A Strategic Framework for Green Stormwater Infrastructure across the Maltese Islands

GOVERNMENT OF MALTA
MINISTRY FOR PUBLIC WORKS AND PLANNING

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Glossary

Green stormwater infrastructure (GSI) is a suite of rainwater management tools that use both engineered and nature-based solutions to protect, restore, and mimic the natural water cycle.

Green stormwater infrastructure (GSI) **Strategy** is a stormwater management strategy that seeks to mitigate the impacts of increased runoff and stormwater pollution. GSI practices manage runoff as close as possible to the source in order to preserve or restore pre-development hydrologic and ecological functions. To preserve pre-development functions, GSI uses site design to minimize runoff and to protect natural drainage patterns. To restore pre-development functions, GSI uses distributed structural practices that filter, detain, retain, infiltrate, evapotranspire, and harvest stormwater. GSI practices can effectively remove sediment, nutrients, pathogens, and metals from runoff, and they reduce the volume and intensity of stormwater flows. Also known as best management practices (BMPs) or low impact development (LID).

A **catchment** is an area of land that drains rainfall to a single point. Water leaves the catchment from this point. Subcatchments are themselves catchments within another, larger catchment.

Abbreviations

BCA: Building and Construction Authority
BMP: Best Management Practice
EWA: Energy and Water Agency
GSI: Green Stormwater Infrastructure
LID: Low Impact Development
LIFE IP: Life Integrated Projects
MEEE: Ministry for the Environment, Energy and Enterprise
MSL: Mean Sea Level
MPWP: Ministry for Public Works and Planning
NFRP: National Flood Relief Project
PA: Planning Authority
Rain WiiN: Rain Water Integrated Infrastructure Network
RBD: River Basin District
SuDS: Sustainable Drainage Systems
WCMP: Water Catchment Management Plan

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Chapter 1
Introduction

1.1 Water management in Malta

The archipelago of Malta has a total area of 315 km2 and given the small size of the three islands, from a management perspective, they have been integrated into one River Basin District (RBD). The Malta RBD, as shown in figure 1.1 below, consists of 76 surface hydrological catchments in Malta, 33 in Gozo, 1 in Comino, and coastal waters up to one nautical mile from the coast.

Fifteen aquifer systems constitute the groundwater bodies of the Maltese Islands, including the mean sea level (MSL) and perched aquifers. Groundwater systems sustain an important part of Malta's water demand, with additional demand addressed through non-conventional water resources. Aquifer abstraction levels have historically been unsustainable mainly due to high demand for agriculture and potable water. Malta's naturally limited freshwater supplies and soakaways to recharge aquifers, have resulted in unsustainable water consumption whereby abstraction exceeds the average annual recharge, hence leading to groundwater quality degradation. Between 2007 and 2014, the long-term annual average Water Exploitation Index (WEI+) stood at 78%, significantly higher than the 40% threshold, indicating conditions of high-water stress, reflecting Malta's semi-arid climatic conditions. The MSL aquifers suffer from over-abstraction leading to seawater intrusion and therefore increased salinity. This also has economic repercussions due to the resulting increased requirement to dilute such water with desalinated water to ensure its potability prior to distribution through the national network. Agriculture is highly dependent on groundwater for irrigation, with the other major use being water abstraction for municipal supply purposes. In 2018, agriculture contributed to around 57% of total groundwater abstraction while the national distribution network contributed to around 37%[1]. In this regard, while agriculture is highly dependent on groundwater, it also constitutes a major pressure on this resource. Therefore, the sustainable management and use of this natural resource by the agricultural sector is imperative for its sustenance and future economic viability. The domestic demand for water is high due to Malta's increasing population density. This is further increased by the influx of tourists during the summer season, combined with the higher consumption rates of tourists when compared to domestic consumption. In addition, the potential to reduce water stress by harvesting rainwater and reducing wasted surface runoff is not being maximised. This is due to an increase in sealed non-permeable surfaces, misuse of existing

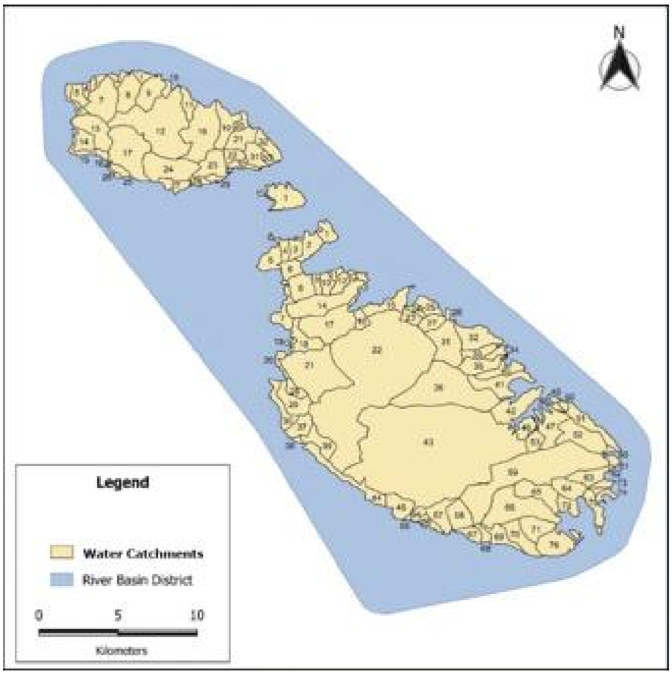


Figure 1.1
Water Catchments of the Maltese Islands
(EWA/PA)

1. Eurostat indicator "Annual freshwater abstraction by source and sector". Retrieved from *https://ec.europa.eu/eurostat/databrowser/view/env_wat_abs/default/table?lang=en*

water harvesting infrastructure, and a general lack of integration of water-harvesting considerations in urban infrastructure amongst others. Current infrastructure does not have the capacity for heavy rainfall events, leading to large amounts of water being lost. Current building control policies stipulate that all new developments should be provided with a water reservoir to store and re-use water runoff. However, the implementation, maintenance and enforcement of this obligation require further consideration and improvement. In terms of pollution, 80% of groundwater bodies are of poor quality[2]. The most problematic contaminants which contribute to this are nitrates. The most important source of nitrates is arable agriculture, more specifically the overuse of fertilisers. Nitrate levels tend to be higher in perched aquifers, especially in areas of intensive agricultural activity. Another potential source of nitrates is the mismanagement of sludge originating from animal husbandry. The presence of other chemical contaminants, including pesticides, has so far not been detected in groundwater bodies[3].

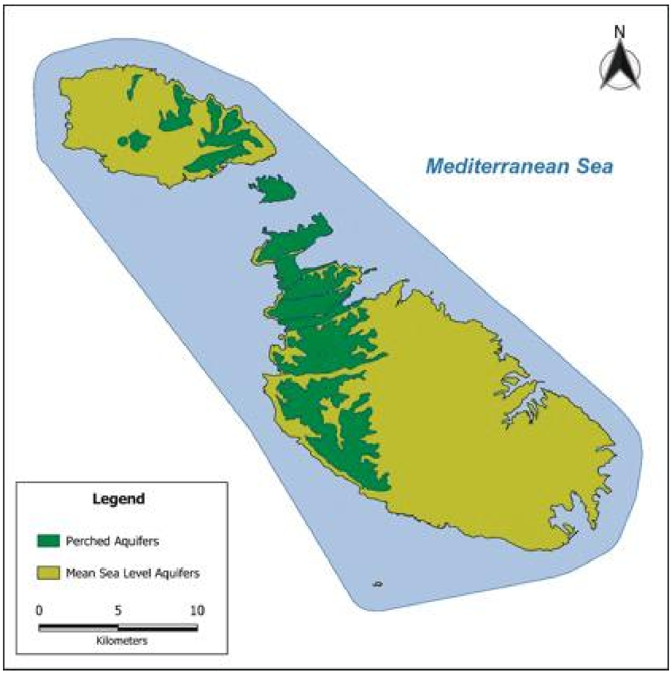


Figure 1.1
Water Catchments of the Maltese Islands
(EWA/PA)

Inland surface water bodies include watercourses, standing pools, and transitional wetlands. Chemical contamination of these waters is also of concern. Nitrates are again problematic, particularly in watercourses found in agricultural areas. Other detected contaminants in these water bodies include di-2-ethylhexyl phthalate, nickel and lead[4].

The cross-cutting nature of water necessitates the involvement of various Government entities throughout its implementation cycle with each entity being responsible for one or more component of this cycle (Figure 1.3). Malta's second Water Catchment Management Plan (2nd WCMP) was published in 2015 and covers the period 2016-2021, establishing measures for enhanced water resource administration, and supply and demand management; enhanced knowledge base and data management; improved contingency response planning; and the implementation of communication, education and awareness projects. The LIFE Integrated Project (LIFE 16 IPE MT008) was initiated to support the implementation of the 2nd WCMP as well as contributing to the preparation of the 3rd WCMP, thus moving towards the optimised management of all water resources on the Maltese Islands. The Project, which involves various partners across the water sector, includes several preparatory and concrete actions pertaining to stock-taking and mapping, research, plan development, awareness raising and education, monitoring, infrastructural

2. Energy and Water Agency & Environment and Resources Authority (2015). *The 2nd Water Catchment Management Plan for the Malta Water Catchment District 2015-2021*. Retrieved from *https://era.org.mt/wp-content/uploads/2019/05/2nd_Water_Catchment_Management_Plan-Malta_Water_in_Maltese_Islands.pdf*
3. Ibid.
4. Ibid.

developments and others. Measure FLD3 calls for the carrying out of a comprehensive assessment for the inclusion of SuDS and Natural Water Retention Measures to mitigate flood hazard and risk. This measure seeks the development of a master plan identifying the poten tial inclusion of SuDS and National Water Retention Measures as environmentally friendly flood mitigation measures. The master plan shall identify key measures and projects wherethe introduction of such measures can be undertaken on a national level. A guidance document to better guide the adoption of these measures was published in 2022[5]. Various initiatives have been carried out to increase the water storage capacity of a number of local valleys, including Wied il-Għasel and Wied il-Qlejgħa, thus contributing to increased aquifer recharge. Various initiatives have been carried out to increase the water storage capacity of a number of local valleys, including Wied il-Għasel and Wied il-Qlejgħa, thus contributing to increased aquifer recharge.

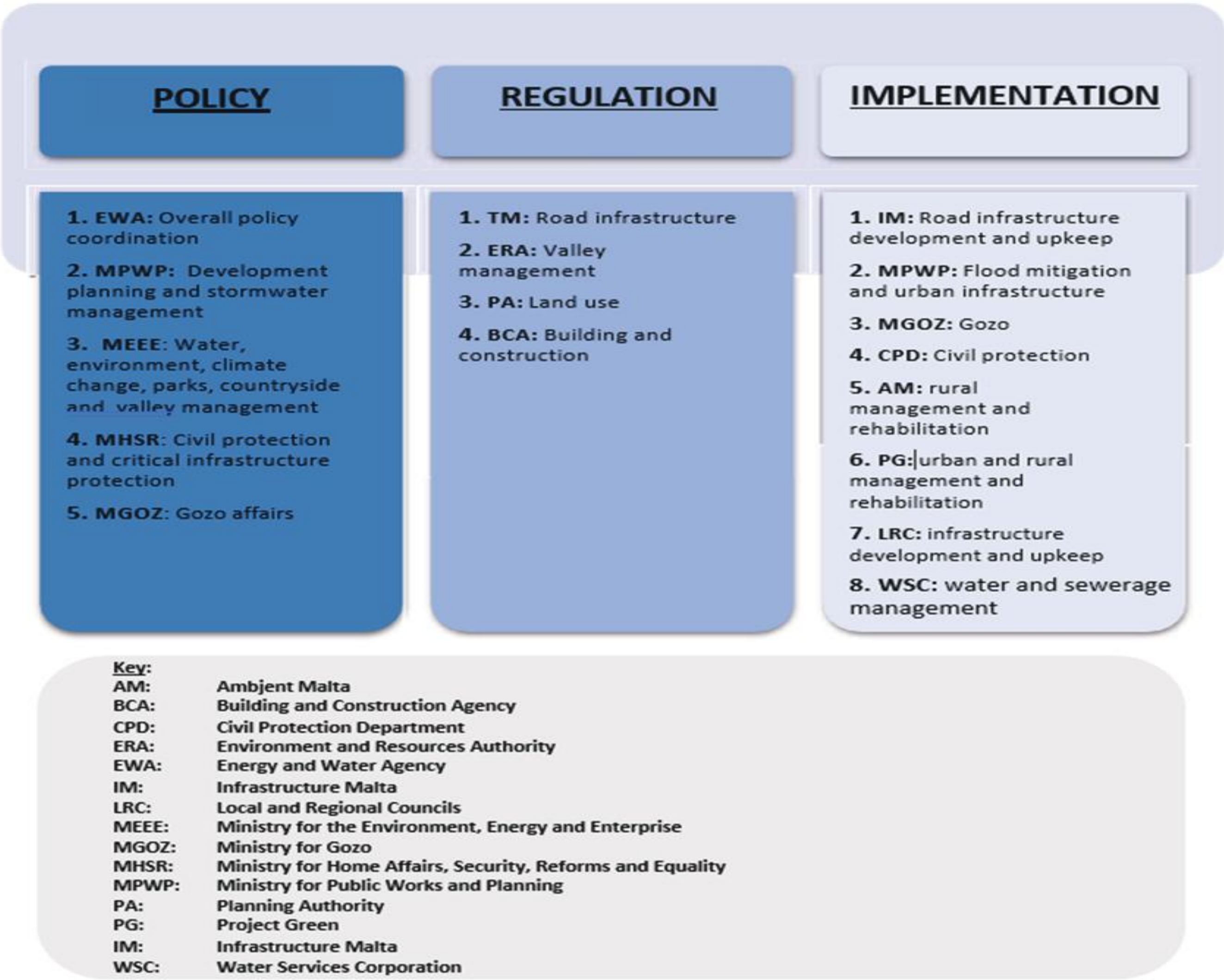


Figure 1.3 Governance Structure for Water Management in the Maltese Islands

5. Ministry for Public Works and Planning (2022). *Green Stormwater Infrastructure Guidance Manual*. Retrieved from *https://meae.gov.mt/en/Public_Consultations/MTI/Pages/Consultations/GreenStormwaterInfrastructureGuidanceManual.aspx*

1.2 Stormwater mitigation in Malta

Flood mitigation infrastructure in Malta was scarce prior to the National Flood Relief Project (NFRP). Prior to this project, almost all the runoff water in the main catchments used to converge to the main roads of the urban areas due to the fact that in most cases part of the road network was built upon dried-out valley beds.

Over hundreds of years, small dams and reservoirs have been constructed within the Maltese Islands along natural valleys and roads to catch flowing runoff water. These water retaining structures provided a useful supply of freshwater for the local population in times of limited or no rainfall. The total dam capacity in the Maltese Islands is estimated at 200 000 m^3 whereas the total volume of small open water retaining reservoirs is estimated at 250 000 cubic metres[6]. In both cases, these water retaining structures are located in rural areas where the generation of surface water runoff is lower than that occurring in urban areas. Given their reduced size, the contribution of dams and reservoirs to flood mitigation is limited since their capacity is negligible compared to the runoff volumes generated by extreme rainfall events. Moreover, these infrastructures are generally full at the onset of the first rainfall events, and therefore are subject to overflow when high intensity rain events occur.

1.2.1 The National Flood Relief Project (NFRP)

The project incorporates a pumped soakaway with a capacity of 10,000 m^3 at the mouth of Wied Għollieqa, upstream of Gżira. Runoff is pumped in this soakaway from Ta' Xbiex outfall. The overflow from the soakaway discharges into the Gżira underground tunnel (778 m long) that is connected to the Birkirkara - Ta' Xbiex tunnel. This soakaway has the potential to give useful data on percolation rates and water quality characteristics. It also can alter the phreatic surface of the groundwater in the area.

A separate component drains the Qormi - Marsa drainage catchment into the Marsa harbour; this generally follows the previous open concreted channels in the valley bed which were hydraulically improved. Another component drains the Żabbar drainage catchment into the sea just north of Żonqor Point, Marsaskala.

The NFRP does not cover the whole country and is totally absent in Gozo. The drainage catchments covered by the NFRP have experienced an increase in flood protection since its introduction.

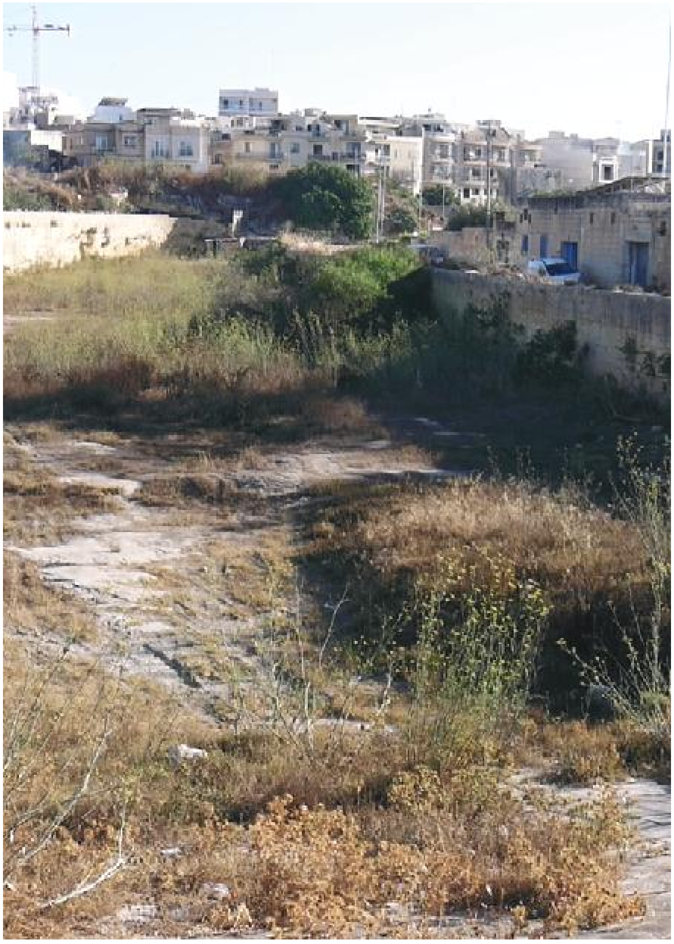


Figure 1.4 Gudja Ta' Ħabel Wati soakaway

6. FAO, (2006). Malta water resources review. Rome, FAO.

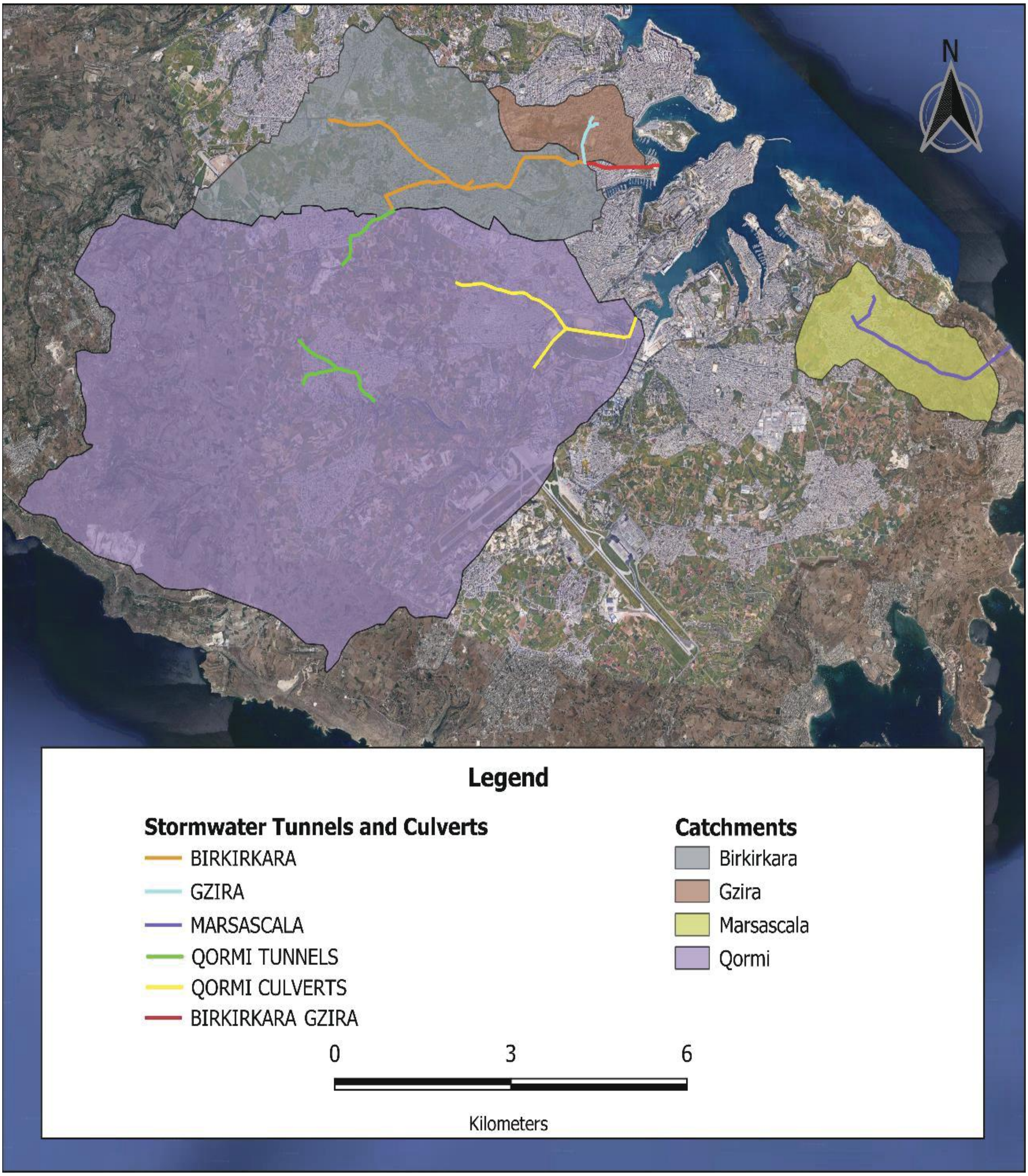


Figure 1.5 Flood mitigation infrastructures developed as part of the NFRP

1.3 Malta’s stormwater challenges

1.3.1 Causes

Managing stormwater is no easy task. Fifty mm of rain nation-wide generates over 15 million cubic metres of stormwater. Some of the stormwater soaks into the ground, while most flows into the drainage system.

Malta’s stormwater management challenges are rooted in our history of development. Spanning over 500 years, development has converted permeable natural areas into thousands of hectares of impervious surfaces such as buildings, roads, etc. As of 2019, 34 percent of Malta’s land area[7] was either paved or covered with buildings. These surfaces do not allow rainwater to infiltrate into the ground as most are designed to drain stormwater away as fast as possible increasing resulting flows and the accompanying runoff pollution. Low-lying areas including valleys have been built and incorporated into the main urban fabric over time. Therefore, when a storm event occurs, dry valleys act as a conveyance channel for stormwater, which flows, along the path prior to being discharged into the sea.

Without green space to absorb rainfall, the drainage system is required to handle large volumes of stormwater. Stormwater sent to our sewers is no longer available to naturally irrigate or recharge groundwater.

1.3.2 Effects

Stormwater runoff causes several problems when it is not effectively managed. During heavy rains, stormwater overwhelm the drainage system, thus resulting in flooding, traffic disruption, public health risks, business stoppages and property damage. As communication links and infrastructure such as roads are disrupted, economic activities come to a standstill, resulting in dislocation and the dysfunction of normal life for a period beyond the duration of the flooding. Similarly, the direct effect on agriculture can inhibit regularly activity. Sediment is the most common pollutant associated with storm water runoff. Sediment accumulation decreases the drainage system’s capacity to carry water.

Figure 1.6 9 February 2023 storm flooding

7. Various Central Statistics Office/NSO publications

1.4 Climate Change

In recent years, Malta has witnessed intense rainfall events that have caused nation-wide flooding occurrences. Unfortunately, these storms have exceeded expectations and point the way to a new normal.

Malta has experienced 2 storms in the last 3 years (September 2020 till August 2023) that have exceeded the rainfall amount of a historical "10-year storm" (rainfall in excess of the historical 1922 – 2005 (Gumbel distribution) of 106 mm of rain in 1 day) namely on 13/14 September 2020 and 9 February 2023.

While it is not possible to attribute a single storm event to climate change, the strong storms that have impacted Malta in recent years are consistent with the climate change projections. Extremes only occur in a conjunction of several preconditions. For example, extreme rainfall requires maximized ("potential") moisture transport into the region, high temperatures (or large temperature gradients) and significant instability of the atmosphere. An alignment of these "ingredients" is relatively rare. Under climate change, however, some of these conditions might see a systematic increase in occurrence, which is particularly true for temperatures across the globe. If that one condition - higher temperatures - is more often fulfilled, then the chance for a combined occurrence can also increase. Warmer temperatures are especially important for precipitation because the Clausius-Clapeyron-Relationship dictates that for every 1°C of increased air temperature, that air's potential to carry moisture increases by 7%. Thus, the warmer the air, the much more moisture it "can" carry, and therefore if rain were to form, much more water could be tapped into.

Figure 1.7 Climate change effects of flooding

1.5 Moving forward

Green Stormwater Infrastructure (GSI) is a term used to refer to practices for handling storm precipitation where it falls rather than after it has run off into a drainage system. GSI is therefore an alternative or complement to conventional stormwater management approaches. Conventional approaches, or grey stormwater infrastructure strategies, typically involve enlarging drainage systems, increasing the capacity of wastewater treatment plants, or constructing for conveying stormwater.

Using a GSI approach means designing the built environment to capture rainfall and storing it for use or letting it infiltrate into the ground, replenishing vegetation and groundwater supplies. The goal is to keep water out of overtaxed sewer systems and better mimic conditions that existed before the occurrence of development. GSI employs natural systems such as vegetation and park space to handle rainfall. It can also include the use of constructed solutions such as rainwater harvesting systems or permeable pavement. GSI strategy is also referred to as low impact development (LID), best management practices (BMPs), or source controls. Examples of GSI include green roofs, bioswales, soakaways, reservoirs, cisterns, permeable pavement and porous concrete and asphalt.

A GSI can provide multiple benefits beyond just managing rainfall and runoff. These benefits include environmental, economic, and social improvements, such as cooling and cleansing the air, reducing asthma and heat-related illnesses, decreasing water loss, lowering heating and cooling energy costs, boosting economic development, creating jobs, enhancing recreational amenities, and beautifying neighbourhoods. Conventional grey stormwater infrastructure, such as drainage tunnels, wastewater treatment plants, and underground storage systems, addresses the symptoms of stormwater runoff.

Instead, GSI focuses on the root problem, which is the imperviousness caused by land development. GSI utilizes an underlying philosophy of pollution prevention and the premise that it is better to prevent pollution that to treat it. This approach views stormwater as a resource, not a waste. This GSI Strategy is the next step to prepare for the future.

This Strategy builds upon and extends the commitments made by Malta's Sustainable Development Strategy for 2050[8] and National Strategy for the Environment 2050[9]. We will continue to invest in GSI because it provides meaningful storm-water management benefits now, and it offers long-term potential to serve as a cost-effective supplement or alternative to traditional grey stormwater infrastructure investments.
Through this Strategy and our future efforts,

8. Ministry for the Environment, Energy and Enterprise. (2022). *Malta's Sustainable Development Strategy for 2050.* Retrieved from *https://sustainabledevelopment.gov.mt/wp-content/uploads/2022/12/Maltas-Sustainable-Development-Strategy-for-2050.pdf*
9. Environment and Resources Authority. (2022) *National Strategy for the Environment for 2050: Public Consultation Draft. Retrieved from https://era.org.mt/nse2050/*

we will determine the best balance between investing in green and grey stormwater infrastructure to most cost-effectively manage stormwater and provide the greatest benefits.

This Strategy provides a framework and initial implementation plan to meet the goals of using GSI to enhance stormwater management, protect water quality, and build a vibrant economy on 21st century infrastructure.

Dealing with stormwater management challenges is critical for the future, and this Strategy lays out steps to build GSI now as well as plan through additional analysis concerning long-term water infrastructure strategies and needs. This Strategy recognizes many important existing conditions, strengths and limitations regarding stormwater management in Malta. This Strategy's initiatives are designed to address these issues.

We recognize that significant long-term investment in stormwater infrastructure is necessary. Our challenges with flooding and water quality pollution (mostly sediment) are longstanding problems. They were caused by a complex setof factors and decisions that have occurred through the last 50 years. While we will not be able to solve our stormwater challenges overnight, we know that we can make steady, significant progress through good planning, smart investments, and a sustained commitment.

While this Strategy specifically addresses the role of GSI to reduce flooding, we recognize that traditional grey stormwater infrastructure investments are also critical. GSI manages stormwater at its source where it falls as opposed to attempting to manage stormwater at the end of the pipe through traditional grey stormwater infrastructure such as conveying the water to an outfall into the sea. Our planning and implementation efforts recognize that Malta's green and grey stormwater infrastructure are ultimately integrated that must work in concert to effectively address our runoff challenges.

Solving our stormwater challenges will require meaningful and sustained collaboration among key stakeholders and their continued participation is essential. Also, solving our stormwater challenges will require the efforts or private landowners and citizens since their actions can meaningfully contribute to finding and implementing solutions.

Malta has made significant progress over the last decade upgrading and implementing GSI.

Our next step is to continue critical drainage infrastructural projects, build additional GSI, and develop a nation-wide implementation plan for stormwater management. This Strategy is a major step toward solving our stormwater challenges, but much more work is needed.

Chapter 2

The Role of Green Stormwater Infrastructure

This Strategy encompasses a set of tactics that are specifically focused on managing the impacts of rainfall and runoff. Many use the term green infrastructure to refer to all natural and vegetated systems that provide ecological services. These include natural features such as trees, flowers, grass, urban agriculture, etc. Others go further by considering green infrastructure to include any sustainable strategy such as recycled materials with post-recycled content, and bicycle lanes.

2.1 Findings

2.1.1. Stormwater management is fundamental to all aspects of land planning processes

Policy P47 of the Development Control Design Policy, Guidance and Standards 2015[10] obliges all new development to be provided with a water reservoir to store and re-use rainwater runoff from the built-up area and having a volume that is established in Technical Guidance Document F. The Building and Construction Authority updated the rainwater conservation and re-use requirements in dwellings and non-dwellings in 2023 (Technical Document F[11 12]). This legal document prescribes the minimum size of rainwater reservoirs and provision for the re-use of rainwater.

At drainage catchment level, the current regulatory framework lacks specific guidelines, leading to inconsistent and fragmented approaches to stormwater management. This hinders compliance with regulatory obligations. Opportunistic implementation of GSI fails to meet our regulatory obligations and policy goals. Moreover, the ad hoc nature of opportunistic implementation does not align with the comprehensive needs outlined by our policy goals, which emphasize sustainable and resilient stormwater management practices. As a result, challenges such as flash floods, water scarcity, and water quality issues persist. To address these limitations, a strategic framework is crucial. This framework will ensure compliance with regulatory requirements, promote integrated stormwater management approaches, and facilitate the adoption of effective and sustainable GSI. By establishing such a framework, we can fulfil our regulatory obligations and policy goals, achieving improved stormwater management outcomes and fostering resilience in the face of evolving environmental challenges.

2.1.2. Stormwater management solutions are most effective when planned at a drainage catchment level

Stormwater management solutions are most effective when planned at a drainage catchment level[13]. This is because drainage catchment level practices allow for an integrated approach that considers the entire hydrological system. By focusing on the drainage catchment, stormwater management can address the varied challenges and opportunities specific to that area. This holistic perspective considers factors such as topography, soil conditions, hydrological patterns, and existing infrastructure, leading to more tailored and effective solutions.

One of the key benefits of drainage catchment-

10. Planning Authority. (2015) *Development Control Design Policy, Guidance and Standards 2015*. Retrieved from *https://issuu.com/planningauthority/docs/dc2015_851e7b0de470e8*
11. Building and Construction Authority. (2023) *Technical Document F Part 1: Dwellings Minimum Energy Performance and Building Envelope Requirements*. Retrieved from *https://bca.org.mt/wp-content/uploads/2023/06/Technical-Document-F-Part-1-Dwellings-Minimum-Energy-Performance requirements-and-building-envelope.pdf*
12. Building and Construction Authority. (2023) T*echnical Document F Part 2: Non-Dwellings Minimum Energy Performance and Building Envelope Requirements*. Retrieved from *https://bca.org.mt/wp-content/uploads/2023/06/Technical-Document-F-Part-2-Non-Dwellings-Minimum-Energy-Performa nce requirement-and-building-envelope.pdf*
13. City and County of San Francisco. (2019). *Urban Watershed Planning. San Francisco Public Utilities Commission*. Retrieved from *https://sfpuc.org/programs/san-franciscos-urban-watersheds*

level planning is improved flood mitigation. By considering the upstream and downstream impacts of stormwater runoff, flood risk can be minimized through floodplain preservation, natural watercourse restoration and the strategic placement of retention basins. This approach enables the identification of critical areas prone to flooding and allows for the implementation of targeted measures. In addition to flood mitigation, managing stormwater at a drainage catchment level enhances water quality. By integrating techniques such as bioretention areas and sedimentation interceptors strategically, drainage catchment-wide pollutant loads can be reduced, leading to improved water quality downstream. This comprehensive approach to water quality management ensures that stormwater is effectively treated before it enters the receiving bodies.

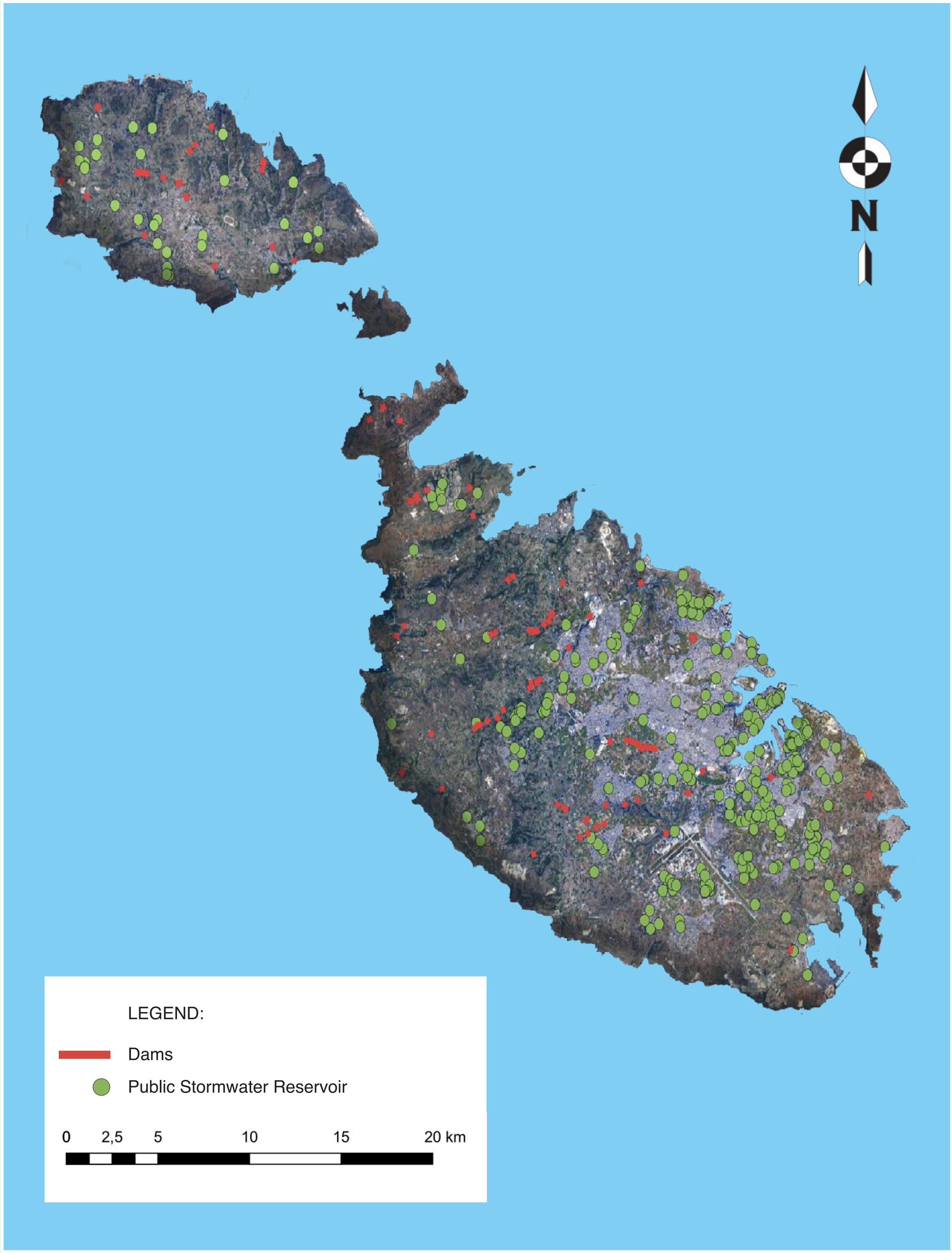
Drainage catchment-level planning also encourages collaboration among various stakeholders, including local councils and the communities. This inclusive approach facilitates shared responsibility, knowledge exchange, and coordinated decision-making. By involving stakeholders in the planning process, stormwater management strategies can be developed that are not only technically sound but also feasible and accepted by the communities.

2.1.3. Green stormwater infrastructure is versatile and can be designed to manage most types of rain events

GSI exhibits remarkable versatility and can be designed to effectively manage most types of rain events. They offer a range of features and techniques that can adapt to different rainfall patterns and intensities, making them a flexible solution for stormwater management. One of the key strengths of GSI is their ability to handle varying rain event magnitudes. GSI such as permeable pavements and infiltration basins can be designed with different capacities to accommodate rainfall volumes. This versatility ensures that GSI can efficiently capture, store, and control stormwater regardless of whether it is a light shower or a heavy downpour.

GSI also excels in managing different rain event frequencies. In areas experiencing frequent, low-intensity rainfall, GSI elements designed for infiltration, such as permeable pavements or bioretention systems, can effectively absorb and filter the water. On the other hand, during intense rain events or infrequent storms, GSI like detention basins can temporarily store excess runoff and release it slowly, mitigating the risk of flooding. Furthermore, GSI is adaptable to address both short-duration and long-duration rain events. Their design can incorporate features that capture and manage rainfall during short-duration events, preventing localized flooding and reducing strain on conventional drainage systems. Additionally, GSI can provide long-term stormwater management by allowing infiltration into the ground or controlled release into water bodies, ensuring water resources are replenished and protecting water quality.

The versatility of GSI extends beyond their ability to manage rain events. They can also be integrated into a wide range of urban environments, including residential, commercial, and industrial areas. GSI can be implemented in new developments or retrofitted into existing infrastructure.


N
LEGEND:
Dams
Public Stormwater Reservoir
0 2,5 5 10 15 20 km

2.1.4. Opportunistic implementation of green stormwater infrastructure will not reach our regulatory obligations and policy goals

The current regulatory requirements for GSI are restricted, resulting in inconsistent and fragmented stormwater management practices. This inadequacy hampers our ability to fulfil the necessary compliance standards. Furthermore, the ad hoc nature of opportunistic GSI implementation fails to align with the comprehensive needs outlined by sustainable development policy goals. These goals emphasize the importance of sustainable and resilient stormwater management practices to mitigate flooding, enhance water quality, and promote environmental sustainability. By relying on opportunistic implementation alone, we are unable to achieve the broader objectives and fulfil our policy commitments effectively.

Because of these limitations, significant stormwater management challenges persist. Flash floods, water scarcity, and water quality issues continue to pose substantial risks to the environment and public safety. The fragmented and inconsistent approach of opportunistic GSI implementation fails to address the comprehensive stormwater management needs required to tackle these challenges adequately. To overcome these limitations and ensure compliance with regulatory obligations and policy goals, it is imperative to develop a strategy for GSI implementation. By adopting such a comprehensive approach, we can address the unique challenges of our region effectively and promote sustainable and resilient stormwater management practices.

The Strategy provide the necessary structure and guidance to integrate GSI into the existing infrastructure and planning processes. It will facilitate the implementation of effective and context specific GSI solutions, aligning with regulatory requirements, and promoting long-term sustainability. By establishing this Strategy, we can enhance our ability to meet regulatory obligations, achieve policy goals, and address stormwater management challenges in a comprehensive and sustainable manner.

2.1.5. An integrated grey-green infrastructure approach to drainage infrastructure is economically preferred

An integrated grey-green infrastructure approach to drainage infrastructure is an economically preferred option[14] . By combining the strengths of both grey and green infrastructure, this integrated approach offers numerous economic benefits that make it a favourable choice for drainage management. By integrating grey and green infrastructure, the economic advantages become evident. Firstly, the upfront construction costs of grey infrastructure can be significantly reduced by supplementing it with green infrastructure elements. For instance, using soakaways or green roofs alongside conventional drainage conveyance can reduce the scale and cost of traditional pipe networks.

Secondly, the maintenance and operational costs of an integrated grey-green infrastructure approach are often lower compared to relying solely on grey infrastructure. Vegetation and natural systems require less maintenance than traditional stormwater infrastructure, leading to

14. Roseen, R.M., Janeski, T.V., Houle, J.J., Simpson, M.H., & Gunderson, J. (2011). *Forging the Link: Linking the economic benefits of low impact development and community decisions*. Retrieved from https://scholars.unh.edu/stormwater/89/

long-term cost savings. Additionally, green infrastructure features can provide additional benefits such as urban heat island mitigation, carbon sequestration, and improved air quality, which can result in cost savings in other sectors like energy and healthcare. Furthermore, an integrated approach to drainage infrastructure can provide economic resilience in the face of climate change and extreme weather events. Green infrastructure offers increased adaptability and flexibility to absorb and store stormwater, reducing the need for costly retrofits or system expansions in response to changing rainfall patterns and increased urbanization.

2.1.6. Water harvest and reuse is a key approach to conserve, protect and preserve water resources

Water harvest and reuse is crucial to conserve, protect, and preserve water resources. Harvesting techniques such as rainwater harvesting, stormwater capture, and greywater reuse provide opportunities to collect and store water for various purposes. This approach reduces reliance on freshwater sources, particularly in rural areas with limited access to traditional water supplies. By implementing water harvesting and reuse practices, water resources can be protected from depletion and degradation. Rather than heavily depending on unsustainable extraction from groundwater bodies, harnessing alternative water sources helps alleviate stress on natural water systems. This approach promotes the sustainable use of available freshwater resources. Furthermore, water harvesting and reuse contribute to preserving water quality. Through appropriate treatment and filtration, harvested rainwater and reused greywater can be effectively treated to meet specific water quality requirements. This ensures that water resources are protected from contamination and pollution, thus safeguarding public health and the environment.

This water management practice also fosters resilience in the face of changing climate patterns and increased water demands. By capturing and reusing water, communities can mitigate the impacts of droughts, reduce reliance on seawater desalination, and enhance overall water security. This approach empowers individuals and communities to become more self-sufficient and less vulnerable to water scarcity-related challenges.

2.1.7. Operations and maintenance, rehabilitation and renewal are critical needs for long-term success and performance of a green stormwater infrastructure strategy

For long-term success and performance of a GSI strategy, the critical needs of operations and maintenance, rehabilitation, and renewal cannot be overlooked. Operations and maintenance play a pivotal role in preserving the functionality and efficiency of GSI. Regular inspections, cleaning, and upkeep of elements such as soakaways and permeable pavements are essential to prevent clogging, maintain proper water flow, and maximize their stormwater management capacity. Adequate training and resources for personnel responsible for the operation and maintenance tasks are crucial to ensure the longevity and optimal performance of GSI.

Furthermore, rehabilitation efforts are vital to address any deterioration or damage that may

occur over time. Continuous monitoring of GSI allows for early detection of issues such as erosion, vegetation decline, or structural degradation. Prompt rehabilitation actions, such as repairing erosion-prone areas, replanting vegetation, or addressing sediment build-up, are necessary to restore the functionality and effectiveness of GSI components. In addition to rehabilitation, regular renewal of GSI components may be required to accommodate changes in land use, urban development, or evolving climate conditions. As urban areas evolve, GSI should adapt to new challenges and opportunities. This may involve modifying or expanding existing features, integrating additional GSI elements, or incorporating innovative technologies to meet the changing needs of stormwater management effectively.
Recognizing the criticality of operations and maintenance, rehabilitation, and renewal is essential for ensuring the long-term success and performance of GSI. By allocating resources, establishing proper protocols, and fostering a proactive approach, the ongoing functionality and effectiveness of GSI can be maintained. Incorporating these elements into the programme's framework promotes sustainability, resilience, and the continued realization of the anticipated benefits of GSI in managing stormwater effectively.

2.1.8. Strategically planned, operated, and maintained green stormwater infrastructure can support climate adaptation while also sequestering CO2

Strategically planned, operated, and maintained GSI have the potential to simultaneously adaptation efforts and contribute to carbon dioxide (CO2) sequestration. Study findings[15]

Figure 2.1 Mqabba, Triq Ganni Darmanin, Soakaway during contruction.

15. Kavehi, E., Jenkins, G.A., Adame, M.F., & Lemckert, C. (2018). *Carbon sequestration potential for mitigating the carbon footprint of green stormwater infrastructure.* Renewable and Sustainable Energy Reviews, 94. 1179-1191. https://doi.org/10.1016/j.rser.2018.07.002

Figure 2.2 Mqabba, Triq Ganni Darmanin, Soakaway after completion

underscore the importance of considering GSI as a multifunctional solution that can address climate change challenges. When GSI are strategically planned, they consider local climate conditions and projected impacts of climate change. By incorporating climate adaptation measures into their design, such as green roofs and bioswales, GSI can effectively manage stormwater runoff, reducing the risks of flooding and enhancing the resilience of urban areas in the face of changing climatic conditions. Furthermore, GSI offers an opportunity for CO_2 sequestration, contributing to climate change mitigation. The inclusion of vegetation within GSI acts as a carbon sink, absorbing CO_2 from the atmosphere and storing it in biomass and soils. Trees, shrubs, and other green features not only enhance the aesthetic appeal and biodiversity of urban areas but also actively contribute to reducing greenhouse gas emissions. To unlock the fullpotential of GSI, their operational and maintenance aspects are crucial. Regular inspection and proper upkeep of vegetation, sediment management, and permeable surfaces are essential for ensuring the long-term functionality and performance of GSI. Effective operation and maintenance practices enable GSI to fulfil their climate adaptation role and maintain their CO_2 sequestration capacity over time.

2.1.9. Green stormwater infrastructural approaches will broaden responsibilities for stormwater management and shifts how funds will be spent over the green stormwater infrastructure asset lifecycles

Many studies[16] have reinforced that GSI pro-

16. Canadian Nursery Landscape Association. *Life Cycle Cost Analysis of Natural On-site Stormwater Management Methods*. Retrieved from *https://cnla.ca/uploads/pdf/LCCA-Stormwater-Report.pdf*

vides economic rainwater management services delivery, often at a lower overall life cycle cost than traditional methods. Adopting a holistic and integrated approach to rainwater management, however, requires breaking down financing and delivery barriers between upfront capital cost, ongoing operations and maintenance costs, renewal costs and identifying who is responsible for what. Moving to a greater reliance on GSI over traditional approaches will often mean a shift in expenditures at different stages of a GSI asset's life cycle and to different work skills. Compared to grey infrastructure, GSI has lower upfront capital and renewal costs but increased ongoing operations and maintenance costs.

2.1.10 Green stormwater infrastructure implementation requires establishing a culture of collaboration and fostering partnerships

The integrated nature of green stormwater infrastructure means that the role of water management extends beyond sewerage and drainage. Planning, design, implementation and care of GSI, requires cooperation between a variety of groups, including both public and private property owners. It requires deliberate coordination between various specialists in engineering, landscape architecture, urban design, urban planning, ecology, horticulture, construction, maintenance, and public and industry engagement and education. In recognition of the level of cooperation required, paying attention to the culture shift and what it means for individuals and groups is essential. Developing partnerships with industry, communities, and academia and breaking through silos between professions, departments and agencies is essential for long-term success. This requires updating existing internal governance structures and processes, such as decision-making and collaboration systems. This update can foster and facilitate effective cross-disciplinary, cross-departmental, cross-agency and cross-sectoral collaboration, decision-making and partnerships. It also requires alignment of resources to achieve the lasting environmental, social and economic benefits of GSI implementation.agencies is essential for long-term success.

2.2 Benefits

Using GSI can provide many benefits beyond improving the management of rainfall and runoff. These benefits include environmental, economic, and social improvements (figures 2.3, Appendix figures 6.1a and 6.1b).

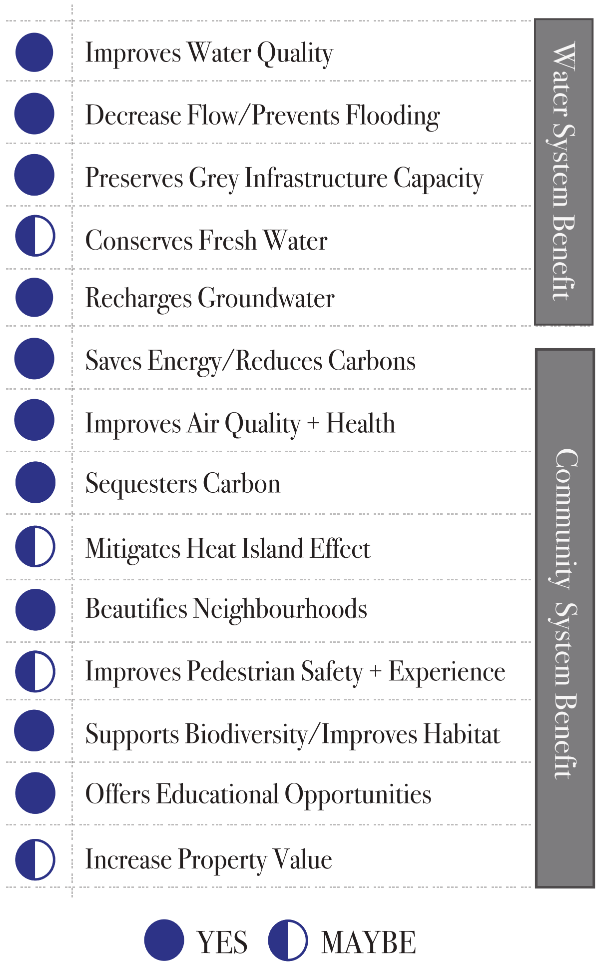


Figure 2.3 Benefits of Green Stormwater Infrastructure

2.2.1 Environmental

GSI, particularly those practices that use trees and vegetation, provide multiple environmental benefits. GSI can improve air quality by filtering and removing pollutants from vehicles and industrial sources. Some practices can reduce the urban heat island effect by providing shade or converting impervious surfaces into vegetated or permeable landscapes. Increasing vegetation can also improve biodiversity by expanding the number of plants and providing additional species habitat. All of these benefits improve the quality of life for communities and help achieve other environmental objectives, such as reducing energy use and building resilience to the impacts of climate change. GSI can also decrease water loss. Since GSI captures water before it enters the drainage system, more water remains in the drainage catchments by an increase in rainfall that is infiltrated.

2.2.2 Economic

Widespread implementation of GSI potentially offers significant economic benefits, such as deferring or even replacing costly large grey stormwater infrastructure projects. These large installations, such as major drainage tunnels, are costly to construct and take years to complete. They also have long lead times for planning, design, construction, leaving them vulnerable to escalating costs from external market conditions for materials, labour, and financing. Compared to large grey infrastructure projects, the incremental construction of GSI typically uses more level cash flows that provide flexibility and better financing. GSI reduces the costs for treatment at water treatment plants since this rainfall is instead filtered and treated naturally. GSI can also reduce the need for water purification if the runoff is captured and reused. This decreases the costs for energy and chemicals and also reduces air pollution and carbon emissions.

2.2.3 Social

Implementing GSI provides opportunities to increase the quality of neighbourhoods and add community amenities. Installing grey stormwater infrastructure typically means digging up streets to install underground infrastructure or tunnelling deeper below the ground. These projects provide benefits for stormwater management, but the result is typically a restored street that functions the same as before the project but with a new impervious paved surface. GSI can provide additional social benefit, such as through planting trees that offer shade, installing green roofs that provide open space, or enhancing parks that serve as public gathering places.

Figure 2.4 Flower Garden

2.3 Current Constraints

Green infrastructure provides many benefits, yet there are also several unknown issues where additional data and analysis will help determine how GSI can best complement traditional grey stormwater infrastructure.

Malta has, until now, implemented sporadic GSI projects. This has allowed policymakers, civil engineers and architects to understand the great potential that GSI offers for solving stormwater management challenges. However, there is no strategy to implement a nationwide large-scale GSI programme. Therefore, water management experts still have much to learn and analyse about the ability of GSI to minimize flooding.

One of the largest knowledge gaps surrounding GSI is the actual costs and benefits to manage stormwater. Important pilot or demonstration projects that provide cost information and short-term performance data were built, but these projectsare not able to provide cost information for building many installations at a large scale, nor are they able to provide the stormwater benefits of implementing many installations in proximity within a drainage catchment or large community area. Also, there is limited data concerning long-term effectiveness and maintenance needs.

GSI installations can also have physical limitations depending on the technique used. The most significant limitation in dense urban areas is space. Physical constraints limit the effectiveness of infiltration techniques, such as the presence of underground utilities or poorly infiltrating soils like clay, which is found throughout North-western Malta and southern and central Gozo. Compared to centralized grey stormwater infrastructure, decentralized GSI is usually built gradually. The effectiveness of such decentralized systems depends upon the aggregate, cumulative effects of many small-scale measures. Since it takes many years of adoption to achieve significant numbers of installations, a GSI strategy requires that public agencies, local councils, and landowners have a long commitment to a comprehensive GSI programme.

Maintenance is also a critical consideration. GSI installations may have diminishing effectiveness over time or failure if not properly maintained. When implementing a large-scale green infrastructure programme, it is necessary to ensure that there are sufficient resources and people that are trained to properly install and maintain installations.

Lastly, it is important to recognize that GSI installations are well-suited to handle the rainfall volume from small rain events, but that large storms can generate immense stormwater runoff that can easily overwhelm installations like rain gardens and soakaways.

2.4 Opportunities

Malta is a dense country, yet there are still many opportunities to implement GSI. Building GSI in a dense country requires policymakers, planners, designers, and engineers to think differently about how they construct the fundamental components of the built environment, including buildings and sites, roads, parks and open spaces (figures 2.5, Appendix figures 6.2a and 6.2b).

2.4.1 Buildings and Sites

There are three basic GSI strategies for buildings and sites – manage water as it flows off the roofs, manage water on the roofs, or manage water where it falls on sites. Managing water as it flows off the roof requires directing water to reservoirs or to infiltrate into a vegetated or permeable area. Rain gardens are small vegetation-filled depressions that accumulate runoff, promoting increased infiltration as well as providing additional storage. Rain gardens can be at the front or back yards in residential areas or on green spaces. Yard and roof runoff reaches the rain garden by way of overland flow, redirection, or pumping. In a rain garden, flow has an opportunity to infiltrate into the soil or escape into the atmosphere via transpiration. Rooftops cover a significant part of land area, and many of those rooftops are flat surfaces that are conducive to capturing and holding rainfall. The Maltese flat roofs are ideal candidates for green roofs. Green roofs treat stormwater through retention or bioretention. Green roofs are comprised of a structurally sound roof, a waterproofing and root barrier, a drainage layer, a permeable fabric, a growing medium, and vegetation.

2.4.2 Roads

Malta has an extensive road network stretching over 2,400 kilometres of road in 2014. Malta also has one of the densest networks in the world with 762 km of roads in every 100 km^2 of land area[17].

There are two basic green infrastructure strategies for roads – capture stormwater in constructed containment infrastructure or vegetated areas or use permeable pavement practices to allow water to percolate into the ground. Water containment infrastructure include reservoirs and detention basins. Vegetated controls, apart from offroad pervious land infiltration in natural areas/detention basins, include tree pits, bioswales, rain gardens, filter strips, Green Streets, and stormwater planters. They are typically designed to capture runoff from the adjacent road, typically through a specially designed inlet. Soil systems in vegetated controls usually contain a high-infiltration soil layer underlain by more typical planting soils and gravel. Plant selections for vegetated controls that accept road runoff are made to account for the impacts of pollutants that can be carried into the installation. Permeable pavement technologies, including permeable pavements, porous asphalt or porous concrete, allow water to pass through or between the paved surfaces into a specially designed subgrade gravel bed or other porous medium.

Permeable pavement systems can act as a

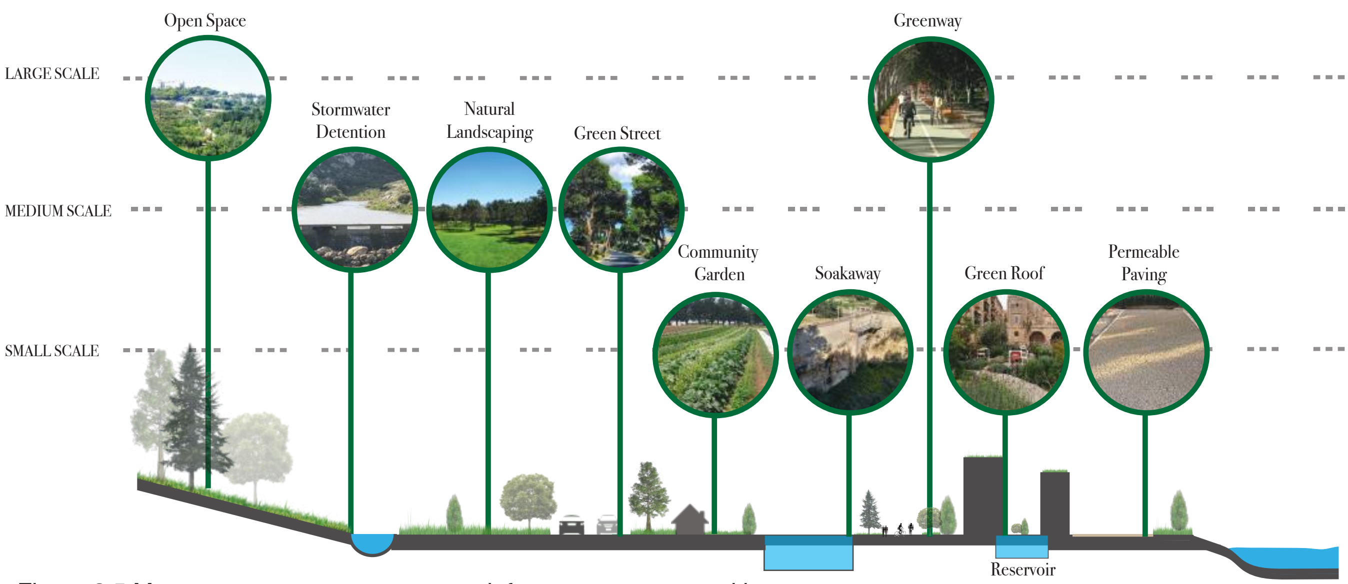


Figure 2.5 Most common green stormwater infrastructure opportunities

17. Transport Malta. 2016. *National Transport Strategy 2050*. Retrieved from *https://www.transport.gov.mt/strategies/strategies-policies-actions/national-transport-strategy-and-transport-master-plan-1343*

detention or retention technique since water stored in the subgrade medium can percolate into the ground, evaporate, or leave the system laterally through an overflow pipe or underdrain. Extensive areas of alleys, pavements, parking bays, plazas and other low-traffic areas represent potential permeable pavement sites. Permeable pavements generally are used on surfaces that are subject to low-speed, low-impact use by vehicles.

2.4.3 Parks and Open Spaces

Malta has a wide variety of open spaces that could be utilized for GSI, including parks, playgrounds, school grounds, and vacant land. Open spaces and natural areas (figure 2.6) can be harnessed to absorb and filter stormwater that would otherwise flood our roads.

Parks contain significant permeable surfaces that already absorb rainwater. If properly designed and integrated into ongoing restoration work, many park sites can be enhanced to create hydraulic connections to larger land areas that are generally impervious.

Therefore, GSI in parks and natural areas can be used to capture runoff from surrounding impervious surfaces. In particularly, school grounds represent a significant opportunity for GSI since Malta has over 120 state educational institutions, many of which are characterized by large expanses of impervious surfaces. Vacant lands also provide an opportunity for additional stormwater control if properly designed and integrated into a broader neighbourhood revitalization effort.

2.4.4 Green Stormwater Infrastructure in Malta

Legislation and Policies

Legislation Stipulating the Construction of Rainwater Harvesting Systems in Buildings

The Conservation of Fuel, Energy and Natural Resources (Minimum Requirements on the Energy Performance of Buildings) Regulations[18], 2015 and Technical Document F: Minimum Energy Performance Requirements for Buildings in Malta, applicable for new or renovated buildings from 1st January 2016, requires the collection of rainwater in reservoirs. Technical Document F specifies the bare technical requirements related to the construction and size of reservoirs as well as rainwater drainage, and its non-potable use. The volume requirement in m^3 is the total roof area (m^2) multiplied by a factor of 0.45 m. Technical Document F encourages the use of permeable pavement and green roof solutions.This Regulation, which is under the remit of the Building and Construction Authority , is self-regulating with the obligation being placed on the periti and the developers. Water Services Corporation advises developers to adhere to the Regulation (amongst others) in its standard response as a statutory consultee in the vetting of development planning applications.

Malta's Sustainable Development Strategy for 2050

Strategic goal 1: Transitioning Towards a Cli-

18. Legal Notice 434 of 2015.

Figure 2.6 Wied il-Ghajn dam and basin

Building Type	Constant use of collected rain water (m^3)
All Building Roofs	Total roof area (m^2) x 0.45 m
External paved areas (including open terraces and balconies)*	Total paved area (m^2) x 0.45 m
*Note: This requirement applies only to total exposed areas equal to or larger than 20 m^2 per multiple tenanted building, and only to total exposed areas equal to or larger than 30 m^2 per singularly owned building. Areas occupied by soil or planters are excluded from the calculation of such area.	

Figure 2.7 Technical Document F: Minimum energy performance requirements for buildings in Malta sizing of reservoirs.

mate-Neutral Green and Blue Economy, shall be achieved by strategic objective 3: Protecting, Conserving and Enhancing Natural Capital to Improve Ecological Resilience through investment in stormwater management through green and blue infrastructure, and, support and implementation of national water conservation awareness campaigns as well as provision of various incentives to encourage behavioural changes.

Programmes

Investment in Green Open Spaces

Project Green Agency has been entrusted to provide a better quality of life for the people of Malta, with the creation, maintenance and invigoration of parks, gardens and other green infrastructure, for healthier, happier lifestyles and a more sustainable environment. It is entrusted with the Government's seven-year-plan for everyone to enjoy green recreational spaces a short walk from home, wherever they live.

Malta Operational Programme 'Towards a smarter, well connected and resilient economy, a greener environment and an integrated society'

Specific objective: RSO2.7. Enhancing protection and preservation of nature, biodiversity and green infrastructure, including in urban areas, and reducing all forms of pollution of Priority: 2. PO 2 - ERDF: Promoting clean and fair energy transition, sustainable wastewater management and green investment provides for investment in green ecological corridors and Natura 2000 sites, and restoration of biodiversity through green infrastructure and gardens.

Figure 2.8: Birzebbuga, Benghajsa family park

Chapter 3

Our Strategy

Water management is a necessity for any country and has significant potential to enhance our environment and the daily experiences of life. Historically, stormwater management has meant quickly moving stormwater out of our public spaces and into a drainage network. This leaves water unseen, undervalued, and disconnects our relationship with water and natural systems in many ways. It has also led to impacts on receiving waterbodies and ecosystems that are difficult to perceive or experience. Through the GSI Strategy process of exploring our relationship with stormwater and water more broadly, we see a need to reframe our thinking about the role and value of water in our country and over a longer time horizon. Holistic and integrated water management approaches can do more than serve the stormwater and wastewater management needs of a country.

3.1 Vision and Guiding Principles

As an overarching and transformative direction, the Strategy recommends that Malta strives to become a water savvy country and that this aspiration shapes input into land use, infrastructure and environmental plans and programmes.

The concept of a water savvy country recognizes how human influences and land use decisions impact the environment. A water savvy country is one that seeks to embed holistic, integrated, and inter-generational water thinking in the planning, design, and delivery of water services. It seeks to protect and enhance the health of receiving waterbodies and natural systems, reduce flood risk, and develop buildings, public spaces and infrastructure that can harvest, clean and reuse water. It advocates fit-for-purpose water use and delivery of water through both centralised and decentralised infrastructure to deal with shocks and stressors. It shall achieve these outcomes using the tool of green spaces and systems that enhance biodiversity, mitigate pollution, reduce flooding, and promote well-being and physical activity.

The framework is founded on the idea that water management approaches and drivers are not static; they transition over time as the needs of a country evolve. This transition is not, however, a process over which we have complete control. It evolves either unconsciously or more purposefully as a country works to achieve a broader set of outcomes for its citizens.

The following guiding principles are developed to guide and support Malta's evolution towards becoming a water savvy country. Embedding water savvy values, behaviours and design principles into systems planning is critical. Countrywide systems and networks, such as our sewer and drainage system, transportation network and natural assets must consider the full water cycle in their planning processes. Becoming a water savvy country requires alignment between water management and the built environment.

3.1.1 Design our country as a water supply catchment

When we design the country as a water supply catchment, we no longer see water of any kind as a waste product. By valuing all water resources, we can close the loop, restoring the circular nature of the water cycle. This approach means managing rainwater where it precipitates, rather than prioritizing conveying it away. This approach supports a decentralized and resilient infrastructure system and prevents stormwater from reaching flood-prone areas that are the most vulnerable to impacts from sea level rise, storm surge and overland flood-

flooding from upstream drainage catchments. As such, implementation of GSI should strive to manage stormwater if conditions are particularly favourable for managing a greater volume of rainfall.

3.1.2 Design our country and infrastructure to deliver ecosystem services and biodiversity

Often, when we think of development and infrastructure, we think about how to limit impacts on the environment. How would our country be different if our built environment and service systems were designed to deliver, restore, and enhance ecosystem services instead of simply reducing impacts on ecosystems? Integrating GSI into integrated water utility planning and all facets of planning and design delivers multiple ecosystem services, including stormwater management, microclimate regulation, flood protection, habitat, and other liveability benefits.

3.1.3 Design our country for water resilience, adaptability and flexibility

Water, sewerage and drainage infrastructure makes up one of the largest components of public utilities budgets. This vital infrastructure is very costly and is typically challenging to readily modify or adapt to changing needs over time. Looking ahead, in the context of climate change and a growing population, there is increasing uncertainty about future needs and conditions. A transition towards a water savvy country calls for deliberate consideration of how we can build more flexible systems that can adapt in function and service levels over much shorter time frames than traditional water infrastructure enables.

3.1.4 Design our country to encourage collaborative action and enable water wise behaviours

Achieving lasting benefits through GSI implementation means a lot of change, new skills, and new practices in how organizations do their business. This means intentionally designing, supporting, and enabling opportunities and avenues to create, develop and share knowledge and best practices. Engagement with Government agencies, enterprises, academia, non-governmental environmental organizations and communities will help fully understand the dependencies and synergies of water management and reach overall maturity of the sector. It is also about recognizing that all of us have a role to play to make a difference. Continued public engagement, educational and training programmes and demonstration projects are essential in building capacity, developing acceptance for new kinds of water design solutions, and enabling water wise behaviours.

3.1.5 Design our country to support an equitable water future

Water and climate related challenges affect all communities, and those that are already overburdened with economic, social, and health challenges are especially vulnerable. An equitable water future can ensure that water services are accessible to all and that co-benefits of GSI implementation are maximized and distributed equitably, such that they address the needs of all people. Leveraging water, transportation, parks, and public space investments can support neighbourhoods that are green deficient, and physically prepare these neighbourhoods for a changing climate in terms of flood

management, urban heat, etc. GSI implementation can also help create and cultivate opportunities in contracting and stewardship and educational programmes.
An integrated approach can augment economic growth through workforce development and green jobs, help protect and restore the environment through healthy water catchments and ecosystems planning, and enhance public health, climate resilience and quality of life. How we manage our water resources and services also has a significant effect on affordability and equity in our country.

3.2 Goals and Objectives

In 2021, Malta set the Sustainable Development Vision for 2050[19] which states that 'it is worth looking at the potential Sustainable urban Drainage Systems and Natural Water Retention Systems offer for the development of a 'greener' infrastructure aimed at optimising the upstream management of stormwater thereby relieving the downstream reaches of the catchments'. The 2022 Sustainable Development Strategy for 2050 translates Malta's Sustainable Development Vision for 2050 into a strategic policy direction for the environmental protection and socio-economic development of Malta. It sets out five strategic goals which outline how to effectively achieve it. Strategic goal 1: transitioning towards a climate-neutral green and blue Economy shall be achieved by 5 strategic objectives among which protecting, conserving and enhancing natural capital to improve ecological resilience and sustainability. The latter objective shall be achieved, among others, by investment in stormwater management through green and blue infrastructure. Malta's objective is to ensure that the natural

Improve and protect Malta's water quality

Increase Malta's resilience through sustainable water management

Enhance Malta's liveability by improving natural and urban ecosystems

Figure 3.1 Strategy Goals

19. Ministry for the Environment, Sustainable Development and Climate Change. (2021). *Malta's Sustainable Development Vision for 2050*. Retrieved from *https://sustainabledevelopment.gov.mt/wp-content/uploads/2021/10/Maltas-Sustainable-Development-Vision-for-2050.pdf*

capital is managed and coordinated in an integrated manner that delivers significant benefits for society, the economy and the environment. The underlying idea of water sustainability for Malta by 2050 is to further appreciate water as a valued resource with enormous potential to build healthy water catchments and ecosystems where people and wildlife can thrive. In addition, stormwater management is a means by which we can become more resilient in terms of sea level rise, flooding, drought, urban heat and other water-related shocks and stressors.

To reach this Vision, three supporting goals are being established to guide decisions and actions in relation to stormwater management and implementation of GSI.

The goals intersect and are intended to reinforce one another. The following six objectives have been identified to guide GSI implementation towards these goals.

3.2.1 Remove pollutants from water and air

GSI can contribute to the reduction of water and air pollutants, such as sewer overflows, heavy metals, hydrocarbons, litter, organic material, greenhouse gases, dust and other sediments, improving water quality and liveability. Preventing pollution in runoff at the outset is critical.

3.2.2 Increase managed impermeable area

Using GSI to manage stormwater runoff from more impermeable areas will increase the effectiveness of GSI implementation and supports all three goals.

3.2.3 Reduce volume of stormwater entering the drainage system

GSI, designed to capture rainwater (infiltrate, evaporate or reuse), will reduce the volume of stormwater entering the drainage system.

This will reduce the likelihood of overflow occurrences and improve water quality and climate resilience.

3.2.4 Harvest and reuse water

Systems that harvest and reuse all types of water, whether in a single building, or at an area-wide level allow us to conserve potable water for the uses that require it and minimizes waste of our valuable water resources. These systems increase resilience and can help improve water quality.

3.2.5 Mitigate urban heat island effect

GSI features that include vegetation or surface water will cool the air around them, mitigating urban heat island effect and enhancing the liveability and climate resiliency of dense, urban neighbourhoods.

3.2.6 Increase urban green spaces

Increasing the amount of urban green spaces and ensuring that those areas are designed to treat rainwater runoff will improve liveability, water quality and resilience.

Figure 3.2 Strategy Objectives

Chapter 4

Initiatives

GSI is a key tactic in Malta's efforts to reduce flooding risk. This Strategy builds on a series of successful policies and programmes by pursuing two main objectives - committing additional public funding for planning studies and to build GSI to determine the long-term role that GSI can play alongside traditional grey stormwater infrastructure as we address Malta's rainfall runoff challenges.

4.1 Plan for the Future

With this Strategy, we are taking action now while we also collect and analyse new information to scale up as we move forward. We will develop a long-term stormwater management strategy by launching a series of planning studies. By planning for the future while simultaneously building GSI, we recognize that green practices are an important tool in our kit, particularly when they are cost-effectively integrated with other capital projects that would happen anyway. We also recognize that we need better data and more analysis to determine the long-term cost-effectiveness of green infrastructure to solve our flooding and water quality challenges.

Our planning effort will engage stakeholders to evaluate the best solutions to our stormwater challenges. We will learn from the GSI installations that have already been built.

We will seek knowledge from other places and from our past, but we will tailor our approach to Malta's unique conditions and future needs. After we complete the studies, we will release a stormwater management plan that lays out a long-term vision and strategy for implementing both grey and green stormwater management infrastructure.

4.2 Initiative 1

Green Stormwater Infrastructure Study

- We will undertake a study to determine the costs and benefits of using green infrastructure to manage stormwater -

We have learned much in the last ten years about how to design, build, and maintain green infrastructure, but we need additional data and analysis to determine the appropriate type, amount, and location of green stormwater infrastructure to address our challenges into the future.

GSI is an important and effective strategy. However, we do not yet have data to determine how a large-scale, drainage catchment-wide investment in GSI might cost-effectively displace needed potential investments in future grey stormwater infrastructure. Additional work and analysis are necessary to determine the best balance between green and grey stormwater management infrastructure and the most cost-effective overall approach to address long-term stormwater challenges.

There are two primary aspects of GSI that we must study further – analysing the costs and benefits of potential long-term green implementation scenarios and using a computer model to simulate the effects on drainage system performance and project reductions in flooding risk and improvements to water quality.

First, we will evaluate the full costs and benefits of GSI. Many environmental and engineering organizations and academics have evaluated the costs and benefits of GSI, yet we do not currently have up-to-date data that reflects the true costs to build green infrastructure in Malta or the expected performance of these installations to manage stormwater. We will take an inventory of existing GSI in Malta and develop a catalogue of the costs and benefits from various types of installations, such as permeable pavements, on-site rainwater storage, green roofs, and other techniques.

We will then evaluate various scenarios for a large-scale implementation of GSI by drainage catchments. These scenarios will be based on the unique land use conditions and consider the feasibility of various green infrastructure practices by area. This analysis will provide us with an understanding of the costs and benefits for widespread green infrastructure implementation and an estimate for the total volume of stormwater that we could keep out of our drainage system.

4.3 Initiative 2

Updated Stormwater Master Plan

- We will create a comprehensive plan that establishes a long-term vision and implementation strategy for managing stormwater with green and grey stormwater infrastructure -

Malta has undergone intensive development since when the 2008 Stormwater Master Plan for the Maltese Islands was prepared. The 2008 Master Plan did not consider global warming effects.

GSI will be a key strategy in addressing our stormwater management challenges, and it will complement our efforts to increase and enhance drainage and storage capacity. By 2028, we will create a long-term public plan for how Malta will comprehensively invest in stormwater management infrastructure. The Plan will be informed by the studies we are launching to analyse the costs and benefits of and the impacts of climate change.

An updated national stormwater management plan that establishes a long-term vision and implementation strategy for managing stormwater with both green and grey stormwater infrastructure shall be finalised by 2028. Through this Strategy and our future efforts, we will determine the best balance between investing in green and grey stormwater infrastructure to manage stormwater and provide the greatest benefits most cost-effectively.

Build Green Stormwater Infrastructure

We will demonstrate near-term action by allocating more finances over the next five years to build green stormwater infrastructure. This funding will go to projects that will deliver immediate benefits and improve our knowledge and understanding of GSI. We will target these investments in communities that have the biggest challenges with stormwater management. We will evaluate these projects to determine how these initiatives may be scaled up in the future.

We will focus on implementing cost-effective GSI actions, with a particular emphasis on integrating green stormwater designs into existing and future capital projects. This will allow us to leverage our funding by making incremental investments which are less costly than building stand-alone stormwater infrastructure projects, ultimately maximizing value. This significant investment in GSI will result in important reductions in the volume of stormwater runoff.

4.4 Initiative 3

Capital Projects

- We will incorporate green stormwater infrastructure into future public capital projects -

MEEE and MPWP are developing the Rain Water Integrated Infrastructure Network (Rain WiiN) in response to the current unsustainable state of Malta's natural water resources and existing knowledge gaps that deter the devel-

22. Tahal Group. 2008. *Consultancy for the Formulation of a Storm Water Master Plan for the Maltese Islands*. Retrieved *from https://www.parlament.mt/mt/paper-laid/?id=10620*

opment of adequate designs, plans and management of stormwater.

The overall goal of the Rain WiiN project is to increase available water resources through the harnessing and utilisation of stormwater and thus address the gap between the mean annual water supply and demand. Several strategic planning and specific operational shortfalls are currently undermining the resolution of the above issues. This requires an improvement both in the approach to the planning of stormwater infrastructure as well as physical development and management of the infrastructure for the harvesting and reuse of natural freshwater resources in an integrated manner. In addition, Rain WiiN is developing information that is needed to guide future project proposals by addressing existing information gaps.

Three key areas of concern in the sector of stormwater management are the absence: of data on the rainfall-runoff-aquifer infiltration characteristics in catchment areas; of a comprehensive and strategic framework for rainwater harvesting; and the inadequacy of physical infrastructure to achieve this in practice, in different areas of action.

Rain WiiN includes various action areas of intervention, all coordinated within a planning framework for such actions at catchment level. An extensive part of the planning framework is being developed through the LIFE Integrated Project (LIFE 16 IPE MT008) through the establishment of an integrated framework for the optimised management of all water resources, modelling of catchment areas and demonstration projects on the applicability and benefits of SuDS.

Phase 1 of Rain WiiN have been completed and included two elements, namely, Element (1) the planning and information-gathering action including the formulation of a planning framework for natural water retention systems in valleys and Element (2) stormwater reservoir management. The planning framework included the development of plans and design project proposals for each of the above components in five catchments with the highest water harvesting potential in Malta, namely the Salini/Burmarrad, Qormi/Marsa, Wied il-Qoton, Żabbar/Marsaskala and Dwejra catchments. These plans focus on attaining the reduction of water demand and augmenting water supply in synergy and coordination with stormwater management across the board. Element (1) lays the foundations for the integrated planning of project interventions in a broad range of action areas. These actions will be guided by the above-mentioned plans, which will be co-ordinated at catchments and sub-catchment level and will address the specific needs of different thematic and spatial areas of action.

Element (2) included the comprehensive study intended to develop data needed to guide future project proposals by addressing existing knowledge gaps. It involved the development and execution of Wied il-Għasel, located in the limits of Mosta and Burmarrad, as a pilot project for integrated valley management. The works comprised a 'cradle to grave' approach. Natural water retention systems for aquifer recharge (the 'cradle') were constructed. A management plan for the integrated management of the valley for water conservation is being implemented. The plan defines the parameters for land and infrastructural management for stormwater harvesting and provides the necessary structures and resources for the long-term management of the valley resources. Water depth data are being gathered and extrapolated for other sub-catchments with similar characteristics to develop informed future project proposals. The experience gained from developing the overall project planning framework, and from putting it into practice through pilot projects, is paving the way for other project actions of Rain WiiN. Forthcoming actions will involve the implementation of the individual plans and designs developed in Element 1 of Phase I and the execution of the component action areas at catchment and sub-catchment scale. Site selection and designs will also be informed from the monitoring strategy carried out in Element 2 of Phase I.

Road infrastructural projects shall feature more green infrastructure elements of natural drainage improvements, new stormwater basins, green streets (combinations of green infrastructure practices in transport networks), for either new development, redevelopment or retrofits including permeable pavement to decrease the vulnerability to flooding. Government is committed to making the biggest investment in the environment and in the quality of people's lives. Project Green was set up to coordinate the implementation of one of the main measures of the Government's Electoral Manifesto, namely the allocation of €700 million over a period of seven years to environmental projects. Urban regeneration projects by Project Green, Local Councils, MPWP, MEEE, Infrastructure Malta, etc. shall aim to:

• better management of water and reduce flood risk through sustainable drainage and natural flood management measures, water storage and reuse;

• create high-quality public green spaces, especially in highly urbanised locations and where this will help reduce health inequalities;

• restore and create wildlife habitats;

• improve streets and other public spaces at neighbourhood scale by retrofitting green and climate resilient infrastructure including sustainable drainage, trees, outdoor nature-based cool spaces and pocket parks;

• improve underperforming open spaces or poorly used amenity green spaces by making them more welcoming; and,

• create open spaces which reflect the demographic needs of the surrounding community.

Figure 4.1 Paola, Silvio Parnis Garden: A Water Conservation Project.

4.5 Initiative 4

Community and Streetscape Projects

- We will increase the use of green stormwater infrastructure in community and streetscape projects -

Further implementation of comprehensive street tree or urban green spaces, including tree biofiltration planters to manage additional stormwater and enhance tree health provide also hanging out spots for the communities to break from the daily routines.

GSI generates multiple co-benefits that traditional grey stormwater infrastructure does not. Grey conveyance infrastructure - tunnels and pipes - carry stormwater and do not provide any other benefits. Hydrodynamic separators remove sediment, oil, and debris from stormwater but do not restore water balance.

The realization of the Sustainability Urban Mobility (SUMP), which include significant infrastructural investments to provide better options for travellers who prioritise active mobility, shall be an opportunity to implement GSI infrastructure while transforming urban spaces for connections for safer active mobility.

Street trees intercept and absorb rain, reducing and slowing the amount of runoff that makes its way to the drainage system. A mature tree can intercept about 10 cubic metres of rainfall per year in its crowns and can intercept more than twice that amount in its pit, particularly when designed with an inlet to accept stormwater runoff. Mature trees provide exponentially more benefits than newly planted trees, so it is particularly important to preserve mature trees as well as plant new trees that contain enough soil volume to allow for full maturation.

Figure 4.2 Għajnsielem, Gozo, Amabile Cauchi Playing Field Rainwater Harvesting Park.

Chapter 5

Conclusion

5.1 Conclusion

This strategic framework outlines a comprehensive approach to address the unique water management challenges faced in the Maltese context. It aims to provide a structured and forward-looking perspective on the implementation of GSI practices, ensuring that they align with the specific needs and characteristics of Malta's environment. Taking inspiration from holistic approaches, this GSI framework views water management as an ecosystem that extends beyond mere drainage solutions. It encompasses not only flood risk mitigation and water quality improvement but also sustainable urban development, environmental conservation, and resilience to climate change.

One key aspect of this framework is the emphasis on stakeholder engagement and inclusivity. It recognizes that successful GSI implementation requires collaboration among government agencies, local communities, developers, and environmental organizations. By involving all relevant parties, we can ensure that GSI projects are tailored to meet local needs and gain widespread support. The framework provides a roadmap for the proactive planning, implementation, and maintenance of GSI initiatives in Malta. It outlines clear objectives and targets, including reducing flood risks, enhancing water quality, and promoting sustainable urban development. However, it is essential to acknowledge that the proposed actions and recommendations within this framework are not fixed in stone. They should be flexible and adaptable to accommodate evolving social, economic, and environmental factors. The success of this strategic approach hinges on the commitment and collaboration of all stakeholders, from political and economic entities to the broader community.

Apart from setting the stage for a strategic and collaborative approach to water management in Malta, this document also calls for cooperation and coordination among all stakeholders to ensure the long-term sustainability and successful realization of the goals outlined within this framework. By working together, we can build a more resilient and sustainable future for Malta's water resources and environment through the implementation of GSI.

Chapter 6
Appendices

GSI Tool		How it works	Benefits
Bioretention		SOAKS IN, SLOWS, CLEANS	• Can manage large amounts of runoff • Can be designed to calm traffic • Adds beauty, habitat, and green space • Protects against future flooding risks due to climate change
Rain Garden		SOAKS IN, SLOWS, CLEANS	• Manages runoff from roofs, paths, etc. • Adds beauty and habitat to your property • No technical knowledge is required for routine maintenance
Stormwater Cisterns		SLOWS, STORES + REUSES	• Easy to design, install, and maintain • Water can be used for irrigation and can reduce overall water use
Swale/ Infilration Trench/ Soakaway		SLOWS, SOAKS IN	• Manages runoff from roof, paths, roads, etc. • Inexpensive in settings with sufficient space
Biofiltration		SLOWS, CLEANS	• Cleans large amounts of runoff • Can add beauty and habitat to a range of sites

Figure 6.1a Green stormwater infrastructure types: how they work and benefits

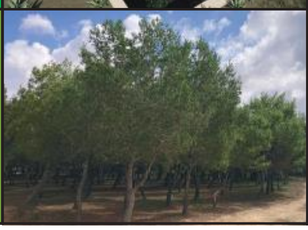
GSI Tool		How it works	Benefits
Permeable Paving		SOAKS IN	• Manages runoff and maintains a durable driving surface for vehicles and pedestrians • Can add visual interest/design detail
Green Roofs		SLOWS, EVAPORATES	• Adds more green space to your property • Adds habitat for birds and beneficial insects • Improves air quality • May be designed for food production
Depaving		SLOWS, SOAKS IN	• Frees up underutilized paved space for trees, plantings, and other uses, including GSI • Allows stormwater to soak into the ground where it falls instead of picking up and carrying pollutants into the sea • Can restore habitats for birds, insects, and other wildlife
Trees		SLOWS, EVAPORATES	• Tree planting and care is easy and fun • Mature trees improve air quality • Trees offer cool shade in summer and protect against strong winds • Adds beauty and green space to urban areas

Figure 6.1b Green stormwater infrastructure types: how they work and benefits

GSI Tool		Space Efficiency	Use in Shared Space	Use in Private Space	Use where infiltration is restricted?	Considerations
Bioretention		These approaches can manage runoff from an area of impervious surface many times larger than the facility.	✓	✓	Only with a liner and an underdrain	• A street slope of less than 6% slope is preferable • Bioretention requires consistent long-term maintenance • Designs may affect street parking and underground utilities • If an underdrain is needed, this requires careful layout and design • Bioretention usually requires geotechnical study and engineering • Avoid difficult-to-maintain areas like medians and arterials
Rain Garden		RUN OFF FROM THIS IMPERVIOUS AREA IS MANAGED HERE	✓	✓	✓	• Requires a level space (up to 5% slope) • Requires site be free of big tree roots and utilities • Requires a way for stormwater to flow into rain garden • Requires an overflow design
Stormwater Cisterns			✓	✓	✓	• Requires a level location and a solid foundation • Requires an overflow design
Swale/ Infilration Trench/ Soakaway			✓	✓	No	• Requires an infiltration rate of 3"/hour
Biofiltration			✓	✓	Only with an under drain	• Requires a minimum 60 m flow path, so opportunities to use this approach in a dense urban setting are very limited

Figure 6.2a Green stormwater infrastructure types: siting considerations

GSI Tool		Efficiency	Use in Shared Space	Use in Private Space	Use where infiltration is restricted?	Considerations
Permeable Paving		These approaches manage (or prevent) runoff from an area about equal to their own size.	Only for Code	✓	Only with a liner and an underdrain	• Requires a near level space (up to a 5% slope) • Professional installation is recommended for driving surfaces
Green Roofs		THIS IMPERVIOUS AREA MANAGES ITSELF	✓	✓	✓	• Requires a structure that can support a green roof • Irrigation may be required, especially in the first three years
Depaving			✓	✓	With Caution	• Some paving, such as concrete with steel reinforcement will require professional removal • Decompact the top 30 cm of uncovered ground and amend with 5 – 8 cm of compost to help restore permeability
Trees		These approaches manage runoff from an area smaller than their own area/size. THIS TREE MANAGES RUNOFF FROM THIS AREA	✓	✓	✓	• Ensure design has sufficient space for trees to grow to maturity • All newly planted trees shall be irrigated during the summer for the first 3-5 years after planting • Choose evergreen trees wherever possible

Figure 6.2b Green stormwater infrastructure types: siting considerations

Life

RBMP
LIFE MALTA

GOVERNMENT OF MALTA
MINISTRY FOR PUBLIC WORKS AND PLANNING