supplementing existing natural freshwater resources and making use of such resources in substitution of natural freshwater resources – in particular for cases where lower quality water to drinking water is required – such as landscape irrigation and toilet flushing.

Therefore, the application of NCWR can have a different context, depending on the spatial extent of the application typically varying between local and regional/national levels. Application at the local level considers technologies and techniques which can be applied at the point of use, that is at the level of the water user. Typical examples include rainwater harvesting at the field or household level, or decentralised technologies such as nature-based solutions and other greywater treatment systems. On the other hand, the regional/national level refers to larger structures, involving significant capital investment. Typically, such applications would include large dam retaining structures for water runoff, or the construction of water treatment plants such as desalination plants for sea-water or treatment/polishing plants for wastewater. Both levels of application are relevant from the perspective of integrated water management, and can be considered as complementary to each other. This highlights the flexibility in the application of NCWR, where different approaches can be adopted to ensure the integration of NCWR at different water management levels.

NCWR applications related to water reuse also contribute towards achieving an element of efficiency in water use, since these applications enable water demands at the local and/or regional level to be met with a lower input volume in the water supply system, entailing lower pressures on natural water resources.

1.3 Role of NCWR in Water Management Planning

NCWR therefore provide additional flexibility in water management planning particularly under conditions of water stress, particularly where natural freshwater resources are not sufficient to meet water demands. NCWR solutions provide functionality in the diversification of water supply resources, enabling the development of additional water resources to sustain the water supply system, whilst favouring the sustainable use of limited natural freshwater resources. NCWR development however needs to be undertaken in parallel with the development and application of water demand management solutions, to avoid that increases in water supply availability be matched by a corresponding increase in water demand through what is commonly known as the rebound effect.

The adoption of NCWR solutions provides added focus on the links between water and energy, given the energy requirements for the operation of NCWR solutions. Hence the adoption of such solutions will need to be aligned with the availability of energy supplies, and can be particularly relevant to drive the uptake of renewable energy solutions to increase the green credentials of NCWR solutions. The efficient use of energy in the whole urban water management cycle will therefore gain more relevance in water management planning, with energy efficiency measures in water production and distribution becoming increasingly important in water management plans. The adoption of NCWR solutions therefore calls for the increased mainstreaming of the WEFE (Water-Energy-Food-Ecosystems) Nexus in water management planning.

Considerations to the quality of water produced by NCWR solutions is also of relevance, in particular to ensure the safe use of these solutions. Water Quality standards reflect the intended use of the product water, where various uses requiring lower quality (second class) water can be addressed with NCWR solutions, including within an urban context such as the irrigation of green spaces and toilet flushing. The development of risk assessment and management protocols during the planning of NCWR solutions is therefore important to ensure that such applications can be implemented in a safe manner which ensures a high level of protection to human health and the environment.

1.4 Status of NCWR Adoption in the Region

The harvesting of rainwater runoff is a historic application in the Mediterranean, defining the water culture of the region. The dry semi-arid Mediterranean climate required the carrying over of rainwater from the mild-wet winters to the long dry summers, through its storage in tanks and underground cisterns. Rainwater harvesting applications can be adopted at the regional or local level, with local applications being generally favoured due to the availability of the harvested water at the point of use, therefore avoiding the need of distribution facilities.

The production of freshwater from seawater through desalination processes is gaining in importance in the Mediterranean region reaching a total production of 2.3 billion m3 in 2021. Desalination activities are physically limited to the coastal regions, and primarily undertaken at the utility (water supplier) level, where desalinated water is produced to supplement natural freshwater resources for municipal supply purposes. Private application of smaller-scale desalination solutions is however also steadily emerging, with applications for tourism purposes (hotels) and agriculture being increasingly adopted in the region.

Reclamation of wastewater and its reuse particularly for agricultural and landscaping purposes is progressively being introduced throughout the Mediterranean region. In EU Member States this is further promoted through the EU Urban Wastewater Treatment Directive and the new Regulation on Water Reuse for Agricultural Irrigation which establishes common standards to ensure the safe use of reclaimed water. Regulations and quality standards are also increasingly being applied in other Mediterranean countries, as wastewater reclamation and reuse gains increased importance as an alternative source of water in view of the general lack of conventional water resources – also as a result of the impacts of climate change.

The development of desalination and water reclamation applications has primarily been undertaken at the utility level, and therefore at the national or regional level. This approach results in the production of significant volumes of water at a particular location, requiring the eventual distribution of the product water to the point of use. This limits flexibility in the use of the produced water to the areas covered by distribution facilities such as piped networks. Opportunities for the diversification of water production closer to the point of use are therefore warranted to facilitate the uptake of NCWR solutions.

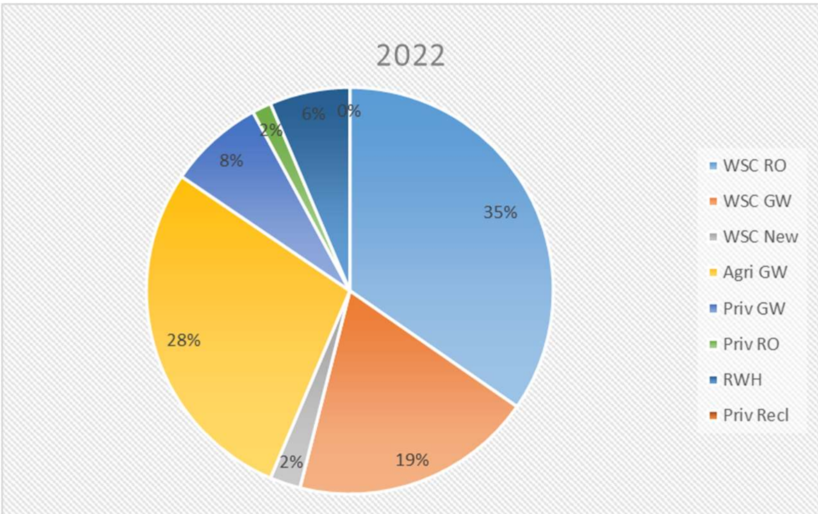

Figure 3: Malta - NCWR make up around 45% of the total water supply capacity in the island

1.5 Opportunities for the adoption of NCWR Resources

The application of NCWR solutions at the local level (or at the point of use) provides significant opportunities for diversifying the adoption of these solutions. Small scale NCWR solutions have been traditionally applied through the harvesting of rainwater runoff in onsite cisterns in both the urban and agricultural sectors, but the development of safe approaches for the reclamation of greywater opens up other opportunities for the application of these solutions particularly in urban areas, thereby enabling NCWR solutions to help address urban water demands.

Urban areas provide opportunities for the development of NCWR solutions at the communal and user level to address requirements for second class water (water intended for secondary uses such as landscape irrigation and toilet flushing). In addition to addressing urban water demand and substituting the pressures on conventional (natural) freshwater resources, NCWR solutions such as green walls and constructed wetlands provide additional direct opportunities for greening the urban environment and thereby enable additional benefits such as urban areas embellishment, improving the quality of life and increase resilience in case of prolonged droughts.

The decentralised application of NCWR solution however calls for the development of strong regulatory frameworks to ensure the safe use of such solutions. The protection of human health and the environment is an important objective to which the application of NCWR solutions must be fully aligned. The development of quality standards and appropriate risk assessment protocols is therefore an important element required to guide the uptake of these solutions.

This document will focus on the requirements for the development of policy frameworks for the application of NCWR solutions, promoting the outcomes of stakeholder discussions undertaken in the countries participating in the NAWAMED Project – Italy, Malta, Tunisia, Lebanon and Jordan, with a view of presenting a regional (Mediterranean) policy vision for the promotion of NCWR solutions in the region.

2. NCWR Technologies

2.1 Decentralised NCWR Technologies

Traditional solutions for wastewater treatment and reuse depend on end-of-pipe solutions where wastewater is collected and treated in Urban Wastewater Treatment Plants (UWWTP) before discharge to surface or marine waters. Additional treatment installed within the UWWTP can optimise the quality of treated wastewater enabling its safe reuse, primarily in the agricultural, commercial and/or urban landscaping sectors.

Decentralised solutions on the other hand refer to water treatment technologies which can be applied at (or close to) the actual point of use. These solutions therefore avoid the need of collection of wastewater and the eventual conveyance of the treated waters back to the point of use. The level of application of decentralised solutions can vary from the single building to condominia/public buildings to the communal level, and hence can be flexible enough to address different water management contexts.

Similar conditions apply for rainwater harvesting applications where large-scale solutions involving the construction of dams in valley systems capable of storing millions of cubic meters of waters are generally given higher consideration than smaller scale solutions. In the urban sector small scale solutions involve the construction of cisterns (rainwater harvesting reservoirs) or the installation of rainwater tanks at the household or the communal level. Water stored in these structures can then be utilised for secondary uses ranging from toilet flushing, to urban greening applications and street cleaning. Rainwater harvesting is a traditional water management technique in the Mediterranean region, which defines the water saving culture of the region.

Figure 4: Recently restored rainwater harvesting reservoir in Malta (Alteraqua Programme)

The NAWAMED Project focuses on changing urban water management practices by mean of innovative, sustainable, and low-cost treatment technologies, applicable in a decentralised way, to replace the use of potable water with good quality NCWR. In this way the NAWAMED project aims to provide a solution to growing demands for municipal (drinking) water in the Mediterranean region, in particular in growing urban centres which are increasingly becoming hotspots of water demand. Therefore, through the application of water demand management measures focused on the decentralised application of NCWR, NAWAMED aims to contribute to ensuring urban water supply security in the region.

From a technical perspective, decentralised solutions can be divided into two broad categories:
(i) Closed Solutions, generally requiring a minimum level of user interaction, and a low installation footprint (land-area) such as greywater treatment appliances, and
(ii) Applied Solutions, generally requiring a high level of user interaction, and a medium/high installation footprint (land-area) such as green walls and constructed wetlands.

The following sections present an outline of the decentralised NCWR solutions considered under the NAWAMED Project.

2.2 Closed (High-Tech) Solutions

2.2.1 Membrane Treatment Solutions for Greywater

In “western style” sanitation systems most of domestic water is greywater (60-80%), lightly polluted and easy to treat. Treated greywater has lower quality compared to collected rainwater, but is produced continuously and doesn’t require large storage tanks. It can be used for toilet flushing, irrigation and other external uses (washing of cars or external surfaces); in some countries the use of treated greywater is allowed also for clothes washing (washing machines).

Reuse of greywater inside the building requires:
- the construction, operation and maintenance of a treatment system,
- the separation of grey and black wastewater collection systems inside the building,
- the installation of “non-potable” water distribution network, and
- the use of ancillary pumps with their operation and maintenance costs.

Small high tech (closed) grey water treatment systems are available on the market from the size of a single family (3-4 persons) to any larger possible size. Family treatment systems can be compared to any other home appliance, with a treatment capacity of around 300litre per person. They require periodic maintenance operated by specialized personnel and have higher operation requirements compared to natural systems.

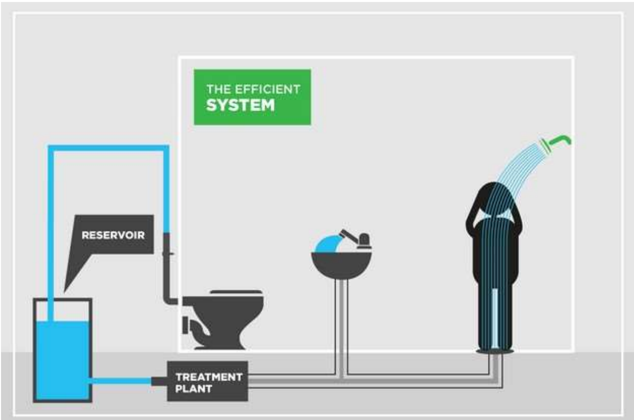

Figure 5: Schematic of in-house greywater recycling system linking shower greywater for toilet flushing. (Courtesy: LIFE, Investing for Water Project)

2.3 Applied (Low Tech) Solutions

2.3.1 Green Walls

Living green walls are composed by a series of pot lines build along the external wall of the building, to create a treatment system developed vertically rather than horizontally (as CW and GF). Pots are waterproof and filled with a granular medium which hosts the plants. In terms of treatment processes, they are equivalent to a vertical flow constructed wetland and need to be fed by pumping the greywater to be treated on the upper surface of the system, while treated water is collected at the bottom of the system.

Green Walls do not require any area of the ground, but is considered as the more requiring Nature Based Solution in terms of operational and maintenance effort.

Figure 6: Green Wall system installed by the NAWAMED Project in Ferla (Italy)

2.3.2 Constructed Wetland

Constructed wetlands (CW) used for greywater treatment are horizontal flow systems. They are rectangular basins, generally dug into the soil less than 1 metre deep, water proofed and filled with gravel or other granular media hosting aquatic plants.

CWs require a significant area (around 1 square metre per person served) which is not always available in the urban context – particularly so under dense urban conditions.

It is the simplest nature-based treatment system, requiring low energy inputs (the system works by gravity) and very little and easy operational and maintenance practice.

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Figure 7: Constructed Wetland (Courtesy - Stefanakis, et. al.)

2.3.3 Green Façade

Green Façade (GF) are treatment systems located at the bottom of the building wall, made of a waterproof container (dug into the soil or built over it) filled with a granular medium hosting the roots of both aquatic plants (contributing to the treatment process) and climbing plants that grow along the wall for aesthetical and microclimate regulation reasons. In terms of treatment processes, they are equivalent to a vertical flow constructed wetland and needs to be fed by pumping the greywater to be treated on the upper surface of the system, whilst treated water is collected at the bottom.

These systems require less space compared to horizontal flow CWs (around 0.8 square meters per person served) but need more energy to feed and run.

2.3.4 Rainwater Harvesting

Rainwater can be harvested in underground cisterns (cut in rocks) or in tanks, and can be considered as a traditional or historical water management practice in the Mediterranean region. Rainwater collected from roofs is generally high-quality water which can be used for all domestic purposes except drinking and cooking.

Reuse of rainwater inside buildings requires:
- the installation of a “non-potable” water distribution network, and
- the use of private pumps with their associated operational and maintenance costs.

Rainwater has to be stored to be available during dry periods, where in Mediterranean countries dry periods could range between 90- and 150-days during spring and summer months.

3. Barriers

The adoption of Non-Conventional Water Resources (NCWR) technologies come with challenges of its own, which limit the adoption of these technologies on a wider scale. These challenges where extensively discussed in the Local Water Tables held in the partner countries (Italy, Malta, Tunisia, Jordan and Lebanon) of the NAWAMED Project. These discussions resulted in the identification of seven (7) key barriers to the adoption of NCWR technologies, which are listed hereunder:

(i) Availability of affordable technologies

The low availability of NCWR technologies in the local market (technologies and services) is an important barrier to their adoption by users. Household bio-mechanical grey-water treatment systems are still making their market entry, whilst suppliers of green-walls and constructed wetlands are limited. Hence consumers with an interest of investing in such NCWR technologies find accessibility as an important barrier to the eventual uptake of these technologies.

(ii) Building type and space availability

The dense urban nature of cities limits the opportunities for the application of NCWR technologies due to limited space for their installation. The prevailing dense urban fabric limits the use of traditional wetland type applications, whilst the increased use of multi-story buildings also limits the opportunities for rainwater harvesting installations. Furthermore, the demand for parking space for vehicles, generated in dense urban environments provides also a conflict with land availability for NCWR installations.

Constructed wetlands (reed-beds) are a tried and tested solution for the treatment of grey-water. But such systems require land-area (challenge in urban areas) and a higher level of maintenance/attention. Also, such “open” systems – present a more difficult safety certification framework.

(iii) Perceptions of Users

The perceptions of consumers with respect to non-conventional water resources are generally negative, with the cost, safety and management of these installations featuring strongly as barriers for the uptake of decentralised NCWR installations.

Users’ perceptions need to be addressed through the provision of clear information on NCWR technologies, given that lack of awareness on these technologies also features strongly as a concern.

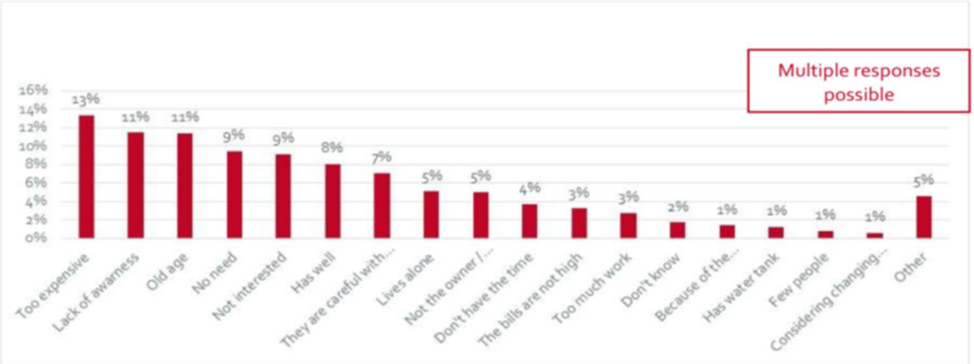

Figure 8: Outcome of a questionnaire undertaken in Malta where users were asked about the primary factors that would constrain them from investing in water saving technologies

(iv) Lack of Regulations

Lack of specific regulations on the reuse of harvested rainwater and/or reclaimed greywater in most of the participating countries. Specific legislation is required which also sets acceptable water quality standards for greywater reuse – which ensure safety.

This situation is further compounded by a weak regulatory framework resulting from the fragmentation of the regulatory responsibilities of different Ministries and Public Institutions with a role in regulating the effective implementation of non-conventional water resources applications. Effective regulatory frameworks need the joint and cohesive involvement from the Health, Environment, Resources, Development and Finance sectors, which is generally difficult to attain, leading to separate and sometimes unaligned sectoral policy frameworks.

(v) Separate plumbing systems (plumbing codes)

Plumbing safeguards are important control mechanisms against contamination. First of all, the mains supplied water should be kept separate from any other water that is supplied form a private source or non-potable water. Therefore, reclaimed greywater and rainwater should be kept separate from the municipal water supply within the domestic distribution system.

No cross connections should be provided within an installation, e.g. from a supply pipe (service pipe up to tank) to a distributing pipe (portion of pipe from tank to faucets). In this manner potentially contaminated water in a distributing system cannot reach the supply pipe. Similarly, no pump or any other device should be connected to cause water to flow back into the supply pipe.

A specific Plumbing Code and training/certification of plumbers would be a pre-requisite to the introduction of greywater treatment systems – to ensure the safety of installations.

(vi) Cost-effectiveness (pay-back period)

The pay-back period of any investment for the installation of NCWR technologies takes into account both the capital and the recurrent costs. Capital costs include the costs related to the equipment and the works required for the installation of the technology, whilst the recurrent costs include all the costs related to the operation of the technology including costs of electricity, chemicals and maintenance. Additionally, the pay-back period depends also on the actual cost of municipal water – namely the water being replaced by the harvested rainwater or the recycled greywater. The higher the cost of municipal water contributes to a shorter pay-back period.

Ideally one should aim to a short pay-back period in the region of a less than 5-years – to make the installation financially feasible for consumers.

(vii) Lack of financial support schemes

The relatively high payback periods for greywater recycling and rainwater harvesting systems can be mitigated through financial support schemes. Such schemes have been widely used, even in the participating countries, to support the uptake of renewable energy and energy efficient technologies such as photovoltaic cells (PVs), solar water heaters and heat pumps. However, currently, there is limited support for new rainwater harvesting or greywater recycling systems intended to support consumers in addressing the additional capital and/or operational costs. The introduction of any such scheme would need to be effectively marketed with both suppliers and consumers.

Support schemes would also give due recognition to the economic externalities generated through the adoption of such schemes.

(viii) Lack of knowledge on Non-Conventional Water Resources

The lack of technical knowledge on Non-Conventional Water Resources applications limits the availability of "service offers" for their installation. Capacity requirements need to be addressed at the planning level (the integration of NCWR installations in the urban fabric), the technical and implementation level (the design of NCWR installations and their actual implementation) as well as the regulatory frameworks for ensuring the safe use of NCWR installations.

These barriers were identified from discussions in the National Water Tables which were undertaken during the course of the NAWAMED project in the participating countries. An outline of the barriers identified by each national water table is presented hereunder:

Table 1: Barriers for the adoption of NCWR technologies as identified in the respective water tables in the partner countries participating in the NAWAMED project

Barrier	Tunisia	Italy[2]	Lebanon	Jordan	Malta
Availability of affordable technologies	✓		✓	✓	✓
Building type and space availability		✓		✓	✓
Perceptions of users	✓		✓	✓	✓
Lack of Regulations – Water Quality Standards	✓	✓	✓	✓	✓
Separate Plumbing Systems (Plumbing Codes)			✓		✓
Cost-Effectiveness (Pay-Back Period)	✓			✓	✓
Lack of Financial Support Schemes		✓	✓	✓	✓
Lack of Knowledge on Non Conventional Water Resources		✓	✓		✓

[2] Italy includes the replies from the Water Tables undertaken in both Latina (Province of Rome) and Sicily.

4. Financial and Economic Feasibility

The application of NCWR solutions in the urban environment, particularly in households and smaller scale buildings needs to take into consideration feasibility issues particularly when compared to the practices and technologies being replaced. NCWR solutions, much like other green solutions, are generally expected to be more costly compared to install, maintain and operate to existing grey technologies and hence their market entry needs to be facilitated.

Assessing the gap between NCWR and existing grey solutions can provide important guidance on the need and level of additional support measures required to promote these solutions and therefore assist the development of appropriate policy measures.

Since related costs vary from country to country, such analysis will need to be undertaken at the level of each country. The scope of this chapter is therefore that of providing a high-level outline of how feasibility analysis can be undertaken.

Feasibility analysis can be limited to financial considerations, where monetary costs and benefits related to the installation, operation and maintenance of the NCWR systems assessed. Economic feasibility analysis additionally takes into consideration the value of external benefits or impacts related to the installation and operation of NCWR systems. The valuation of these external benefits will once more depend on the prevailing local conditions.

4.1 High-level framework for undertaking a preliminary financial feasibility assessment of NCWR Technologies

Financial feasibility assessments generally present the costs and benefits associated with a measure in a balance-type of framework, enabling the estimation of the positive and negative financial impact related to the adoption of the specific measure. In its simplest form, a financial feasibility assessment can assess the pay-back period (i.e. the time needed for the user to recoup the cost).

The main financial cost lines which are considered in financial feasibility assessments include:

(i) the costs related to the installation of the specific NCWR technology (capital cost),
(ii) the operational and maintenance costs, and
(iii) the financial savings achieved through the substitution of water supply – that is the volume of water which is produced by the NCWR system and hence not derived from the conventional supply (according to prevailing tariffs)

The table below presents an outline balance framework for the estimation of the payback period of a greywater recycling system in a household where greywater from showers is used for toilet flushing. The estimation assumes five flushes per day per person in the household with a flushing tank size of 6 litres for a standard toilet and 4.5 litres for a low flush toilet. The water tariffs are set on the tariffs applied in Malta.

Table 2: High-level shower to toilet flushing financial feasibility assessment for a three-person household in Malta for a (i) low tariff band scenario, and (ii) high tariff band scenario

	Standard toilet	Low flush toilet
Litres per flush	6	4.5
Flushes/person/day	5	5
No of occupants	3	3
Total flushes/day	15	15
Daily use (litres)	90	67.5
Annual use (m3)	32.9	24.6
Unit cost of water supply (Eur/m3)	1.4	1.4
Estimated savings from greywater (Eur/year)	45.9	34.4
Cost of greywater system (Eur)	3,500	3,500
Payback (years)	**76**	**102**

	Standard toilet	Low flush toilet
Litres per flush	6	4.5
Flushes/person/day	5	5
No of occupants	3	3
Total flushes/day	15	15
Daily use (litres)	90	67.5
Annual use (m3)	32.9	24.6
Unit cost of water supply (Eur/m3)	5.1	5.1
Estimated savings from greywater (Eur/year)	168.8	126.6
Cost of greywater system (Eur)	3,500	3,500
Payback (years)	**21**	**28**

4.2 Identification of key determining factors which determine the economic feasibility of NCWR Solutions

Economic feasibility assessments give due consideration to ancillary benefits or impacts generated through the installation and use of the NCWR solution. The assessment attempts to provide/estimate a monetary value for these benefits and impacts in order to include them in the balance assessment. Economic feasibility assessments therefore provide a more comprehensive overview of the impact of the particular measure, going beyond strict financial considerations.

In the context of NCWR solutions, external benefits and impacts which could be considered in an economic feasibility assessment include:

(i) the lower dependence on natural water resources (saving natural water resources);
(ii) the lower use of energy to produce and distribute the water (hence less emissions associated with energy production);
(iii) reduction in building temperature through the use of green solutions on the building fabric;
(iv) optimisation of the urban environment through the use of green solutions, including improved aesthetics which can affect the value of the property;
(v) improvements in the quality of air arising from the installation of green infrastructures;
(vi) in the case of communal infrastructures, the benefit generated in the community through the use of the harvested or treated water; and
(vii) benefits related to the reduction of flood risk in urban areas (risk of flash floods).

4.3 Variability in the importance of these factors across the different countries

The outcomes of financial and economic feasibility assessments are highly dependent on local conditions, and variable outcomes are possible reflecting the different weight of key assessment factors such as:
(i) water and energy tariff structures,
(ii) labour costs (particularly in relation to installation and maintenance costs), and
(iii) the cost of equipment, particularly when this has to be imported).

The plots below illustrate the high variability in two key factors – water consumption per capita and water price (tariff) in the countries participating in the NAWAMED project. Higher tariffs and higher per capita consumptions tend to favour the feasibility of the specific NCWR technology; however, such factors may be balanced by differences in other cost factors. Thus, the need for comprehensive assessments considering as broad a range of financial and economic factors as possible.

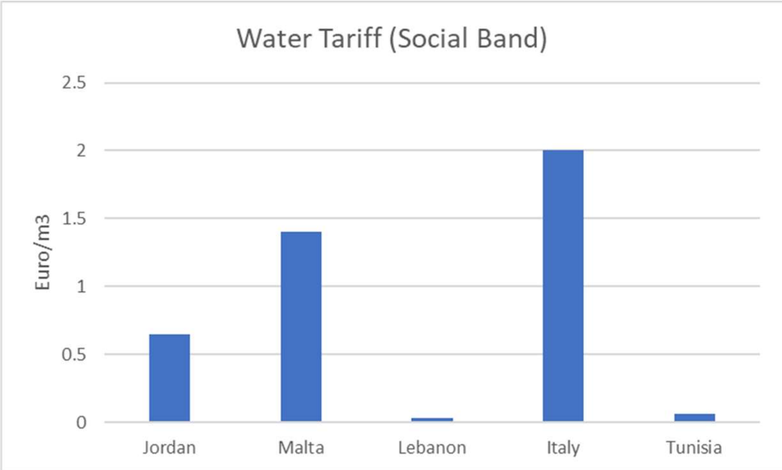

Figure 9: First (or social) band of the water tariffs in the countries participating in the NAWAMED project

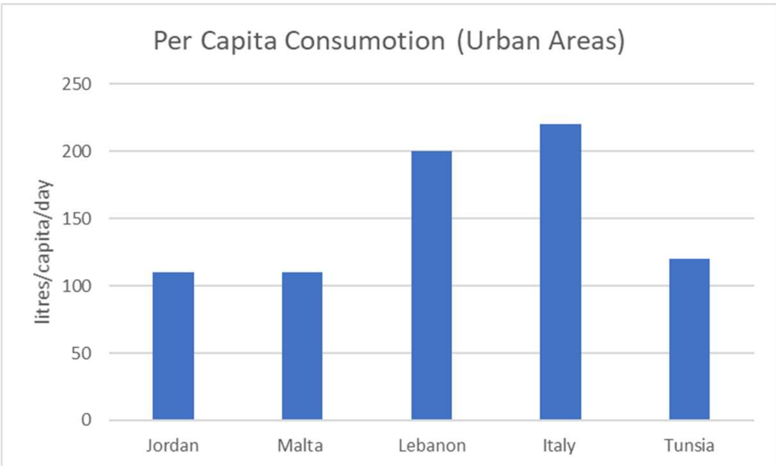

Figure 10: Water consumption per cpaita in urban areas in the countries participating in the NAWAMED project

5. Solutions

5.1 Addressing identified barriers

The promotion of NCWR solutions starts with addressing the identified key barriers, particularly those which are common across the region. An outline of the key

(i) Increasing the knowledge base

The development of focused training opportunities at the design and technical level on the application of NCWR solutions is warranted to ensure that such solutions are offered by professionals addressing the development of the urban sector and to ensure the necessary resource base to facilitate the installation and implementation of these solutions on site. Therefore, training on NCWR solutions needs to be further integrated in academic courses for building design (such as architecture and engineering) and technical applications (such as technician courses).

(ii) Development of Institutional and Regulatory capacity

The integration of NCWR solutions in water management planning needs to be accompanied by the development of robust regulatory frameworks to ensure the safe application of these solutions, particularly in a vulnerable context as urban areas – where ensuring safety and health of users is of paramount importance. Therefore, policies should aim to establish clear regulatory roles and responsibilities, enabling regulatory entities to establish standards and benchmarks to enable their effective enforcement.

(iii) Determining Quality Standards

The establishment of clear quality standards for water produced from NCWR solutions for secondary use in the urban environment would enable technology developers and suppliers to have clear targets for the future development of these technologies. Increased clarity will support the market availability of safe technologies enabling the further uptake of these solutions. Standards should also look at the integration of NCWR solutions within the building fabric, and thereby the integration of NCWR solutions in building codes is warranted.

(iv) Promotion of NCWR applications

The promotion of available NCWR solutions which can be applied in the urban sector and the challenges related to their application with the public at large is an important step in the development of the demand for NCWR solutions. Media campaigns promoting NCWR solutions giving practical examples of their application and their potential impact are an important element to be undertaken in support of NCWR solutions.

(v) Financial Support Schemes

Financial schemes to support users in adopting NCWR solutions should be considered, as long as such solutions remain financially more expensive than traditional "grey" solutions. The element of financial support of such schemes should ideally reflect the economic benefits arising from the application of NCWR solutions and therefore provide recognition to the environmental and social/community benefits which the application of NCWR solutions is generating.

5.2 A Common Mediterranean Approach

Mediterranean countries are increasingly facing similar challenges related to water management, where particularly due to the impact of climate change episodes of prolonged drought and associated water scarcity are becoming increasingly common. All countries have developed adaptation and mitigation measures to address these emerging challenges, most of the time in isolation from each other. It is therefore important that experiences are shared so that all Mediterranean countries can together develop stronger adaptation frameworks, including on the application of NCWR solutions, based on the positive and negative experiences gathered throughout the years.

A comprehensive regional policy supporting the promotion of NCWR solutions provides opportunities for linking up with the WASH – Water Access, Sanitation and Hygiene priority under the Union for the Mediterranean's Water Agenda, highlighting the role of decentralised NCWR solutions facilitating access to water and sanitation whilst addressing water demand.

Importantly, NCWR solutions cannot be promoted in isolation but within an integrated water management framework which promotes NCWR as part of a comprehensive solution for addressing water supply and sanitation security whilst ensuring a high level of protection for the water environment. NCWR solutions are therefore to be considered as part of the solution and not the sole solution which can address water management in the Mediterranean.

Finally, it is important that the promotion of NCWR solutions is accompanied by the parallel development of a financial support framework which supports the development and adoption of these solutions, and which gives due consideration to the environmental and social benefits generated through their adoption within an integrated water management framework.

6. Conclusion - Vision

6.1 High Level Policy Message

The NAWAMED Project highlights the safe-adoption of Non-Conventional Water Resources (NCWR) such as rainwater harvesting and greywater treatment solutions as a central measure to address water supply security in urban areas within the Mediterranean region. NCWR solutions can supplement stressed natural freshwater resources by addressing specific water demands, particularly for addressing secondary water uses such as landscape irrigation and toilet flushing.

NCWR applications provide opportunities for increasing water use efficiency within urban areas, enabling the better management of demand in urban water demand hotspots. NCWR applications can potentially reduce the per capita water demand, by introducing feedback loops within the urban water cycle and enabling the need for water use in households to be addressed through the need of a lower input of water from the municipal supply. Hence this ensures the better management of natural freshwater (or conventional) resources, which generally are the principal resources in municipal water supplies, by lowering demand pressures and therefore ensuring their long-term protection.

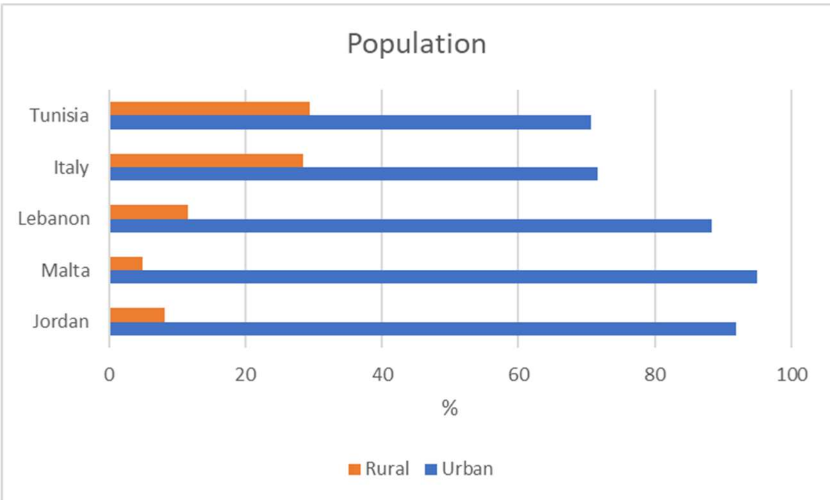

Figure 11: % of population living in urban and rural areas in NAWAMED countries

Furthermore, the application of NCWR solutions in urban areas provide additional environmental and social benefits such as increased urban greening, optimised flood risk management, urban temperature control and improved air quality which need to be considered as part of a comprehensive urban regeneration framework, particularly in view of challenges arising due to Climate Change.

6.2 Why NCWR?

An increase in the water demand in Mediterranean urban areas is projected for the coming decades due to demographic shifts which will see the consolidation and expansion of big urban centres (cities) but also due to climate change which will reduce the availability of freshwater resources whilst in parallel creating conditions conducive for a higher water demand. In as much, the impact of cities on the natural water environment will increase where lower availability of natural freshwater resources compounded with higher water demands will increase the risk of water supply security failures. Therefore, the need to develop increasingly resilient water management frameworks. NCWR solutions offer the potential of a decentralised water supply framework introducing an internal water efficiency loop in the urban water cycle – lowering the input (volumetric) requirements and hence the pressures on natural freshwater resources. NCWR when applied within a comprehensive water management framework therefore provides the opportunity for the increased protection of natural freshwater resources ensuring their long-term capacity to sustain national water demands.

6.3 Key Policy Measures to bring about adoption of NCWR technologies

The NAWAMED Project has analysed the policy framework required to effectively promote the uptake of NCWR solutions in the Mediterranean region. The outcome of this analysis highlights the following four key measures, required to ensure the safe adoption of NCWR solutions and ensure that these increasingly sustain urban water management frameworks in the region:

- **Investing in Capacity Building**, at both the technical, planning and institutional level to ensure that professionals involved in the development and water sectors are prepared to manage the inclusion of NCWR solutions in future urban water management frameworks.

- **Clear Regulatory Framework**, which establishes the roles and responsibilities of authorities in approving and promoting NCWR solutions as well as water quality standards and building codes intended to ensure the safe application and use of these solutions.

- **Financial Incentives**, to support the financial gap between the application of NCWR solutions and conventional grey infrastructures, taking due consideration of the social and environmental benefits generated through the adoption of NCWR solutions.

- **Promotion of NCWR solutions**, with the general population to increase awareness on these solutions and their potential benefits in the urban environment. Increasing awareness leads to increased demand and hence increased uptake of these solutions.

6.4 Broader Perspective

The application of NCWR solutions needs to be considered within a broader urban area management framework, given that NCWR solutions' contribution goes beyond water demand management. In fact, the application of NCWR solutions can be framed within broader policy frameworks such as those related to climate change adaptation, decarbonisation, flood risk management, and urban health. Hence the need of considering the application of NCWR solutions within broader urban development frameworks fully integrating NCWR measures within broader urban area management plans, and therefore going beyond the strict confines of the water sector.

Additionally, the application of NCWR solutions in an urban context supports the achievement of the following Sustainable Development Goals, enabling the integration of these solutions within a broader sustainable development framework:
- Clean water and sanitation (SDG 6),
- Sustainable cities and communities (SDG 11),
- Climate action (SDG 13), and
- Life on land (SDG 15).

Figure 12: Sustainable Development Goals (SDGs) supported through the application of NCWR solutions in the urban environment

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