DOC n°1 – WP4.2.1	First draft on: 5th March 2013
	Final draft on: 30th March 2014

Feasibility study on SWMED solutions for the project target areas in Malta

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1. Analysis and selection of the target areas

1.1 Summary

This document aims to present the feasibility study developed by the Malta Resources Authority and the Ministry for Gozo, partners of the project SWMED – Sustainable Domestic Water Use in Mediterranean Regions in order to support the integration of ad-hoc sustainable strategies into the Mediterranean local/regional policies.

During the development of this study, the specific characteristics of urban, rural and touristic areas in the island of Gozo were analysed in order to allow the identification of the best suite of measures which can be considered for optimising the management of water demand and wastewater re-use in the island of Gozo. This also with a view of developing national and regional policies aimed at reducing the water demand of the municipal sector, and thereby contributing to the sustainable use of water resources.

The identification of these characteristics was enabled through the collaboration of the Water Services Corporation, the main public utility in the Maltese islands in as much as water production, distribution and wastewater collection facilities are concerned and the National Statistics Office in relation to water use data. Specific local information on the anthropogenic characteristics of these urban typologies was collated by the Ministry for Gozo, which is a regional administration together with the collaboration of Local Councils (local authorities) present in the island.

This analysis was undertaken on an island-level and no specific representative localities were considered. Instead the analysis focused on the main broad typologies identified, namely urban, rural and touristic agglomerations/villages and this with the scope of developing the necessary information base which can lead to a policy document which can be broadly applicable to the whole island of Gozo.

1.2 Regional Scenario

Gozo is the second largest island in the Maltese archipelago. It covers 67 square kilometres and has a population of 31,052 of whom 6,400 live in its capital Victoria, also known as Rabat. The island which lies approximately 6 kilometres north-west of the nearest point of the main island of Malta, is of an oval form, and is 14 kilometres long and 7.25 kilometres wide.

Water services in the island are provided by the Water Services Corporation, which is the main public utility in the Maltese islands. All the urban, rural and touristic areas in the island are connected to the municipal water distribution network, which supplies water which reaches the quality standards required under the European Union's Drinking Water Directive. Furthermore, the same areas are all connected to the centralised sewage collection network, with all the sewage collected being conveyed to a single outflow point at Ras il-Hobz located on the south-eastern coast of the island.

The main source of water utilised for the purposes of the municipal supply in the island is the sea level aquifer system which practically underlies the whole island, with the exception of a small area around the harbour of Mgarr. The higher areas of the island present a number of small perched (high lying) groundwater systems sustained by the occurrence of impermeable marly geological formations. Although these low yield aquifer systems are not exploited by the Water Services Corporation, they are still utilised by the domestic sector through a relatively high number of old hand-dug wells (locally known as spieri). Due to their variable quality and low yield, groundwater abstracted from these wells is primarily used for secondary purposes such as gardening/landscaping or various washing purposes.

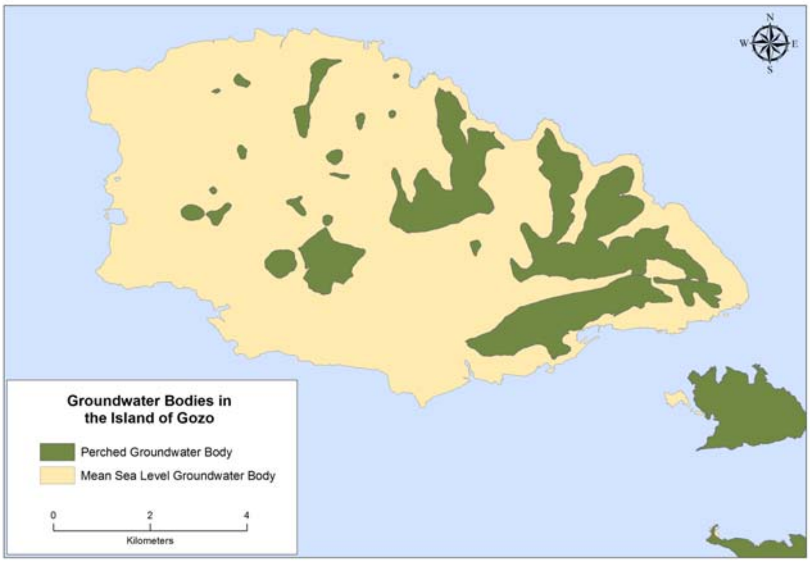

Figure 1: Groundwater Bodies in the island of Gozo

The abstraction of groundwater for the purpose of municipal supply by the Water Services Corporation is undertaken through 75 boreholes and 2 pumping stations tapping the Gozo sea-level aquifer system. Production from these groundwater sources is supplemented with desalinated water produced at the Cirkewwa Reverse Osmosis plant located in the northern coastal area of Malta, and which reaches the island of Gozo through a submarine pipeline. Water transfer from Malta through this submarine pipeline accounts for around 20% of the municipal water distributed in the island.

Groundwater abstracted from the above mentioned boreholes is collected in a main distribution reservoir located at Ta Cenc, on the south-eastern part of the island. In order to attain the quality levels required by the European Union's Drinking Water Directive, part of this groundwater is polished through a low-pressure reverse osmosis system in order to reduce its salinity. This, to ensure that the water supply blend from the whole of the Gozo well-field achieves the established quality requirements of the Directive. In periods of high water demand, desalinated water transferred from the island of Malta is also introduced to the municipal supply system at this reservoir. Due to its high quality, this desalinated water has a positive impact on the water supply of the island. It is noted that raw abstracted groundwater is not delivered directly to the consumers, but delivery of water is only undertaken following blending and polishing at the Ta Cenc reservoir complex.

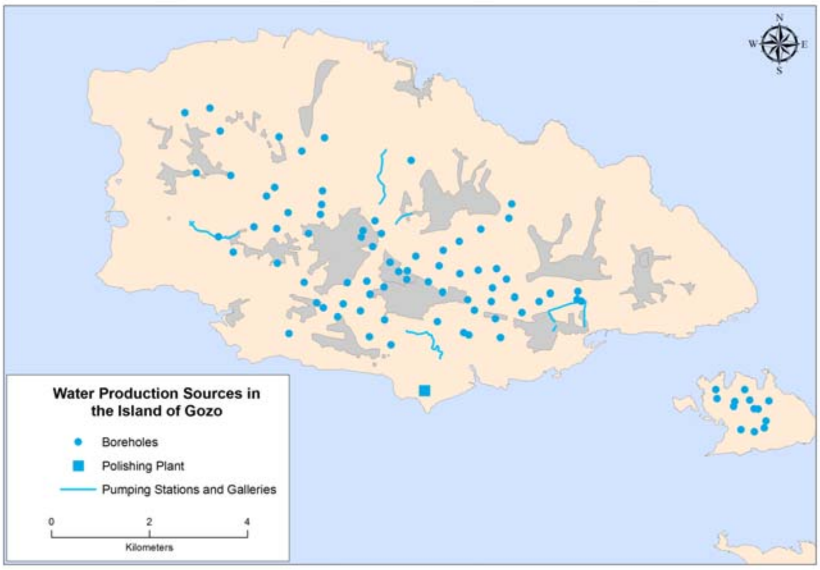

Figure 2: Public Groundwater Abstraction Sources in the island of Gozo

The municipal water distribution network reaches all the built-up agglomerations of the island. From an island perspective, it is noted that the Water Services Corporation has been undertaking a focused programme of network maintenance and management aimed at reducing the level of leakages from the distribution system. In fact, the distribution network in the island of Gozo has reached levels of the order of 1.2 on the Infrastructure Leakage Index scale developed by the International Water Association. This entails that leakage levels have practically been reduced to practically the lowest technically achievable levels.

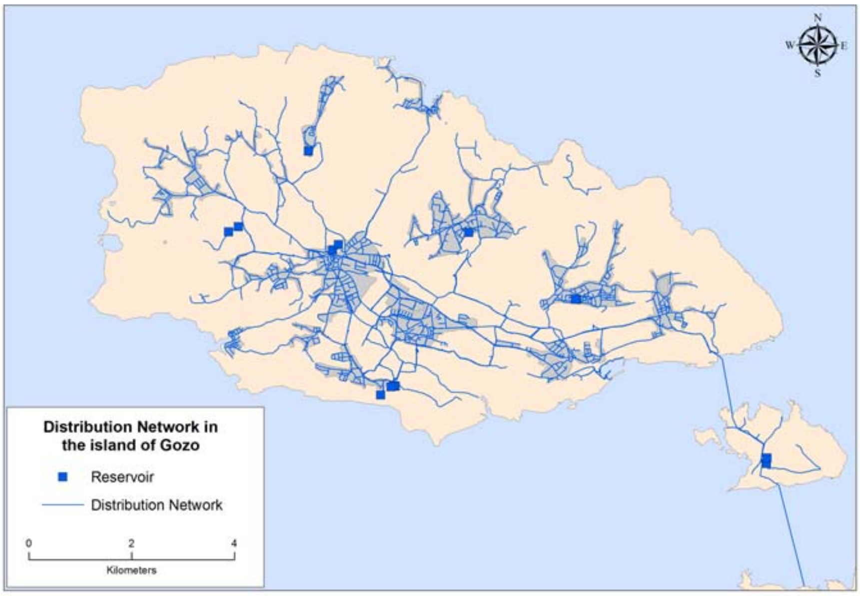

Figure 3: Municipal (Drinking Water) distribution network in the island of Gozo

The annual water production by the Water Services Corporation in the island of Gozo varies between 2.5 and 3 million cubic metres. Table 1 below presents a detailed breakdown of water production and consumption during the last ten years.

Year	Groundwater Production (m3)	Desalinated Water Transferred from Malta (m3)	Total Water Production (m3)
2001	2,321,222	133,030	2,454,252
2002	2,278,766	240,439	2,519,205
2003	2,180,825	380,879	2,561,704
2004	2,146,660	450,355	2,597,015
2005	2,205,559	344,618	2,550,177
2006	2,251,504	488,300	2,739,804
2007	2,357,428	517,073	2,874,501
2008	2,480,542	479,460	2,960,002
2009	2,288,012	638,290	2,926,302
2010	2,195,921	488,360	2,684,281
2011	2,079,210	515,280	2,594,490

Table 1: Municipal Water Production in the island of Gozo

The sewage produced in the island is all collected through a centralised sewerage network which is also managed by the Water Services Corporation. Similarly to the municipal water distribution system, the sewer network reaches all the built-up agglomerations of the island. The sewerage network conveys all the sewage to a single outflow point at Ras il-Hobz on the south-eastern coast of the island. A wastewater treatment plant (conventional biological treatment plant) has been developed at the discharge point to treat all the sewage prior to its discharge to the sea. The treatment capacity of this wastewater treatment plant amounts to around 6,000 cubic metres of sewage per day.

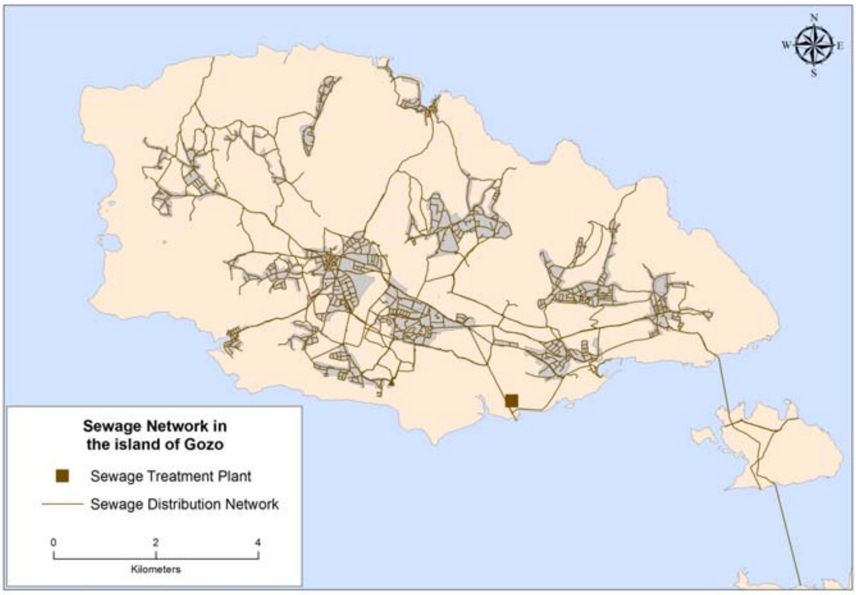

Figure 4: Sewerage network in the island of Gozo

Further polishing facilities are currently being installed at this wastewater treatment plant in order to enable the production of a treated effluent of a sufficiently high quality to enable its re-use. This polishing plant will consist of an ultra-filtration unit coupled with a low pressure reverse osmosis unit able to produce around 3200 cubic metres per day of highly polished reclaimed water. The envisaged use of this reclaimed water is primarily for secondary uses such as irrigation, landscaping and alternative uses in industry. A main distribution network to supply this reclaimed water to the point of use is also being planned.

1.3 Criteria of Selection of the target areas

The study undertaken in Gozo did not focus on specific target areas but instead considered the main built-up environments of the island. Three broad categories were identified, namely:

(i) urban areas – mainly comprising the larger villages of the island (Fontana, Ghajnsielem, Kercem, Nadur, Qala, Xaghra, Xewkija and Zebbug) and the regional capital of Victoria. This category is mainly considered as including densely populated areas and medium to large urban centres.

(ii) rural areas – mainly comprising the smaller villages and other small agglomerations such as Gharb, Ghasri and San Lawrenz. This category is mainly considered as including low-density built-up environments.

(iii) touristic areas – mainly confined to the two localities of Xlendi and Marsalforn. These localities include a significant number of dwellings which are used as summer residences and therefore experience high fluctuations in their municipal water demand depending on the season.

1.4 Description of the sites

1.4.1 Urban Areas

The urban areas under consideration are mainly comprised of historical village cores surrounded by a newer and relatively high density built-up environment. These areas are fully connected to the main water distribution and sewage collection network of the Water Services Corporation. Their densely built-up characteristics preclude the development of new water management facilities, particularly as regards rainwater harvesting and wetland-based greywater recycling facilities, and in as much any measures developed need to be contained within the urban fabric.

Locality	Occupied Households	Population (2011)
Fontana	321	882
Ghajnsielem	890	2645
Gharb	427	1196
Ghasri	160	431
Kercem	582	1718
Munxar	371	1068
Nadur	1438	3973

Qala	654	1811
Victoria	2139	6252
San Lawrenz	212	610
Sannat	605	1837
Xaghra	1393	3968
Xewkija	1098	3143
Zebbug	670	1841

Table 2: Number of occupied households by locality

1.4.2 Rural Areas

The rural village areas, in particular the villages of Gharb, Ghasri and San Lawrenz present typical old village cores with an extremely low density urban development. Most of the houses in these localities have medium to large gardens/yards and are expected to have surface or sub-surface facilities for the harvesting of rainwater runoff. In as much, these localities present a wider scope for the application of different water demand management measures.

1.4.3 Touristic Agglomerations

The touristic agglomerations of Marsalforn and Xlendi are mainly small fishing villages located by the sea. Marsalforn is found in the north of Gozo whilst Xlendi is located on the western coast of the island. From an administrative perspective, both are not localities in their own right but form part of the Zebbug and Munxar Local Councils respectively.

These localities include a significant number of holiday homes and tourist establishments and therefore their population of Marsalforn and Xlendi varies considerably between the winter and summer seasons. Population peaks during the summer season and in particular during the month of August when internal tourism (from Malta) is at its highest levels.

From a water management perspective, these areas bring about the added challenge related to the adoption of water saving measures by the non-resident population. Measures targeting the resident village population are not expected to have a marked water saving impact, and this due to the high number of local and foreign tourists who significantly outnumber the local population. The water consumption of holiday establishments is generally higher than that of the resident population, since people tend to focus less on environmentally friendly measures when on holiday. This situation therefore calls for soft measures targeting the major consumers of water in these tourist agglomerations, namely hotels and touristic establishments.

2. Elaboration of alternative options

The elaboration of alternative options in the case of the island of Gozo has to take full consideration of the specific characteristics of all the built-up typologies identified; namely that all are fully connected to both the municipal water supply network and the main sewer network. Furthermore national policies in regard to the centralised reuse of treated sewage effluents need also to be considered.

In fact, this situation precludes the consideration of delocalized black and grey water treatment techniques such as constructed wetlands in the case of all the built-up typologies in the island of Gozo.

The options considered thus mainly focus on devices which can optimise the use of water supplied through the municipal distribution network. Rainwater harvesting is mainly considered for the rural agglomerations.

The development of the alternative options also considered the characteristics of household water use prevalent in the Maltese islands, a breakdown of which is presented in figure 5 below.

In this respect it is noted that by far the most important water uses in the home are toilet flushing and personal hygiene which between them account for around 55% of all water used. The options developed and analysed in this report were mainly devised to address these water use characteristics

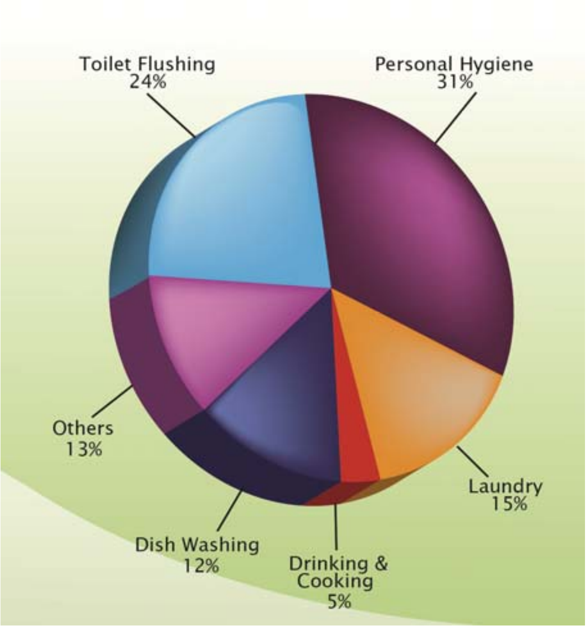

Figure 5: Water use characteristics in Maltese households

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2.1 Water Flow Restriction Devices

The first set of measures being considered are devices which reduce the flow of water at the main outflow points of the home such as faucets and showers. Essentially for the purpose of this project, water efficient shower heads (Figure 6) and tap aerators (Figure 7) are being considered. These devices are considered as soft-measures which are applicable to all the built-up typologies of the island since once fitted they will reduce the flow and therefore the consumption of water.

It is noted that the water efficient shower head presents an improved margin for the reduction of water consumption compared to tap aerators due to the fact that it addresses the 31% of water use in the home for personal hygiene.

Figure 6: Water Efficient Shower Head

The main challenges with respect to these devices are two fold:
(i) the identification of the means of engaging the eventual user to effectively install the device; and
(ii) establish the optimum balance between the reduction in flow and the user experience of water flow to ensure that once the device is installed, this is not removed by the user.

Figure 7: Tap - aerators

These devices are particularly interesting for touristic agglomerations, where they offer the possibility of reducing the consumption irrespective of the level of awareness of the eventual user.

2.2 Volume displacement devices

Volume displacement devices address water use in toilet flushings. The introduction of 1 or 2-litre toilet tank bag in the flushing will ensure the use of a lower volume of water with each flush. These too can be considered as soft measures, which however require the effective engagement of the eventual user to ensure that they are effectively installed in the flushings.

Figure 8: Toilet Tank Bag

This measure-type is applicable for all the three built-up environments considered in this study. It is however noted that the eventual uptake of the measure by the users is an important factor which must be taken into consideration when assessing the utilisation of these devices.

2.3 Water efficient appliances

Dishwashing and laundry activities are estimated consume 12 and 15% respectively of all water used in the households. An effective way of addressing this water consumption category is through incentivising the replacement of existing appliances such as dishwashers and washing machines with more efficient ones.

It is estimated that new water efficient appliances can reduce water consumption by as much as 20%; and can thereby provide a significant water saving margin.

This measure-type is applicable for all the three built-up environments considered under this study.

2.4 Behavioural Change Measures

These types of measures require a high level of engagement with the eventual user since to be effective they require direct and timely inputs from the user when actually utilising the water outflow point. For the purpose of this feasibility study, two such devices which target water use in the shower are being considered:
(i) shower on-off switch; and
(ii) shower timer

Figure 9: Shower on-off switch

The shower on-off switch permits the user to stop water flow with the push of a button. Therefore water flow can be stopped when one is lathering, to be immediately resumed to continue showering.

The shower timer is used to help the user gauge the time spent showering. An alarm goes off after a pre-set time to make the user aware that he has exceeded the intended 'showering time'. The timer allows the user to set a personalized 'showering time'. Since water consumption when showering is directly proportional to the time spent under the shower, reduction in 'showering time' results in a lower water consumption.

2.5 Rainwater harvesting

The collection of roof rainwater in underground cisterns is a historic practice in the Maltese islands, which has been a requirement by law since the mid-16th century.

However, unfortunately during the 20th century, when most of the current housing stock was built, this law was rarely observed. Therefore most recent developments lack such rainwater harvesting facilities, and due to the dense urban fabric – the retro-construction of such facilities is impracticable.

Figure 10: Shower Timer

Roof rainwater harvesting offers a significant alternative source of water in the domestic sector, since collected rainwater can be used for secondary household purposes such as for various washing purposes, toilet flushing and garden irrigation. It is estimated that the use of a 25m3 rainwater harvesting cistern can reduce household water consumption by around 40%.

Current initiatives in this regard are therefore aimed at incentivising the use of existing cisterns by part-financing their repair and the establishment of a second class distribution system to enable the effective use of the harvested rainwater.

The application of such measures is deemed to be most applicable to old village cores where a high density of cisterns is expected.

2.6 In house grey-water recycling

In house grey-water recycling systems offer a significant water saving potential in as much as they can recycle water from various washing activities for use in toilet flushings and gardening purposes.

An analysis of existing systems was undertaken in the frame of this study, in order to assess the applicability of these solutions to the characteristics of households in the areas being considered. The main focus of this analysis was on the ease of retrofitting such systems in current households. No applicable systems were found and the application of these systems was therefore not considered in the frame of this feasibility study.

2.7. Sustainable urban drainage systems

A further water management opportunity which was analysed under the frame of this study relates to the use of sustainable urban drainage systems such as green roofs and permeable pavings, the application of which can reduce rainwater runoff loss from existing households.

The use of such systems was however not considered in the feasibility evaluation since the application of such measures does not lead to effective reductions in the household water consumption.

Figure 11: Inhouse grey-water recycling systems

3. Assessment of the potential impact of the proposed measures

The analysis of potential measures and their applicability to each of the three built-up scenarios undertaken under the previous chapter was used to develop different water saving programmes for each of the built-up typologies.

This assessment also considered the water consumption characteristics of Maltese households to ensure that the water saving devices chosen address the main water use characteristics of the island. An outline water consumption of a typical Maltese household (in l/cap/day) is presented in table 3 below.

Use-Typology	l/cap/day
Personal Hygiene	42.8
Toilet Flushing	31.9
Washing Clothes	19.9
Dishwashing	16.4
Drinking and Cooking	6.6
Other Uses	17.5

Table 3: Water consumption characteristics (average) in Maltese households

3.1 Potential reduction in water consumption

Three water saving solutions were developed specifically for urban, rural and touristic agglomerations and their respective water saving impact per household was assessed.

3.1.1 Urban Areas

The densely built-up characteristics of urban areas led to the choice of a set of soft measures focused on the retrofitting of existing water outflow points and water using appliances. This in order to ensure the ease of application/implementation of such measures. At this stage, the prevailing lack of existing rainwater harvesting facilities within the existing housing stock preclude the inclusion of measures focusing on rainwater runoff harvesting, since the development of such rainwater harvesting facilities within the urban framework was not considered as feasible.

The suite of measures considered for urban areas therefore include:
(i) Application of water saving devices and volume flow reducers. The water saving impact of these devices is assumed at 15% of all water used in taps, showers and toilet flushings
(ii) Installation of water saving appliances in households, through incentivised tax-rebates. The saving effect of this measure is estimated to amount to 20% of all water used by such appliances.
(iii) Undertaking a water saving campaign through the distribution of awareness raising devices and information on how to reduce water consumption. Given the high dependency on the acceptance and behavioural change of the user, the water saving effect of these measures is difficult to quantify.

The water saving impact of these measures is:

Measure	Saving Effect	Current Water Consumption	Potential Saving impact per person per day
Water saving devices and volume displacers	15% of all water used in taps, showers and toilet flushings	74.7l	11.2l
Replacement of water using appliances	20% of all water used by such appliances	36.3l	7.25l
Total saving effect of the proposed measures			18.45l

Table 4: Water Saving impact for measures developed for urban areas

The potential saving effect of these measures therefore amounts to around 13.6% of all water consumed in households.

The saving effect of such a campaign, assuming a 100% uptake of the proposed measures, in the main urban areas of the island is presented in table 5 below.

Locality	Population	Volume of water saved in one year through the application of the identified measures (litres)
Fontana	882	5939608.5
Ghajnsielem	2645	17812091
Kercem	1718	11569442
Munxar	1068	7192179
Nadur	3973	26755175
Qala	1811	12195727
Victoria	6252	42102531
Sannat	1837	12370817
Xaghra	3968	26721504
Xewkija	3143	21165748
Zebbug	1841	12397754
Total Saving Effect (litres)		**196222577**

Table 5: Potential Water Saving impact of the proposed measures in urban areas assuming a 100% measure uptake.

3.1.2 Rural Areas

Rural areas were considered as offering an improved scenario for the application of water saving measures, mainly due to the applicability of rainwater harvesting systems.

The suite of measures developed therefore reflects the measures developed for urban areas with the addition of incentive schemes for the use of rainwater harvested in existing cisterns. The water saving effect of this particular measure is estimated at 50% of all water used for toilet flushings, household washing purposes and gardening.

The water saving potential of these measures is estimated at:

Measure	Saving Effect	Current Water Consumption	Potential Saving impact per person per day
Water saving devices and volume displacers	15% of all water used in taps and showers.	42.8	6.4l
Replacement of water using appliances	20% of all water used by such appliances	36.3l	7.25l
Use of harvested rainwater runoff for household secondary purposes	50% of all water used for toiler flushings, household washing purposes and gardening	49.4l	24.7l
Total saving effect of the proposed measures			38.4l

Table 6: Water Saving impact for measures developed for rural areas

The potential saving effect of these measures therefore amounts to around 28.4% of all water consumed in households located in rural environments.

The saving effect of such a campaign, assuming a 100% uptake of the proposed measures, in the main urban areas of the island is presented in table 7 below.

Locality	Population	Volume of water saved in one year through the application of the identified measures (litres)
Gharb	1196	16763136
Ghasri	431	6040896
San Lawrenz	610	8549760
Total Saving Effect (litres)		**31353792**

Table 7: Potential Water Saving impact of the proposed measures in urban areas assuming a 100% measure uptake.

3.1.3 Touristic Areas

The specific characteristics of touristic areas with a high proportion of holiday homes allow for the implementation of soft and indirect water demand management measures. This due to the fact that the lack of a resident population is expected to result in a lower awareness level and therefore a lower adoption rate for direct measures.

Measure	Saving Effect	Current Water Consumption	Potential Saving impact per person per day
Water saving devices and volume displacers	15% of all water used in taps, showers and toilet flushings	74.7l	11.2l
Total saving effect of the proposed measures			11.2l

Table 8: Water Saving impact for measures developed for touristic areas

The potential saving effect of these measures therefore amounts to around 8.3% of all water consumed in households located in touristic agglomerations. The quantification of the saving effect of these measures is difficult due to the lack of data on the non-resident population of these localities.

3.2 Estimated cost of the proposed measures

Initial cost estimates for all the proposed options in the three identified area categories are also being presented.

3.2.1 Urban Areas

The estimated cost per household of the measures developed for urban areas are outlined in table 9 below.

Measure Type	Device	Estimated cost per household (Euro)
Water Flow Restrictor	Efficient Shower Head	4.02
	Aerator Type 1	5.25
	Aerator Type 2	1.74
Volume Displacement	Toilet Tank Bag	0.78
Water Efficient Appliances	Tax Rebate on new Water Efficient Appliances	15% of price of appliance, capped at a maximum of Eur100
Awareness	On-Off Switch	3.86
	Shower Timer	2.50

Table 9: Estimated costs for the measures developed for urban areas.

3.2.2 Rural Areas

The estimated cost per household of the measures developed for rural areas are outlined in table 10 below.

Measure Type	Device	Estimated cost per household (Euro)
Water Flow Restrictor	Efficient Shower Head	4.02
	Aerator Type 1	5.25
	Aerator Type 2	1.74
Volume Displacement	Toilet Tank Bag	0.78
Water Efficient Appliances	Tax Rebate on new Water Efficient Appliances	15% of price of appliance, capped at a maximum
Restoration of domestic cisterns	Fiscal incentive for undertaking the restoration of cistern and the installation of distribution systems	Grant up to Eur1500
Awareness	On-Off Switch	3.86
	Shower Timer	2.50

Table 10: Estimated costs for the measures developed for rural areas

3.2.3 Touristic Areas

The estimated cost per household of the measures developed for touristic areas are outlined in table 11 below.

Measure Type	Device	Estimated cost per household (Euro)
Water Flow Restrictor	Efficient Shower Head	4.02
	Aerator Type 1	5.25
	Aerator Type 2	1.74
Volume Displacement	Toilet Tank Bag	0.78

Table 11: Estimated costs for the measures developed for touristic areas

4. Evaluation of the proposed scenarios based on a multi-criteria analysis

It is noted that the multi-criteria analysis table developed as part of the project is significantly biased on waste-water re-use applications and in as much does not fully apply to the scenarios developed as part of the Gozo case study. Nonetheless relevant categories in the table were given their respective weights.

Health issues		weight (1-5)
Don't causes any risk of	additional mosquitoes (or other insects) growth	n/a
	illness	n/a
Reduced exposure to pathogens	of users	n/a
	of waste workers	n/a
	of resource recoverers /reusers	n/a
	of "downstream" population	n/a
Impact to environment / nature		**weight (1-5)**
Use of natural resources	Minimize water supply use	5
	Low land requirements	5
	Low energy requirements	5
	Uses mostly local Construction material	n/a
Low emissions and impact To the environment	Surface water	n/a
	Ground water	n/a
	soil/ land	n/a
	Air	n/a
	Noise and vibration	n/a
	aesthetic	n/a
	odours	n/a
Good possibilities for Nutrients Recovering resources	energy	n/a
	Organic matter	n/a
	Water	n/a
	Landscape integration	n/a
Technical issues		**weight (1-5)**
allows simple construction		n/a
low level of technical skills required for construction		n/a
High level of efficiency (wastewater input/depurated/timing)		5
Purification capcity (wastewater depurated/soil used by the plant)		n/a
Has high robustness and long lifetime/high durability		5
Enables simple and low operational procedures		5

Low maintenance and low skills required	5
Not reliant on a continuous supply of a resource (such as water or energy)	n/a
Adaptable to unexpected future changes (adaptability)	5
Good quality of effluent (according to the receiving environment)	n/a
Amount and quality of generated sludge	n/a
Reduction of the imbalance water at the basin level	n/a
Economical and financial issues	weight (1-5)
Provides benefits to the local economy (business opportunities, local employment, etc.)	2
Provides benefits or income generation from reuse	n/a
Social, cultural and gender	weight (1-5)
Improves quality of life	1
Requires low level of awareness and information to assure success of technology	4
Requires low operation & maintenance and little involvement by the user/worker	4
High level of satisfaction of the local people regarding the implemented technology	3
Requires low policy reforms at local, regional or national level.	4
Educational impacts	4
Costs	Weight (1-5)
Investment cost (USD)	1
Maintenance cost (USD/year)	1

5. Conclusions

5.1 Definition of the optimal alternative

The solutions analysed in the feasibility study undertaken in the island of Gozo were mainly centred on the retrofitting of existing water outflow points in the home, so as to achieve a more efficient use of water. The alternatives analysed are thus mainly composed of indirect/soft solutions which can be adapted to the specific built-up environments of the island.

The implementation of the proposed solutions needs a high level of engagement of the resident population. Any future measures in this regard will therefore need to be complemented by a wide awareness raising campaign to ensure that the people living in the target areas are made aware of the need to use water sustainably.