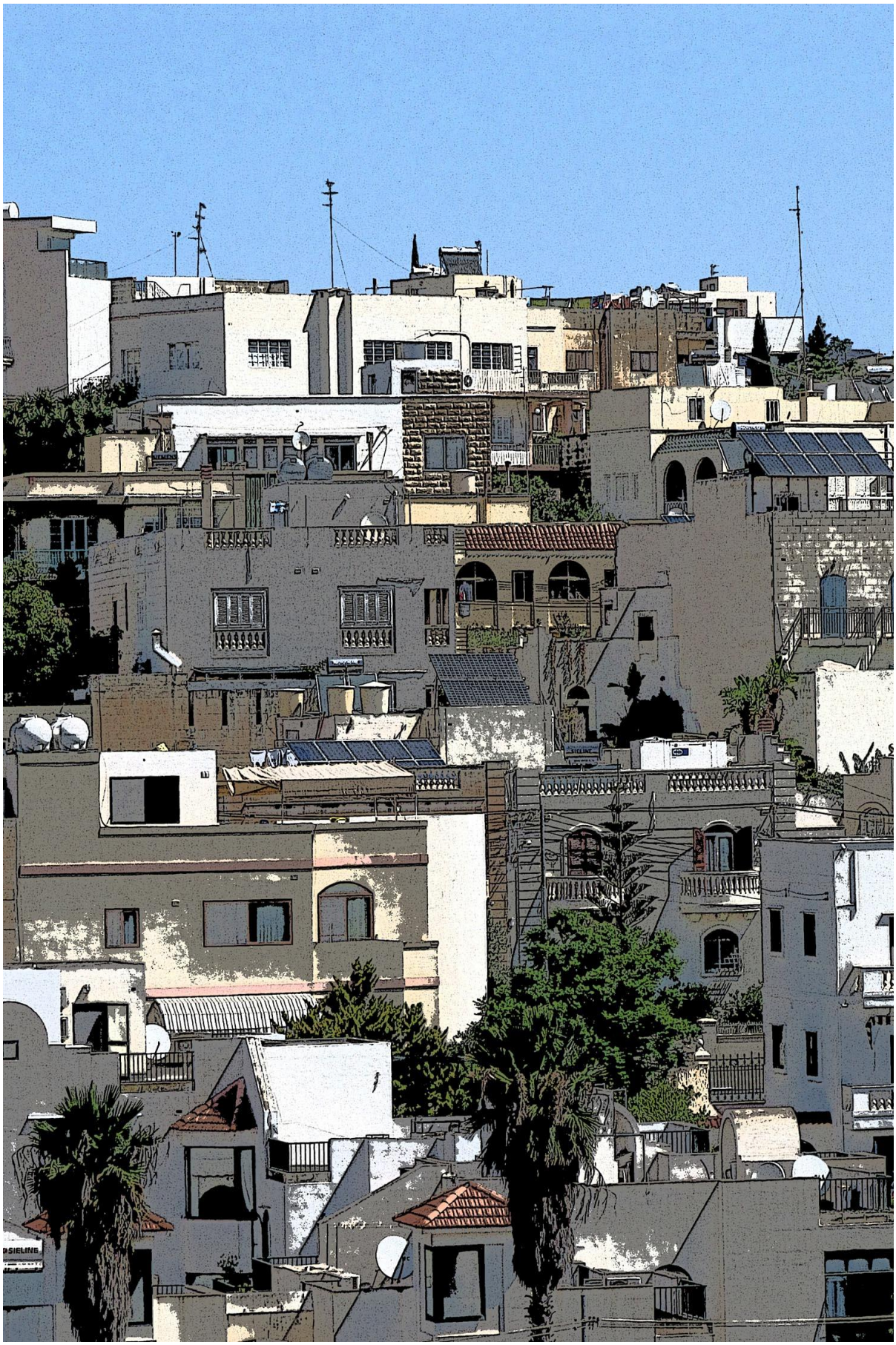

LifeMedGreenRoof Project

Policy Proposal Document

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LifeMedGreenRoof Project

GREEN ROOFS POLICY DOCUMENT

Contents

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Executive Summary

This document has been drafted as part of the LifeMedGreenRoof project. It is partially funded through Life+ which is the EU's financial instrument supporting environmental and nature conservation project throughout the EU and managed by the Faculty for the Built Environment of the University of Malta.

Urban areas are becoming less sustainable due the current development practices and lifestyle. Although in many aspects the quality of life has increased over the past century, in others, such as health and air/water quality there has been a tendency of degradation. Soil sealing, high energy demand and high urban density are major contributors to such issues.

Green roofs can be considered as both a mitigation and adaptation measure. Many countries and municipalities globally have set incentives to increase green roof cover so create more sustainable habitats. Unfortunately, in Malta green roofs are not rife due mainly to misconceptions and misinformation. The LifeMedGreenRoof project has through experimentation and demonstration confirmed that green roofs can be successfully employed to combat climate change issues other related problems. Nevertheless, relying on the voluntary actions of the public to increase green roof cover might not be a feasible way forward. Similar to other European countries, incentives should be set in place to integrate such technology into the building fabric.

The scope of this document is to highlight issues pertaining to green roof technology dissemination, the types of incentives which exist and how similar incentives could be adopted locally in line with what has been suggested in other European countries.

This report is organised in 12 sections. Section 1 gives a brief description of the state of urban areas and the problems they face. It also looks at the benefits of green infrastructure and how the European Union upholds such infrastructure for its wide benefits to society and the economy.

Section 2 introduces the concept of green roofs as an element of green infrastructure.

Section 3 assesses the benefits of green roofs. As green infrastructure, green roof benefits are plenty. Such benefits depend on the type of green roof constructed, location and maintenance regime.

Section 4 explores the need for a green roof policy for Malta.

Section 5 discusses briefly the policy objectives for green roofs.

Section 6 discusses the phases in establishing green roof policies. Such phases are not rigidly classified and can be implemented as necessary.

Section 7 highlights the types of green roof policies which could be taken up and which are normally implemented to encourage green roof technology.

Section 8 looks at case studies in five major European countries. The reason for the implementation of the incentives are listed together with a description of the types of incentives employed. The policy application and results are also highlighted.

Section 9, looks at local planning and construction policies to identify whether they support green roof technology. Some of these policy documents do specify the use of green roofs to combat climate change and other urban related issues, whereas other policies are more broad in nature giving the possibility of including other types of green infrastructure.

Section 10, investigates policies which could be realistically implemented on a local scale. Although existing local policies do allow for the integration of green roofs within the urban fabric, these are generally of a voluntary basis and are not mandatory. Specific action should be taken on a wide scale.

Section 11 looks at the importance of creating awareness whereas Section 12, the Conclusion, gives a summary of the document arguments.

This document forms part of the deliverables required of the LifeMedGreenRoof project, which is an EU funded project under the Life+ Programmeme, in an effort to encourage the widespread use of green roof technology throughout the Maltese territory. The scope of this document is to highlight the benefits of green roofs and to provide a set of policies and suggestions which would integrate green roof technology within current building regulations and policies. This will have an overall benefit of mitigating urban related projects and ameliorate the quality of life of urban dwellers.

1. Introduction - A brief background

In the last 50 years or so Malta has undergone a massive change both in the demographic as well as in the environmental picture. There is no denying that over the years there has been a sustained drive towards urbanisation with large tracts of fertile land being lost to the construction of houses, apartments and industrial buildings. This urban sprawl has resulted in planning policies aimed at restricting the horizontal expansion of urban areas. Such policies have brought about a significant change in the urban fabric where terraced houses are being replaced by predominantly medium rise apartment blocks. (MEPA, 2015) High land prices and the high financial gain realised through an increase in the number of units within one plot has often led to intensification and garden grabbing[1] processes. This practice has unfortunately resulted in the reduction of green infrastructure within urban areas. This, coupled with the absence of other green infrastructure has led to the reduction in urban wildlife and the attainment of ecosystem services.

In principle, the European Union endorses and promotes the benefits provided by natural ecosystems and acknowledges the threats they face due to changes in land use. (European Commission, 2013) It is believed that the unsustainable use of natural resources, pollution and climate change all contribute towards the decline and degradation of the ecosystem. Such degradation could cause irreversible changes that will profoundly affect human society in the long term. The EU believes that the best way to ensure a sustainable livelihood is by maintaining a healthy biodiversity thus maximising ecosystem services. (European Commission, 2016) (European Environment Agency, 2009)

Ecosystem services are the benefits provided by ecosystems that contribute to making human life both possible and worth living. Examples of ecosystem services include products such as food and water, regulation of floods, soil erosion and disease outbreaks, and non-material benefits such as recreational and spiritual benefits in natural areas.

(UK National Ecosystem Assessment, 2012)

The EU sees conservation of ecosystems and the restoration of degraded ones as an opportunity to create jobs thus generating growth and contributing to the EU's development plan. This had been reflected through a number of publications and policies issued by the EU especially the *EU Biodiversity Strategy to 2020*. (European Commission, 2013) This strategy reinforces the EU's commitment to protect and sustainably manage biodiversity.

[1] Garden grabbing is the practice of building over a garden resulting in the annihilation of the same soft area.

2. Green infrastructure and Green roofs

The European Commission defines green infrastructure as
"*a **strategically planned network of natural and semi-natural areas** with other environmental features designed and managed to deliver a wide range of ecosystem services such as water purification, air quality, space for recreation and climate mitigation and adaptation. This network of green (land) and blue (water) spaces can improve environmental conditions and therefore citizens' health and quality of life. It also supports a green economy, creates job opportunities and enhances biodiversity*" (European Commission, 2016).

It is of no surprise that green roofs have become such an important addition to urban environments on practically all continents. The concept of green roofs is not new at all. Evidence of green roofs have been traced, by archaeologists to ancient civilisations which include the Hanging Gardens of Babylon and the Ziggurat in the 6th century BC. Greened roofs of the middle ages include the 14th century Guinigi's Tower. In the latter half of last century, green roofs started appearing in Germany and this phenomenon accelerated with the development of reliable technologies. Such technologies included automated irrigation systems and more reliable damp proofing systems. Over the years, the technology became even more reliable leading to the development of extensive green roofs. This created lighter and cheaper systems which could be utilised on weak structures and requiring less maintenance.

With experience and research the benefits of roof greening became more apparent. Initially green roofs were installed for their aesthetic appeal, insulation properties and the protection of roof membranes from the natural elements. Over the years, additional benefits became apparent and today green roofs are considered an important element in the creation of sustainable urban settlements. Unlike grey infrastructure, green roofs provide a number of beneficial services which target both the owner and the community at different levels.

Green roofs became popular in temperate areas due to the fact that the technology was developed in Germany in recent history. In the Mediterranean this technology is not as advanced although things are slowly changing. Unfortunately, in Malta green roofs are practically non-existent. However, for the past few years both the University of Malta and the Malta College of Arts, Science and Technology (MCAST) have recognised the importance of such technology in mitigating urban related problems and embarked in research and demonstration projects. The University of Malta has obtained funds from the EU through Life+ for the implementation of the *LifeMedGreenRoof project*, with the aim of testing the performance of green roofs within the local context and creating a baseline study to encourage the dissemination of such technology locally. The project is managed by the Faculty for the Built Environment. Partners within the project include Malta Competition and Consumer Affairs Authority (MCCAA), Minoprio Analisi e Certificazioni (MAC) and Fondazione Minoprio (FM).

Figure 1: Guinigi Tower, Lucca (LivornoDP)

For the past 3 years a team of dedicated researchers have undergone the relevant studies to establish the performance of green roofs and their potential in addressing urban related

issues. As a result of the knowledge gained a demonstration green roof has been constructed at the Faculty for the Built Environment which is open to the public.

3. The benefits of green roofs

Green roofs provide a range of benefits to both the owner/occupants of individual buildings and the community. These benefits vary between individual roofs and are dictated by factors such as design and microclimate.

1. Aesthetic benefits

The World Health Organisation (WHO) considers the aesthetic value of urban areas an increasingly important aspect for healthy living (Edwards & Tsouros, 2006). This is because humans rely heavily on vision and good urban design results in attractive environments and healthy communities. Green infrastructure contributes towards an attractive environment and this stems from people's affinity towards what is natural. Studies show that having visual access to the natural environment will increase concentration in pupils (Velarde, et al., 2007), reduce stress and patient recovery time and increase productivity in employees. (Ulrich, et al., 1991) (European Environment Agency, 2009)

Green enclaves in our towns and villages are very hard to come by due to limited land area and the way urban areas are planned. Consequently, the role green roofs play as a means of introducing greenery in urban areas should not be underestimated. Vegetation is known to visually soften the harshness of buildings and reduce glare. This can be considered quite important locally given the long hours of sunshine throughout most of the year and light coloured buildings. Greened roofs also brighten up dull rooftops creating seasonal interest with the potential of masking unsightly features such as mechanical plants.

2. Amenity, open space and agriculture

With the decrease in private gardens and more families living in apartments blocks, open spaces are even more important. Green roofs provide amenity space for recreational purposes and even food production.

On office blocks, green roofs provide space for the employees to mingle just like in an urban park creating a setting for social interaction. Public green roofs can be utilised for community functions and organising special events. This is especially true in cities deprived of open spaces.

Green roofs located on tall buildings can act as a haven or refuge from the surrounding chaos of urban life. Generally, the noise created by traffic does not reach the roof top as it is deflected back by building walls thus creating a sense of tranquillity.

In countries such as Britain, France and the US, restaurants are utilising green roofs not just as a venue to host patrons but also to cultivate their own kitchen gardens. Urban agriculture can be said to be a means of ensuring small scale food security in urban areas reducing the carbon footprint of the food industry (Tolderlund, 2010). They can also be used for educational purposes in schools and other institutions.

Figure 2: The Demonstration green roof - University of Malta, (A Gatt)

3. Heat stress reduction

During the hot summer months, the uppermost floors within a building always suffer from elevated temperatures which cause discomfort to the occupier. This is caused by the sun's radiant energy which is absorbed by the roof slab and converted into heat energy. This heat is also absorbed by

the buildings' external walls if they are exposed. The heat is eventually transferred to the rooms below and even emitted back into the atmosphere during the cooler periods of the day. The effect of the radiated heat emitted by an urban area is so significant that it has been recognised by the meteorological term – Urban Heat Island. Because of the Urban Heat Island phenomenon, the ambient temperatures in urban areas are higher than those of the surrounding countryside. The difference in temperature can be as high as 12°C in larger cities (EPA, 2016). This difference in temperature causes discomfort, necessitating the use of energy demanding equipment such as air-conditioners which, through the burning of fossil fuels, contribute further to climate change. This phenomenon is also exacerbated by residual energy from transport, other machinery and insufficiently insulated buildings.

Studies (Zhao, et al., 2014) have proved that green roofs can be effective in reducing both external ambient temperatures and temperatures within buildings. Green roofs, through their thermal mass and evapotranspiration, are able to limit the energy which reaches the building. This contributes to the creation of a more comfortable internal environment with the advantage of a reduction in the use of air conditioners. (Austin, 2014). The insulation properties vary between one building and the next due to a number of factors which include:

1. The area of roof covered by a green roof (the larger the area of green roof the greater the benefits)
2. The depth of the growing medium and the density and characteristics of the plants cultivated
3. The number of floors (the topmost floor benefits the most)
4. Area of external walls exposed to climatic conditions and their insulation properties
5. Climate and micro-climatic conditions

Because of evapotranspiration, green roofs, are also known to lower the air temperature above them. If widely implemented over an urban area they could reduce the ambient temperature by as much as 3°C. (Austin, 2014) creating more habitable urban environments.

4. Noise buffering

Green roofs are also able to reduce noise levels within buildings by as much as 40-60 decibels (Tolderlund, 2010). The buffering effect is influenced not only by the depth of growing medium but also by the plant type, percentage coverage and humidity levels within the substrate. (Tolderlund, 2010) (T. Van Renterghem, 2014)

5. Flood mitigation

Urbanisation contributes to flooding. Most of the ground within an urban area is covered by impervious material (be it asphalt, concrete or a building) which prohibits the percolation of water into the underlying rock. Instead the water runs over the paved surface which could lead to local flooding. The local situation has become so drastic that a flood relief project was proposed. The first phase of this project has been implemented at a cost of around €43M[2] to relief

Figure 3: Flooding: a common occurrence in urban areas (https://pixabay.com)

[2] The total allocated funds are 42.9 million excluding VAT. (Malta, Government of, 2012))

flooding to the west of the island with two other schemes in the pipeline. Such massive spending could have been avoided in full or in part had adequate green infrastructure been protected from development and planned over the years.
Any soft landscaped area is able to absorb water which finds its way into it. This water is either absorbed by the plants, moves down the soil profile, recharging ground water or evaporates into the atmosphere. In contrast, soil sealing[3] contributes to an increase in surface water run-off resulting in flooding and erosion at point of discharge.

Green roofs absorb and retain precipitation. Both the growing medium and the vegetation have the ability to absorb rain, reducing flooding. By intercepting and retaining water from the early parts of the storm, green roofs limit the release rate of storm water during rain events. Additional water is also stored in the green roof depending on the type of drainage layers used. Some drainage modules are able to retain a substantial amount of water, helping to reduce flooding. Once saturated, the substrate releases the water gently into the drain. The volume of water retained by the substrate depends on the occurrences and intensity of the rain events (the closer the occurrences, the less is the water retained during the rain event) (Berndtsson, 2010) (Stovin, 2012). However, given that in Malta rain events are widely spaced, water retention can be substantial.

Other aspects which effect the extent of flood mitigation include depth of substrate, the make-up of the substrate, the type of drainage layer, roof slope and vegetation type and density (Tolderlund, 2010) (Bursztа-Adamiak, 2012).

6. Air quality

"Across Europe, people are exposed to levels of air pollution that exceed air quality standards set by the EU and the World Health Organization (WHO)" (European Environment Agency, 2009). Air pollution is a justified public concern as it could lead to incidences of respiratory diseases. According to the Eurostat report, deaths related to respiratory disease in Malta are substantial (Eurostat, 2013). Children and the elderly are mostly effected by low air quality increasing the possibility of respiratory and cardiovascular diseases (European Environment Agency, 2009). Good air quality is important for an increased quality of life. The major causes of diminished air quality include transportation, energy generation and the construction industry. Elevated air temperatures can also result in poor air quality (European Environment Agency, 2015).

Although results show that Malta's national air quality meets EU standards, certain areas with elevated traffic are of concern. These areas of high traffic are generally located within urban areas and as such air quality need to be in check. Malta's most significant air pollutants include particulate matter and nitrogen oxides with concentrations in urban areas often exceeding EU standards. (Ministry for Tourism, the Environment and Culture, 2012)

Figure 4: Air pollution over Marsa/Qormi (A.Gatt)

Plants are known to remove pollutants from the atmosphere.

[3] Soil sealing is defined as the covering or **sealing** of the **soil** surface by impervious materials s.a. concrete, metal, glass, tarmac and plastic. [**definition** source: EEA multilingual environmental glossary]

Their effectiveness depends on various factors such as plant type and leaf characteristics. Roof greening also improves air quality by reducing ambient temperatures and the generation of smog (European Environment Agency, 2009). Green roof systems are also known to act as sinks for contaminants. (Vijayaraghavan & Joshi, 2014)

7. Habitat creation and well-being

"Ecosystems provide a multitude of benefits to humanity, from food, clean water and flood protection to cultural heritage and a sense of place, to name but a few. However, many of these benefits, known as 'ecosystem services', are under severe threat from man-made pressures". (Brickhill, 2015)

Studies conducted abroad have demonstrated that the presence of green open spaces and less high rise buildings contribute to a healthier lifestyle whereas people living in areas with ample green open spaces are more active (Ellaway et al., 2005). School children with access to, or in sight of, the natural environment show higher levels of attention than those children without such views (Velarde et al., 2007).

The importance of biodiversity in relation to human health is well documented. Humans feel more at ease when surrounded by what is perceived as natural (Kaplan & Kaplan, 1989). This has been confirmed by studies which state that concentration levels in school children increase and employee performance is heightened. (M.D. Velardea, 2007) (European Environment Agency, 2009)

Green roofs serve to return back to nature a part of what has been taken up by building development and infrastructure. They provide more pleasant views from the conventional black roof tops and can provide visual respite and amenity to the onlookers. Such enhanced views provide the benefits mentioned above.

Green roofs also benefit urban biodiversity, increasing ecosystem services such as pollination (European Commission, 2016). Green roofs provide important habitats for wildlife through the provision of food and shelter. They also provide habitat for wild plants providing an opportunity for native vegetation to once again colonise urban environments (Madre, et al., 2014) (Oberndorfer, et al., 2007). Together with other green infrastructure, green roofs provide for wildlife corridors, especially for mobile creatures such as insects and avifauna.

8. Property value

It has been suggested that more attractive properties fetch better prices in terms of lease and sales. A study in New York has found that properties rented out with a green roof were, on average, about 16% higher than in buildings without green roofs (Ichihara, 2011). A study in Canada estimated that property with green roofs were valued 11% higher than conventional buildings whereas buildings with views onto greened roofs were 4.5% higher in value (Tomalty & Komorowski, 2010).

Figure 5: Typical view of urban area. (Vince Lloyd Morris)

9. Prolonged building life

Green roofs create a permanent insulation cover above the roofing slab and damp proof membrane. On a conventional roof both the slab and the membrane suffer damage due to exposure to the elements resulting in membrane degradation and hairline cracks in the

concrete. This condition is particularly relevant to Malta given the elevated exposure to solar radiation. The protection given by green roofs result in the extended lifetime of the roof resulting in less maintenance and associated costs for the owner. Green roofs maintain relatively constant temperatures especially on a diurnal cycle thus preventing regular shrinkage and expansion of the structure.

10. Solar panel efficiency

Solar panels work efficiently up to 24°C and 25°C. When ambient temperatures escalate beyond these levels, PV panels loose efficiency. Green roofs, through evapotranspiration, are able to lower the ambient temperatures which mean that solar panels work more efficiently thus generating more energy.

In warm climates, PV panels take advantage of the cooler air created by green roofs to maintain or possibly increase efficiency. From experiments carried out in Hong Kong, it transpired that green roof surface temperatures were 5–11 °C cooler than the black roof's, and the green roof–PV system combined produced 4% more power (Nagengast, et al., 2013).

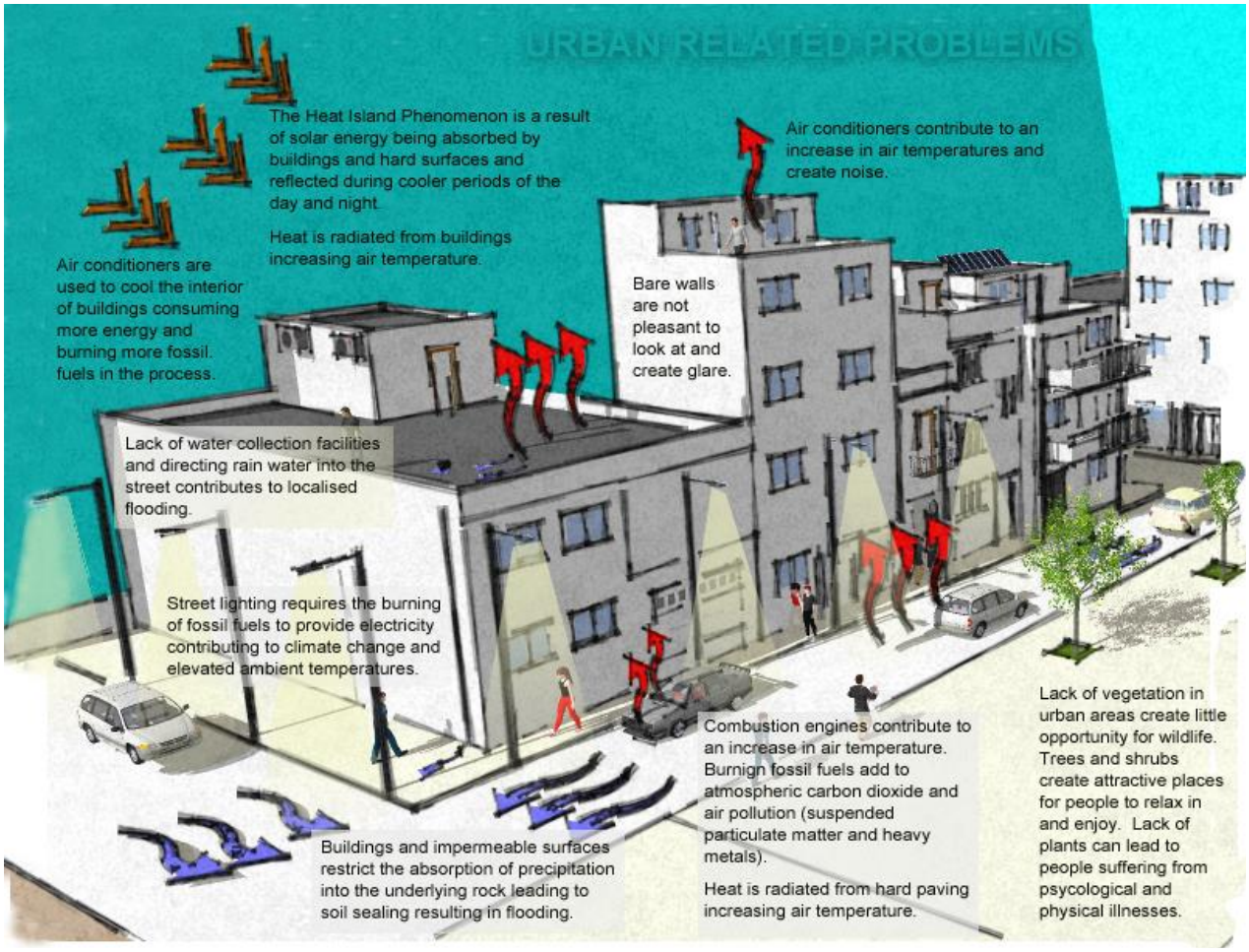
11. Job creation

From an economic approach roof greening also provides benefits (van der Linde, 2010) (Michael Krause, 2010). With the increase in popularity in green roof technology worldwide, job opportunities are created in all sectors of the market from importers of raw material to manufactures, transportation to retail, and from design to construction. They also provide opportunity for research and innovation. The emergence of this technology has created new jobs, benefitting the local economy (Rowe, 2006).

Unfortunately, in Malta, the benefits of green roofs are still not widely appreciated and this is generally due to a series of misconceptions. It is imperative that green roofs are integrated into the urban fabric to reap their benefits. A single roof will have very little impact on the community, however the more green roofs are constructed, the more widespread are these benefits. It is for this reason that green roof policy should be encouraged and such advantages should be outlined.

Typical Public and Private Benefits of Green Roofs	
Community benefits	**Private benefits**
Aesthetic improvement	Aesthetic improvement
Reduces the urban heat island effect and peak load energy demand	Energy savings
Improves air quality	
Increases biodiversity	Urban agriculture revenue potential
Increases tax revenues	Improves marketability
	Increases property value
Creates local jobs	Reduces employee absenteeism
	Increases employee productivity
Decreases infrastructure costs	Increases roof membrane durability
Improves storm water management - quality and quantity	Meets storm water and green space regulations
Facilitates new recreational/educational opportunities	Facilitates new recreational/educational opportunities
Reduces greenhouse gas emissions	Improves solar panel efficiency (PV panels)
Improves community health and well-being	Improves amenity, health and well-being

Figure 6: Urban related problems



4. The need for green roof policy

It has been established that green roofs contribute to increasing the well-being of urban dwellers through mitigation and adaptation. The EU considers green roofs an important addition to sustainable cities. Through directives and policies at high level they encourage their dissemination.

When a green roof is constructed by a private individual, they are also providing benefits to the public. These green roofs are of national interest and as such merit intervention through policies, regulations, incentives and legislation (Carter & Fowler, 208). Individuals who opt to install a green roof could suffer financial setbacks considering that the technology is locally novel. Moreover, there would be limited examples of green roofs to act as a source of reference and comparison.

Although green roofs provide a number of social advantages, it is primarily the private benefits which will induce owners to install green roofs. This highlights the need for the implementation of a national scheme incentivising individuals to install green roofs and encourage the dissemination of this infrastructure over a wider territory. Green roof benefits will only be experienced if the technology is widespread over a territory or district.

In most industrialised countries, policies, incentives and regulations have been used to increase the number of roofs installed. Such a move has been instrumental in maximising the collective benefits of green roofs such as flood mitigation and lowering of ambient temperatures. In Germany, which country is considered the leader on green roofs, the increase in the number of green roof cover has been attributed to legislation linked to collective benefits. It has been shown that relying on the goodwill of building owners to install green roofs is not enough to bring about the desired change. Financial incentives and associated policies are required to fully realise the benefits that green roofs may provide. (Ngan , 2004)

A similar experience can be seen in the installation of photovoltaic panels on residential rooftops in Malta. Before the introduction of the solar panel subsidy schemes, very few owners considered installing photovoltaic panels but, once the relevant policy was put in place, the number of installations increased dramatically.

5. Policy objectives

It has been established that green roofs provide an array of benefits ranging from the personal to the community scale. Some of these benefits target aspects which are important at both regional (flood mitigation) and national levels (meeting national energy targets). The way green roofs are designed affects their performance and their ability to address specific issues. Only through the identification of the benefits required can policy makers set specific goals and define construction conditions. (Ngan , 2004)

Issuing incentives and development regulations which target owners of different building types will ensure a wider uptake of the technology. Making green roof installation mandatory for certain building types is also an option which should be considered and investigated (Ngan , 2004).

6. Developing green roof policy

The document “Green roofs; A resource Manual for Municipal Policy Makers” (Lawlor, et al., 2006) identifies 6 phases in establishing green roof policies. Such phases are not rigidly classified and can be implemented as necessary. The document identifies each phase in

chronological order; however, given that these phases are reasonably interchangeable, they are presented here under simple subheadings.

Introductory and awareness

It is important that stake holders are made aware of the benefits and advantages of green roofs from both an ecological and an anthropogenic perspective. Such awareness can be instilled through the organisation of workshops, information sessions and visits to green roof projects both locally and abroad. Organisations such as Green Roofs for Healthy Cities have been instrumental in helping North American municipalities in getting stakeholders together for information sessions (Green Roofs For healthy Cities, 2016).

Currently, through the LifeMedGreenRoof project the University of Malta's Faculty for the Built Environment is conducting research on green roofs in Malta in association with MCCAA, MAC and FM to establish a baseline study of green roof performance in the Mediterranean context.

Community engagement

Getting the community involved is very important if the technology is to be taken up on a wide scale. It is important that the profile of green roofs is raised and this can be achieved through community meetings, workshops and information lectures. Community leaders, design professionals, educators, NGOs and policy makers should all be engaged in support of green roofs.

One of the aims of the LifeMedGreenRoof Project is to reach out to the prospective stake holders to inform them about the problems facing urban areas and how green roofs can be used as a means of mitigation and/or adaptation. Such information dissemination is being tackled at different levels mainly through site visits to the demonstration green roofs by policy makers, the education establishment, students, local government, businesses, and so forth.

Scepticism and misinformation are factors which prohibit the adoption of green roofs technology. A demonstration green roof could be used to organise information visits and facilitate the collection of information regarding various aspects of the technology. Organised visits would help in the familiarisation of the technology by all stake holders.

The demonstration project at the University of Malta was created for this reason. In addition, scientific research is being conducted to overcome scepticism and prove that green roofs can be successfully implemented in a local context. The project addresses the current misconception that such roofs are impossible to cultivate in Malta, mainly due to climatic factors.

Action plan development and implementation

An action plan is need to introduce green roofs into local policies and create awareness about such technology. Green roof technology should not be viewed as a burden but understood to be of benefit to society. The action plan should be complete, and clear so that all players are made aware of the aims and objectives and the direction to be taken during its implementation.

While the plan might address generalised goals, the various actions determine the specifics to make the objectives a reality.

The plan set out by the LifeMedGreenRoof Project over a four-year period was to create a baseline study on green roof performance in terms of the basic requirements (plant and media choice) and performance in terms of insulation and flood mitigation. Through

presentations and media coverage information about the technology has been disseminated coupled with the construction of the demonstration green roof and the publication of the standard document for green roof construction in Malta.

What is now required is an action plan which would involve policy makers so as to push forward the implementation of green roofs over the whole of the Maltese territory. This can only be done through political will and by the involvement and commitment of the various policy institutions and authorities.

Technical research

This is of importance to substantiate the theory of green roof performance. Many studies dealing with the technical aspects of green roofs have been conducted in temperate regions. Such research, unfortunately, has rarely been applied to the Mediterranean region while, in Malta, it is virtually non-existent. Generally speaking, for a given technology to advance, performance needs to be better understood. Green roofs are undeniably efficient in mitigating urban related problems; however, awareness of their performance locally would provide a stronger tool to encourage its dissemination within the Maltese context.

The Faculty for the Built Environment has, through the management of the LifeMedGreenRoof Project, set the ball rolling in the understanding of the performance of green roofs locally with the assistance of foreign partners in the project. This has led to further cooperation with other research institutions.

The current studies primarily examine the insulation potential and the storm water management of green roofs in Malta. However other potential benefits are also emerging leading to further research and liaising exercises. Such research focuses on the additional benefits of green roofs to the preservation of biodiversity and food production.

The project also encourages research by involving students so as to increase awareness and to understand better the performance of green roofs in the local context and how such performance could prove beneficial at different levels.

Programme and policy development

This stage involves the establishment of schemes such as policies and incentives so as to encourage the dissemination of green roof technology. The use of both policies and incentives is important as they target different stakeholders. Incentives tend to be voluntary and their uptake is generally related to whether stakeholders deem the technology economically feasible. Policies, on the other hand, are a tool which would target specific development proposals more precisely. Both policies and incentives could be tailored to address specific issues such as energy consumption, flood mitigation or biodiversity.

This document is intended to initialise dialogue with policy makers and stakeholders in order to activate the process whereby green roofs are integrated in building and planning policy documents, initiatives and incentives.

Already the LifeMedGreenRoof project is working on developing a green roof standard for Malta. Reference was made to the German Guidelines for Planning, Construction and Maintenance of Green Roofing, (known as the FLL), and the Italian green roof standard

(UNI 11235:2007) for the drafting of the Maltese standard. *The scope of the Maltese green roof standard is to guarantee that green roofs are installed appropriately, minimising the chances of failures.*

Continuous improvement

Once policies and incentives have been set in place, and the technology proven, it is important to assess the effectiveness of such measures. Monitoring Programmes and periodic reviews play a crucial role in providing effective feedback. Mechanisms have to be put in place to collect information and assess results and give feedback to stakeholders. This phase is important as it would involve exploring alternative measures which would target alternative issues, enhance those existing, or request additional studies and clarifications.

7. Types of measures

Measures can take different forms as are listed here under.

Direct financial incentives:

Direct financial incentives take the form of subsidies paid to property owners who construct green roofs very similar to the PV panel incentives in Malta. In Germany they are a common form of subsidy. Such incentives are usually determined either by area of green roof constructed (sum of subsidy per m^2 of green roof) or less commonly, by reimbursing the calculated percentage of costs of construction or construction and design.

Subsidies are generally subject to specific conditions. They can either look at specific construction requirements such as growing medium depth. This guarantees minimum performance or achieve goals which are difficult to quantify. It also makes assessment of the construction easily undertaken. Conversely, policies can be aimed at performance level such as insulation properties or storm water performance. This addresses more accurately specific goals needed to be reached and allows for further innovation. They can also be subject to minimum maintenance period (e.g. 10 year) which would guarantee the existence and performance of the green roof. (Ngan , 2004)

Financial incentives can also be devised to target specific priority areas or specific issues. In Munich city centre, policies were set to encourage the increase in green infrastructure within an area devoid of green spaces (Ngan , 2004).

Green roof policies have also been incorporated in other schemes encouraging broader initiatives as in the case of the Courtyard Greening Programmeme of Berlin implemented between 1983 and 1996. The purpose of the incentive was to encourage the use of green infrastructure to improve the aesthetics and climate in urban areas, and increase the quality of life. During the implementation of the scheme 54ha of courtyards and roofs were greened amounting to €16.5M. (Schmidt, 2000)

The advantages of direct financial incentives include:

- The voluntary adoption of green roofs through the scheme
- They can be designed to reach specific performance and purposes
- They can encourage the adoption of green roofs in specific target areas
- They are effective for retrofit roofs

- The area of green roofs constructed is proportionate to the benefits gained

Limitations include:

- Capital sum required

Indirect financial incentives

Indirect financial incentives generally comprise split wastewater fees. These relate to the pay-per-use concept of storm water disposal. This fee system charges for water consumption rates to cover both grey water and storm water disposal. With split waste water fees, the property owner is charged for both the disposal of grey water based on water consumption and storm water fees based on the total area of impervious surfaces over a property. Systems like green roofs which absorb storm water and reduce the storm water run-off from impervious surfaces earn reductions on fees based on water disposal. On-site storm water control reduces run-off volumes and peak flows being discharged into the public realm. This means less damage to public and private property due to improved flood mitigation. Such incentives also encourage the use of porous surfaces resulting in less local flooding. Run-off coefficients of surfaces and storm water fees and fee discounts are related and can be considered just and fair as the higher the coefficient the higher the fees. Referring to the FLL, the German guidelines for green roof construction, the typical runoff coefficient of a green roof with depth between 15-25cm is 0.3.

When considering the water retention properties of green roofs, one also needs to consider the quality of the water which flows from the roof. Water from a green roof is generally of higher quality as the water is filtered through the substrate and vegetation which act as filters. Such water can be reused for household use in toilet flushing and general cleanliness (Ngan , 2004) Water quality is affected by decaying organic matter content which should be kept to a minimum to limit nitrate levels.

Indirect financial incentive advantages include:

- Storm water fees provide a strong basis for protecting water resources
- Storm water fees are an efficient way of incentivising green roofs and green infrastructure
- Such indirect incentives encourage the voluntary installation of green roofs through monetary gains
- Such policies can run indefinitely as they are not related to the availability of budgets
- It is transparent and easily communicated to the public
- It works well with both new and existing buildings
- Storm water fees are independent of other means of funding and may be more enforceable in the long run

Limitations include:

- Cost of administration
- A system of inspection and maintenance may be needed to ensure continued storm water performance
- Opposition to fees by the public

Ecological compensation

Greenfield[4] and brownfield sites[5] within urban areas provide important ecosystem services and are an important conservation hub (Dearborn & Kark, 2010). Thus the construction of buildings over such sites deprive society from such benefits. To a certain extent, green roofs can be said to compensate in part to this reality. This has led Germany to introduce an ecological compensation policy focused on the 'Intervention Rule'. This is a decision-making process applied at land-use and development levels. The policy is based on segments of the Federal Building Code, the Federal Nature Conservation Act and the Environment Impact Assessment Act. (Ngan , 2004)

The policy is not aimed at rural development and is not implemented to justify rural building interventions. It is however concerned with urban areas and the urban fringe. This is because urban green areas provide ecosystem services such as habitat for wildlife, flood mitigation and ambient temperature control.

Green roofs can be integrated into planning policies and building regulations as a compensation measure. They should not be seen as a substitute but as a mitigation measure.

Ecological compensation measure benefits include:

- Green roofs could provide ecosystem benefits which would have otherwise been had by the greenfield sites
- This measure could be used in addition to other measures and can target specific locations
- This measure could target those developments which have the greatest negative impact on ecosystem services

Limitations include:

- Cost of administration
- A system of inspection and maintenance may be needed to ensure continued performance

Incorporation into Regulations

The adoption of green roof technology should be based on two actions if it is to be successful; incentives and regulations. Incentives are adopted voluntarily by the benefactors whereas regulations are imposed. Because green roofs benefit not only the owner but also society, and because society sacrifices quality of life because of urbanisation and development, imposing green roofs through regulations could compensate for some of these problems. Incorporating green roofs within development regulations ensures the increase in green roof area.
Through such regulations, specific developments could be targeted and minimum performance stipulated. In Germany for example, flat roofs and roofs with falls up to a

[4] **Greenfield** sites refer to undeveloped property in rural and urban areas destined for development.
[5] As per the British definition, **brownfield** sites are being referred to previously developed land that have the potential of being redeveloped. Brownfield sites also refer to (but not exclusively) areas used formerly for industrial purposes and which have the potential of being contaminated. Such site could be rehabilitated and redeveloped.

specified degree have to be greened. In France, 'new buildings in commercial zones must be partially-covered by either solar panels or green roofs'[6].
The type of green roofs to be constructed should relate to the targets and benefits to be reached. Performance could be achieved through the specification of standards which would include substrate depth, species of plants cultivated and so forth. These would, in turn, influence the quality and quantity of storm water run-off as well as and insulation properties.
Regulations may also require public organisations to lead by example by installing green roofs on all existing and future public buildings.

The incorporation of green roofs into building regulations should result in:

- A reduction in the expense of financial grants
- A more effective and efficient targeting of new development
- A major boost to investment in green skills and jobs

The incorporation of green roofs in building regulations may also incur new challenges

- Protests by owners and developers due to the extra cost
- Regulations could be difficult to implement on existing and retrofitting projects

8. Green roof policies worldwide

Green roof situation globally including policies and regulations (greenroofs.com, 2016)**:**
The EU acknowledges that green infrastructure can contribute significantly towards achieving key policy objectives related to sustainability (European Commission, 2013). It acknowledges that green infrastructure provides many social, economic and environmental benefits mostly related to the quality of urban areas. (European Commission, 2016) Green infrastructure is seen as being a means of achieving EU goals and priorities including Europe 2020 (European Commission, 2013),

In northern European countries, governments and local authorities have, for more than thirty years invested and integrated green infrastructure in the planning system and put down regulations to encourage the integration of green infrastructure in the urban fabric to benefit from ecosystem services (Ngan , 2004) (Lawlor, et al., 2006).

The EU encourages the integration of green infrastructure in urban areas to mitigate problems resulting from urbanisation and current lifestyle. Localised flooding, reduced air quality, obesity, urban heat island and climate change are some of the issues faced by urban populations. These impact on quality of life (European Environment Agency, 2009) (European Commission, 2016).

Green roofs are considered to contribute towards climate change as both a mitigation measure and an adaptation. They are a mitigation measure due to their ability to reduce flooding and reduce the heat island effect and climate change adaption when considering their effectiveness at insulating the underlying building from solar radiation keeping the building cool.

Green roofs have become an important addition to the urban fabric and are considered crucial in the creation of sustainable cities. For this reason, more and more countries are

[6] Personal communication through e-mail with Embassy of France in Malta, 21st July 2016

pushing towards the dissemination of green roof technology. Germany has the highest area of green roofs with a conservative estimate of around 86,000,000m^2 of green roofs in 2004 and with an estimate growth of 8,000,000m^2 per annum. Figures in other countries might not be as high but they are expected to increase substantially as can be seen in the table below. (EFB, 2015)

Target country	**Green roof stock total m^2 (2014)**	**Green roofs new/year m^2**
Austria	4,500,000	500,000
Germany	86,000,000	8,000,000
Hungary	1,250,000	100,000
Scandinavia (S,N,DK)		600,000
Switzerland		1,800,000
UK	3,700,000	250,000

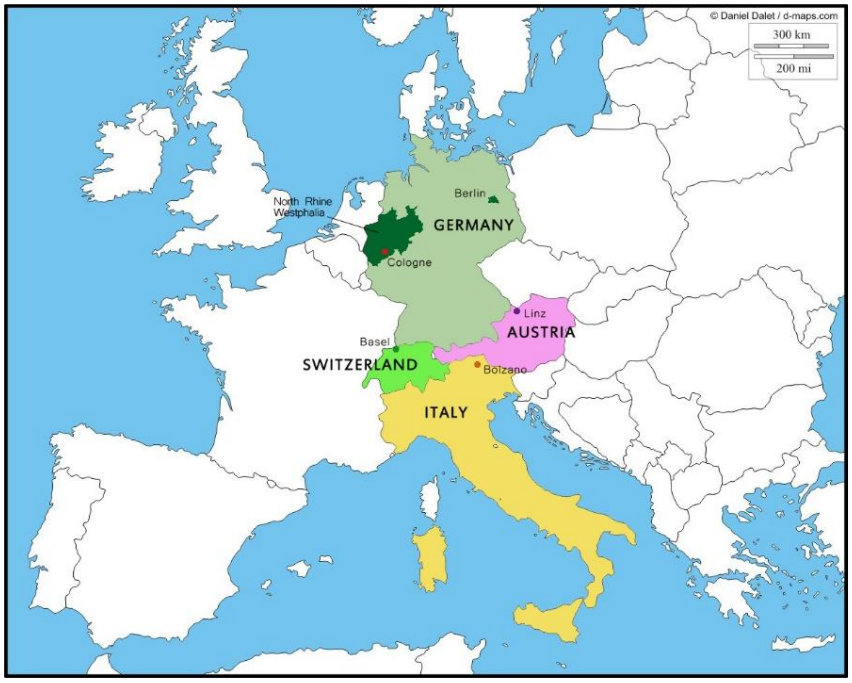
Table 1 Source: European Federation of Green Roofs and Walls - EFB 2015

Various countries and municipalities have adopted different schemes to encourage the increase in green roof cover. These schemes vary in nature but they share a common aim: that of encouraging the dissemination of green infrastructure within the built environment. These schemes are not always aimed directly at green roofs but at all forms of green infrastructure given the broadness of their benefits. However, these initiatives allow for the increase in number and area of green roofs over a specific territory.
Such initiatives vary in nature from policies to legal notices to financial grants. Every country or municipality varies depending on what is deemed important or what the authorities feel would be the way forward to achieving specific goals.

In Denmark, for example, 19 municipalities have included green roofs in their urban planning policies with an effort to become a carbon neutral city by 2025. In 2008 Copenhagen integrated green roofs within their planning policies becoming the first municipality in Scandinavia to require all new buildings with roof slopes inferior to 30 degrees to have green roofs incorporated within them. In addition, all Municipality buildings have to have a green roof installed. Since 2010 they have included green roofs in all new local plans in an effort to combat climate change and urban related issues. Strategies with reference to green roofs include the waste water plan 2008, Climate plan 2009,2012, Climate adaptation plan, and guidelines such as those for sustainability in construction and civil works 2010, and guidelines for handling rain water. The strategy for biodiversity also makes reference to green roofs. Today the City of Copenhagen has more than 40 green roofs. (City of Copenhagen, 2012), (livingroofsworld.com, 2013)
Similar initiatives have been taken in other Danish municipalities.

Case studies

The following are case studies[7] of initiatives undertaken by different municipalities to incentivise the number of green roofs and in the process gain ecosystem services and benefits:



[7] Information compiled from the following sources:
Ngan , G., 2004,
Lawlor G et al., 2006.
(City of Toronto, n.d.)

Jurisdiction	North Rhine Westphalia (NRW) - Germany 
Policy type	Direct Financial incentives
Context	NRW is one of the most densely populated states in Germany. It includes the highly industrialised Ruhr area with a population density of up to 1200 individuals per square kilometre. The state relies on heavy industry (steel works, iron production etc) and the chemical industry for its economic well-being. All this has had repercussions on the environment. Such industry had a very significant negative impact on the biodiversity of water bodies and air quality. Following the cessation of such industry, pollution levels subsided and fish returned into the previously polluted water bodies.
Policy motivators	Water quality was the key motivator for issuing the policy. Green roofs have the ability to control water at source through delaying storm water run-off thus reducing loads on water treatment plants, pressure on the sewer system and consequent flooding.
Policy description	The 'Initiative for Ecological and Sustainable Water Management' is a Programme on state subsidy in several areas of water and wastewater management. The Programme was developed by the Ministry of Environment, Consumer protection, Nature conservation and Agriculture with the aim to conserve and improve water quality of rivers and bodies of water. Funding for the Programmeme was generated from fees imposed on polluters according to the wastewater charges act which requires that these funds are used only for improving water quality. In other words, subsidies have been financed by a 'polluter-pay' principle for wastewater management.
Policy application and result	The Programmeme is administered by the Municipality. The subsidy consists of various areas of eligibility. Green roofs fall under Subsidy area 6; with a subsidy of €15.00/m^2. What is eligible for subsidies are the cost of the insulation layer, the drainage layer, substrate and plants. Other non-vegetation related items such as decking are not eligible. Projects in existing urban areas are targeted whereas in new development green roofs are required to be implemented and as such are not eligible for funding. Green roofs required as compensation measure according to Federal Conservation Act are not eligible. The subsidy can be used with other storm water fee reductions. Between the introduction of the Programme, in September 1999 and the end of 2003 the sum of €12,366,490.00 has been paid in subsidies resulting in the greening of circa 825,000m^2 of green roofs.

Jurisdiction	Cologne 
Policy type	indirect Financial incentives
Context	Cologne is the largest city in the state of North Rhine-Westphalia and the fourth-largest city in Germany. It is located within the Rhine-Ruhr metropolitan region, with more than ten million inhabitants. Cologne is regularly affected by flooding from the Rhine and is considered the most flood-prone European city.[26] An extensive flood control system monitors the river and manages pumping stations and other flood defences to protect against flooding. As the largest city in the Rhine-Ruhr metropolitan region, Cologne benefits from a large market structure. The economy of Cologne is primarily based on insurance and media industries, while the city is also an important cultural and research hub and home to a number of corporate headquarters.
Policy motivators	Of major concern in Cologne is flooding. The city is prone to flooding and the area of impervious surfaces became a subject of concern.
Policy description	Two types of policies to finance green roofs are in place in Cologne. 1. The NRW subsidy (see North Rhine Westphalia (NRW) above) and 2. Storm water fee discounts. The fee is charged depending on storm water disposal at a rate of €1.10/m^3/yr. This means that fees are proportionate to the area of impervious surfaces within a property.
Policy application and result	Since green roofs are considered to be a flood mitigation measure, property owners can claim discounts which reflect the area of green roofs installed. The discounts on green roofs are calculated on run-off coefficients as determined by the FLL guidelines and confirmed by the green roof supplier. The City Drainage Corporation conducts tests to confirm the performance of the green roofs installed and the subsidy applied. Through these policy initiatives the City Drainage Corporation not only managed to keep wastewater levels stable but managed to keep them below the 1993 levels.

Jurisdiction	Berlin-Germany 
Policy type	Unique policies
Context	Berlin is the capital city of Germany with a population of approximately 3.6 million people, and a density of 4,048 inhabitants per km^2.. Its economy is based on high-tech firms and the service sector, encompassing a diverse range of creative industries, research facilities, media corporations and convention venues. Significant industries also include IT, pharmaceuticals, biomedical engineering, clean tech, biotechnology, construction and electronics. Berlin is renowned for its many parks and avenues which are a result of four landscape masterplans for the city (landscape Programme for Berlin 1984/1994) in which green infrastructure was given its merited importance. The administration of Berlin embraces new and innovative ideas especially when it comes to natural resources within the city boundaries. 'Their intuitive acceptance of the less quantifiable, yet scientifically-based green roof benefits have allowed Berliners to enjoy the many advantages of the green roof policy'. This is a trend which the Maltese need to learn from and embrace.
Policy motivators	Berlin has a long history of green roof policies. Since the 1970s researchers from the Technical University of Berlin examined the ecological benefits of green roofs while the population pressed for more environmentally friendly approach to town planning. Between 1983 and 1996, the Courtyard Greening Programme aimed at increasing green infrastructure to reduce soil sealing. This programme contributed to around 65,750m^2 of green roof subsidies. Berlin Water Corporation administers the storm water fees based on the area of impervious surfaces. The aim of the policy is to control storm water at source.
Policy description	A new concept emerged to deal with the impact of high urban density in a number of Districts. The dense development negatively impacted the land mainly due to 1. High density soil sealing, 2. Inadequate replenishment of ground water, 3. Overloaded sewage system, 4. Excessive atmospheric temperatures and 5. A persistent decrease in green infrastructure and urban biodiversity. In the 1980's the city adopted the Biotope Area Factor (BAF (BiotopFlachenFaktor)). This policy tool was

	meant to address the environmental problems above. The scope was to address issues of improving microclimate and pollution, restoring the function of soil and water cycle, enriching urban biodiversity and improving urban quality of life. In 13 areas of Berlin the BAF is obligatory and on a voluntary basis outside such areas. BAF is expressed as a ratio between the ecological effective surface areas over the total property area. For each urban form a specific BAF target value is set by planners; for e.g. New residential areas have to have BAF of 0.60 whereas commercial structures should have a BAF of 0.30. Each type of surface is assigned a measure of relative importance according to its 'ecological value' thus sealed surfaces would have a weighting factor of 0.0 and green roof 0.7/m^2.
Policy application and result	No specific design requirements or performance goals were set for the green roofs; however, they simply have to conform to set industry standards. The policy did suffer minor setbacks such as underdeveloped standards and installers lacking knowledge but these were remediated. Today some of the problems encountered have been solved through technology and good practices. The policy proved successful and the quantifiable benefits could not be accurately calculated. This policy proved popular especially with the professional sector because of its practicality and the immediate results in terms of energy savings. It proved particularly suitable in older neighbourhoods which lack green areas.

Jurisdiction	Linz-Austria 
Policy type	Direct Financial incentives and planning requirements
Context	Linz is the third-largest city of Austria and capital of the state of Upper Austria. It is located in the north centre of Austria, straddling the River Danube and approximately 30 kilometres south of the Czech border. The population of the city is 200,841. Linz is one of the main economic centres of Austria. It houses an important steel industry as well as chemical industry. It constitutes an attractive location in regards to the manufacturing industry, logistic and trading enterprises. Each of the nine counties has a regional development planning act setting out both mandatory and optional regulation included in the local development plans. Green roofs were introduced in 1985 and are regularly included in the development plan.

Policy motivators	The lack of green infrastructure was the key motivator for the green roof policy. The importance of green infrastructure was recognised by 1984 for its positive contribution upon urban climate, pollution control, mental health, local character to mention but few. Objectives were laid down to improve the shortage of urban greening especially where it was mostly lacking. Where land use was incompatible with open space development, green roofs were seen as an obvious solution. The objective of the *Green Space Plan* for Linz was the retention of an adequate "greening level" and the improvement of the lack of sufficient greenery.
Policy description	Two different policies were established for the City of Linz; the implementation of green roofs through the legally binding development plan and the provision of financial support for the implementation of green roofs. The former was first incorporated into the policy documents in 1985 and the text applied to different kinds of land use. Most of the roofs in Linz were included within the policy. The development policy referred to new and proposed buildings with a set area over 100m^2 with a maximum roof gradient included. The policies also gave a minimum thickness of substrate, which depth depended on the type of structure and it included also the minimum plant coverage. Initially the Programmeme was met with scepticism because of the high installation costs of the green roof. As a result, the green roof subsidy was introduced. It was implemented in 1989 and was the first direct financial incentive for green roofs in Austria. The costs also covered the upgrading of the load-bearing structures. 30% of the eligible costs were refunded and did not include the design and contract administration costs. The subsidy covered both voluntary and mandatory green roofs and did not distinguish between extensive and intensive green roofs.
Policy application and result	The subsidy requested that the roofs be maintained over a long term. This was enforced by paying out the subsidies after construction and after the establishment of the vegetation at a ratio of 50% 50%. Inspections were conducted by the committee providing the financial support. The main difficulties experienced included the lack of man power for consultation and monitoring. The incentives proved successful as up to 2001 circa 268,000m^2 of green roofs were constructed with an additional 47,000m^2 the following year. Initially contractors tried to work around the first green roofs, however at present this topic is no longer a matter of debate and building plans submitted often have green roofs already incorporated.

Jurisdiction	Basel, Switzerland[8]	
Policy type	Financial and building regulation	
Context	Basel is a city in north-western Switzerland on the river Rhine where the Swiss, French and German borders meet. It has an area of 23.91km^2 of which 20.67 km^2 or 86.4% is urbanised. Of the built-up area, industrial buildings make up 10.2% while housing make up 40.7%. Transportation infrastructure makes up 24.0%. Parks, green belts and sports fields make up 8.9%. Basel is Switzerland's third-most-populous city with about 195,000 inhabitants. Basel has been a commercial hub since the Renaissance. The chemical and pharmaceutical industries are the main industrial activities.	
Policy motivators	Initiatives aimed at the increase in green roof cover were initially motivated by energy-saving and eventually by biodiversity conservation.	
Policy description	The City of Basel promoted green roofs through two incentive Programmes which constituted a combination of financial incentives and building regulations. The focus on green roofs was promoted by the Zurich University of Applied Sciences in Wadensil which influenced decision makers in Basel to amend the building regulations and offer financial incentives to increase the coverage of green roofs. The schemes initially were intended as an energy saving measure and were funded by the City of Basel. The initiative proved popular amongst residents especially due to the creation of biodiversity habitats. The incentives were targeted at both business and residential buildings. Media played an important role in promoting the incentives. The first scheme was run in 1996 for a year. In the early years of the 1990's the City implemented laws to support energy saving measures. The law required that 5% of energy bills from customers were to be put into an Energy Saving Fund which covered the expenses related to the green roof scheme. In densely built-up areas, where parks and other green areas were impossible to construct, green roofs were a viable option. A second incentive was put forward between 2005 and 2006 which required that all new and renovated flat roofs be greened, not only as a form of insulation, but also to maximise habitat for biodiversity.	
Policy	A comprehensive suite of mechanisms from incentives to statutory	

[8] Information compiled from (European Environment Agency, n.d.)

application and result	regulations ensured a wide uptake of the green roof technology. The green roofs insulated the buildings efficiently. The City also benefited from the mitigation of flooding and the reduction in the ambient temperatures. Through green roofs, indoor temperatures were reduced by as much as 5°C reducing the need for cooling and the related energy use contributing to climate change mitigation and adaptation. It was estimated that 23% of Basel's flat roofs were greened in 2006. Because stakeholders were involved in the drafting of the whole process objections to installing green roofs were limited. In Basel the green roof regulations stipulated measures to encourage the integration of biodiversity while guaranteeing the insulation performance of the green roofs. In total, 135 residences and businesses applied for the green roof subsidy resulting in 85,000m^2 of green roofs. The resultant savings on energy were estimated at 4GWh/year.

Jurisdiction	Toronto, Canada [9] 
Policy type	Financial and Building regulations
Context	Toronto is Canada's largest city with a diverse population of about 2.8 million people. It is the fourth largest city in North America. It's a global centre for business, finance, arts and culture and is has been classified as one of the world's most liveable cities (City of Toronto, 2017). Due to its geographical location within the vicinity of the great Lakes, Toronto enjoys economic benefits. This is due to the development of an efficient rail and trucking system. It is linked to major industrial centres in the United States and to important shipping routes. As the capital of Canada's richest and most populous province, the city has a widely diversified economy. Ontario produces more than half of Canada's manufactured goods and most of its manufactured exports. It has immense resources of raw materials including minerals, timber, water, agricultural products, and hydroelectric power. Tourism is also important to the city's economy. (Howarth, 2010)
Policy motivators	The City of Toronto recognised the environmental benefits green roofs have in reducing the effects of the urban heat island and associated energy use, managing stormwater runoff, and improving air quality. To increase ecosystem services, the City

[9] Information compiled from (City of Toronto, n.d.)

	took the opportunity to create habitat and enhance biodiversity in the urban fabric.
Policy description	Toronto is the first City in North America to have a bylaw to require and govern the construction of green roofs on new development. It was adopted by Toronto City Council in May 2009, under the authority of Section 108 of the City of Toronto Act. (City of Toronto, 2017) The Bylaw applies to new building permit applications for residential, commercial and institutional development made after January 31, 2010 and apply to new industrial development as of April 30, 2012. Design Guidelines for Biodiverse Green Roofs were created to provide guidance and illustrate best practices. The Guidelines cover both construction and maintenance of green roofs.
Policy application and result	From 2010 to 2014, 300 green roof permits have been issued for a total of 250,000 m2 of green roofs. A total of 444 green roofs currently exist in Toronto. The programme uses fees paid by developers to fund green roofs that, in addition to retaining storm water, provide multiple environmental benefits. The programme has funded 137 projects with developer fees, greening and cooling almost 280,000m2 of roof space. In total, energy consumption is reduced by 1,030 MWh, and 121 tonnes of greenhouse gas emissions are avoided annually. In 2014, the EcoRoof Incentive Programme supported 35 projects totalling over 62,450 m2 of roof space. The projects in 2014 alone have reduced energy consumption by 117 MWh per year, avoided over 22 tonnes of greenhouse gas emissions annually, and diverted 525,000 litres of storm water.

9. Local policies supporting green roof initiatives

Already policies exist which could influence the uptake of green roofs locally. Some of these policy documents do specify the use of green roofs to combat climate change and other urban related issues, whereas other policies are more broad in nature giving the possibility of including other types of green infrastructure. Documents which are being referred to have been published by government institutions and authorities and include the Malta Environment and Planning Authority (MEPA) (now Planning Authority (PA)), Buildings Regulations Office (BRO), and the Ministry for Tourism, the Environment and Culture.

The documents referred to include the:

1. National Environmental Policy (Feb 2012) published by the Ministry for Tourism, the Environment and Culture,
2. Document F Technical Guidance (2006) published by the Services Division of the BRO.
3. Strategic Plan for Environment and Development: SPED (July 2015)
4. Development Control Design Policy guidance and Standards (2015) published by MEPA.

1. National Environmental Policy (Feb 2012)	
SECTION	**POLICY**
2 Malta's Environmental Objectives	
2.1 Greening the Economy	
	Green the national economy, steering it away from environmentally-polluting and resource-intensive economic sectors
Integrating environmental considerations into economic development planning	Integrate environmental considerations into economic development planning
Market-based instruments	Promote further use of market-based instruments in environmental policy
Environmental taxation	Continue to take a stepped approach towards environmental taxation
Promoting eco-innovation	Encourage environmentally-friendly innovation
Incentivising the green jobs sector	Promote green jobs
2.2 Safeguarding Environmental Health	
	Improve environmental health in Malta
Air quality	Achieve a high level of air quality in the Maltese Islands, both at a national and a local level, in a timely manner
Noise	Reduce noise-related environmental health impacts
2.3 Using Resources Efficiently and Sustainably	
	Ensure the efficient and environmentally-sustainable use of all natural resources in Malta, including stone, waters, soil and land
Fresh waters	Manage fresh water resources in an environmentally-sustainable manner
Land	Use Malta's land resources efficiently
2.4 A Pleasant Place: Improving the local environment	
	Improve the physical appearance and amenity of urban and rural areas
Greening our cities	Improve the liveability of urban areas in terms of pleasantness and amenity
2.5 Greening Gozo	
	Fast-track the island of Gozo towards sustainable development through

	the Eco-Gozo process
2.6 Long-term sustainability issues	
Climate Change and Energy	Control Malta's greenhouse gas emissions in line with commitments, and enhance Malta's capacity to adapt to climate change
Biodiversity and ecosystems	Halt the loss of biodiversity by 2020
3 Implementing and achieving our environmental policy objectives	
3.2 Leading by example in the environmental field	
	The public sector will lead by example in the environmental field
3.3 Using a range of complementary policy instruments	
	Use a mix of policy instruments to implement environmental policy in the most effective and efficient manner

2. Document F Technical Guidance (2006)*		
The Requirement Document F-Conservation of Fuel, Energy and Natural Resources (Minimum Requirements on the Energy Performance of Buildings Regulations, 2006)		
Conservation of Fuel, energy and natural resources	(I)	A building shall be so designed and constructed as to secure, insofar as is reasonably practicable, the conservation of fuel, energy and other natural resources.
Control of heat power and lighting.	(II)	Reasonable provision shall be made for the conservation of fuel and power in a building by: - (A) Limiting the heat loss in winter and the heat gain in summer through the fabric of the building:
Exploitation of climatic variables	(IV)	A building shall incorporate measures to reduce adverse effects of solar radiation, wind and rain while exploiting the benefits of these climatic variables, according to the seasons
Limits of application		(B) Requirements (II) (A), (B), (C), (D), (E), and (II) apply only to dwellings and other buildings whose floor area exceeds fifty square metres.
2. Resistance to the Passage of Heat		
2.01 General		
2.01.1 The envelope of all buildings shall be designed to resist heat loss or gain or, where appropriate, to encourage heat gain or loss		

3. Strategic Plan for Environment and Development: SPED (July 2015)	
Socio-Economic Development	
Thematic Objective 1: To manage the available potential space and environmental resources on land and sea sustainably to ensure that socio-economic development needs are met whilst protecting the environment and limiting land take up within the Rural Area by:	
7. Increasing green open space	
Thematic Objective2: To ensure that provision is made for new social and community facilities and to cater for extension s to such existing facilities for education, child care, family care, health, the elderly, the disabled, rehabilitation, places of worship and animal welfare which are accessible for all while minimising environmental	

impacts by:
2. Maximising the efficient use and reuse of existing facilities
Environment
Thematic Objective 6: To safeguard environmental health from air and noise pollution and risks associated with use and management of chemicals by:
2.Identifying and designating pollution hotspots including air and water quality, noise and land contamination, and focusing resources for positive actions and improvement
3. Protecting vulnerable areas from sources of pollution
Thematic Objective 8: To safeguard and enhance biodiversity, cultural heritage, geology and geomorphology by:
3. Strengthening the links within the ecological network of the Maltese Islands
Climate Change
Thematic Objective 9: To control Greenhouse gas emissions and enhance Malta's capacity to adapt to Climate Change
5. Promoting energy efficiency in the design of buildings
Travel Patterns
Thematic Objective 10: To facilitate the model shift through the provision of an integrated transport network and a parking framework whilst minimising their adverse environmental impacts particularly on protected areas and species by:
5. Integration of rainwater management infrastructure in road networks
Urban Area
Urban Objective 3: To identify, protect and enhance the character and amenity of distinct urban areas by:
7. Protecting and greening open spaces which contribute towards the character and amenity of urban areas, reduction of soil sealing and support biodiversity with a view of developing ecological corridors
Urban Objective 4: To ensure that all new development are energy and water efficient and provide a sense of place, respond to the local character, improve amenity and the pleasantness of place and ensure safety by:
1. Setting out a policy framework to promote high quality design
3. Ensuring that the design of buildings and infrastructure makes efficient use of energy and resources and reduce waste
5. Seeking to reduce risk hazards through design and location
6 Seeking to integrate the requirements of people with special needs in the design of buildings and facilities
7. Promoting the concept of sustainable urban drainage systems to reduce the generation of rainwater runoff from urban areas
Gozo
Gozo Objective 1: To ensure that the social and employment needs of Gozo are met and to protect the distinctiveness of Gozo's settlements, cultural and natural environment to support the implementation of Eco-Gozo' initiative by:
12. Managing the cultural landscape, the undeveloped coast and enhance its biodiversity

4. Development Control Design Policy, Guidance and Standard: (2015)
4.3.2 Sustainable quality
G25 Design for Energy Conservation and Resource Management
The Authority encourages the consideration of specific energy conservation measures, the use of renewable sources of energy and resource management in the formulation of the design, layout and materials of all new developments, in view of producing nearly zero-

energy buildings (Figure 63). Design measures should be targeted at prioritising the inclusion of passive measures in order to reduce the energy requirements of a development. Furthermore, where possible, existing passive measures such as those attainable through older building fabric should be retained and exploited. In this respect, spaces generated as a result of development or designed as part of such development should give due regard to issues, such as:

- *daylight penetration;*
- *the control of sunlight, in terms of summer and winter variations as well as the implications for glare;*
- *the provision of optimal shading (as and where required);*
- *the consideration of prevailing wind and wind-flows and the avoidance of excessive wind speed generation; and*
- *resource management, namely opportunities for recycling and reuse, such as the provision for water collection and its reuse as a second class water resource.*

Specifically, the Authority encourages the consideration of the following passive design measures at the onset of the design process, which should be guided by the provisions in ***Technical Guidance Document F – Conservation of Fuel, Energy and Natural Resources (Minimum Requirements on the Energy Performance of Buildings Regulations, 2006)****:*

a) Design of the building fabric that considers its thermal mass and the possibilities to incorporate thermal roof and wall insulation as well as green roofing technology, particularly on developments having a large roof area. For exposed roof surfaces, it would be good practice to use a light-coloured finish in order to avoid unnecessary heat gains.

c) The potential for shading external apertures and other building components in consideration of the building's orientation.

4.4.1 Designing public buildings and non-residential developments – design principles

G28 The Design of Public Buildings and Non-Residential Development

The Authority encourages high quality, innovative urban and architectural designs that respect and enrich their surrounding contexts, in line with the discussions in Part 1 of this document and the provisions in Guidance G1.

Public buildings and non-residential developments, particularly those located within designated areas/enclaves (A4b), offer significant opportunities for bold and imaginative architectural statements that add interest to the streetscape and act as landmarks, without diminishing the relevance of other established landmarks, in line with the provisions in Policy P37 (Figure 67). Such treatment may depart in certain respects from a particular provision given in this document, but may be acceptable provided:

d) green measures are implemented, such as green roofs/roof gardens and energy generation through renewable energy sources, particularly in developments characterised by a large roof area, including commercial and industrial developments, and social, cultural, religious and educational establishments.

4.4.2 Medium- to large-scale non-residential developments

G29 Medium- to large-scale non-residential developments

The design of medium- to large-scale non-residential developments requires special care due to their particular requirements for prominence and for the use of space, which may demand:

- *occupying a significant footprint, with resultant roof area;*
- *having higher than normal floors, which are to follow the provisions established in Guidance G18;*
- *making a design statement, due to the particularity of their function or to signify attractiveness, innovation or modernity; and*
- *having large glazed areas or particular façade treatments.*

While acknowledging the need to cater for the above requirements, these developments should nevertheless be guided by the following provisions:

g) The roof area should be exploited for recreational purposes as well as for the integration of green measures, notably the development of green roofs/roof gardens and the provision of PV modules, in line with the provisions in Guidance G25. Use of such roof would be appropriate where this would not lead to a reduction in privacy or amenity of adjoining buildings. Generally, however, the use of the roof of a non-residential development located within or immediately adjoining a residential area would not be allowed for (i) operational purposes; (ii) car parking; or (iii) any other use that would have an adverse impact on the amenity of the area.

10. Green roof policies for Malta

Although existing local policies do allow for the integration of green roofs within the urban fabric, generally, the policies in themselves do not specifically mention green roofs. In addition, one cannot rely on one's goodwill and voluntary action for the introduction of green roof technology. Misconceptions are difficult to correct without an intensive education/information programme and the cost of installing a green roof is prohibitive for many; however, there is an urgent need to introduce green roofs within the urban environment to reap the benefits of the technology, mitigate the problems which such areas experience and help meet energy targets which the country is to respect.

Residents in urban areas have to endure a number of issues which effect their quality of life. The building industry, energy production and transportation increase pressures on local infrastructure and reduce the quality of basic requirements for residents. Moreover, such problems put pressure on government (in terms of spending and logistics) not only in terms of providing social services as a result of these problems; as in the case of increased health risks (European Environment Agency, 2013), but they make it difficult for the government to respect European and international obligations especially those related to emissions and energy targets.

As expressed earlier in this document, green roofs have the potential of reducing urban related issues. However, policies, regulations and incentives are needed to encourage the development of green roof technology as sporadic private interest cannot be relied on.

The implementation of green roofs in Malta can be achieved through the following tools:

- Direct financial incentives
- Indirect financial incentives
- Regulations and policies

and

- Examples

Direct financial incentives:
Direct financial incentives related to subsidies, grants and low interest loans to those who install green roofs which meet specific criteria as placed down by a scheme. Such incentives could apply to various stages leading to the construction of the green roof as well as post-construction such as maintenance (the German system which excludes the design and management phases is sensible as it would reduce abuses rendering the system more transparent). Such incentives would be looked at positively by the public as the importation of materials is generally higher in Malta than that incurred by other foreign countries. As the benefits of green roofs are realised and the technology becomes widely implemented the cost of green roof installation will fall. Direct financial incentives help overcome hurdles that would otherwise discourage the adoption of green roof technology. Furthermore, making the introducing of green roofs easier to uphold will encourage businesses to invest in the technology and encourage the uptake of green roof by the consumer (City of Melbourne, City of Stonnington, City of Yarra, City of Port Phillip, State of Victoria, Univeristy of Melbourne, 2014).

Financial incentives could have different forms; they could work on similar lines as the PV grant scheme whereby individuals who voluntarily install a green roof would be remunerated through a direct subsidy covering a percentage of the cost for constructing the green roof. Depending on whether the green roofs are needed to address specific issues, such as flood mitigation or insulation, conditions are imposed on the beneficiary on the minimum performance of the system adopted. The issues needed to be addressed by the green roofs could also influence the urban typology covered by the financial incentives, thus, if ambient temperatures were being targeted, then highly urbanised localities would be covered by such incentives, on the other hand if the green roofs are needed to target flooding then a specific watershed could be the beneficiary. Since locally all buildings are constructed with a flat roof, the potential for green roof construction is substantial, the only limited factor would be the load bearing capacity of individual buildings and the will of the building owner. Whether to include the retrofitting of existing buildings as part of the financial aid would be a matter of discussion.

Alternatively, green roof construction could make part of other funding Programmes such as the reduction in the rate of loans, as part of a green initiative.

Indirect financial incentives: One of the main reasons for the increase in urban flooding is soil sealing. Existing dwelling with gardens of various sized are being replaced by apartment blocks with underlying garages where in the process any green open space is destroyed and built over.
Introducing an annual soil sealing fee by government or the Water Services Authority could be an incentive to reduce soil sealing. Such a fee would acknowledge the benefits green roof have in dealing with storm water run-off and filtration at source. Setting up soil sealing fees could be managed to improve and fund other green infrastructure project which would lead to ameliorating the urban quality of life. Such a strategy has worked in other European cities and there is no reason why such a scheme would not work locally. It has also been recommended in other countries such as Canada (City of Toronto, 2006). By calculating the areas of sealed land over a property and charging a fee related to such an area will encourage the reduction in soil sealing. Properties which incorporate systems which would favour storm water management at source would qualify for a discount. Such a discount would be calculated on the run-off coefficient of the different types of surfaces.

Green roofs would qualify for such incentives as would other types of green infrastructure including water reservoirs and permeable surfaces.

A rebate on a percentage of fees could also be applied to encourage the widespread installation of green roofs. Such rebates would have to be directly related to the construction of green roofs. VAT rebates could be considered for indirect financial incentives

Such rebates and fees could be justified on the basis of supporting the reduction of practices which contribute to the detriment of public well-being. Any practice which reduces or mitigates such problems would attract rebates and discounts. Discounts and rebates would only be provided to those specified systems which contribute to public well-being and other collective benefit including the reduction in water run-off from a property and the lowering of the carbon footprint of a building. It is acknowledged that the introduction of fees will be looked upon negatively by the tax payer, however this can be compensated through a reduction of other taxes such as VAT or income tax.

There are other indirect financial incentives which other authorities apart from central government could set-up. Local councils, for example, could recommend the expedited issuance of building permits for projects that incorporate green roofs and other green infrastructure (as long as the proposal falls within building regulation and policies).

Building regulations and policies:
Green roofs are not specifically mentioned in building regulations and policies and this is reflected by the fact that green roofs are not installed. Unless they are specifically referred to and encouraged, there is little incentive for developers to incorporate them in their proposed schemes. In addition, architects have no initiative or stimulus to propose or promote such green technology and this can be attributed to the lack of guidance for professionals, awareness of urban related issues and motivation. Where applicants do consider the inclusion of green roofs they are either discouraged by the lack of availability of materials or discouraged by the architect due to lack of consciousness and knowledge.

Although no planning permits are needed to construct a green roof (depending on specific cases), planning permits are needed to construct and carryout infrastructural works on roofs so as to sustain a green roof. Permits are also needed for the construction of structures such as pergolas which could be an integral part of a green roof design. Although by tradition roofs were used for domestic activity such as clothes drying and socialising, these practices have diminished in recent years due to the change in the urban fabric. However, with the introduction of green roofs the use of the roof space for recreation may re-emerge. This may rekindle issues such as overlooking into third party property, light pollution and possibly public nuisance. Such issues will need to be addressed so as to avoid confusion and inconsistent decision-making as so as to avoid disincentivising green roof technology.

In addition to the above and to existing policies which indirectly encourage green roofs, planning application processes could be remodelled to provide encouragement to green roof technology. Such could be the preferential treatment for developments that incorporate green roofs and other green infrastructure such as:

- Fast tracking of the planning application and the
- Waiving of a percentage of planning fees.

Such incentives could target both business and residential building proposals. These should not be used to justify expansion of the building zones or to justify the issuance of a permit but to reduce the impact building developments have on the locality. In fact, such incentives could be imposed on urban areas with specific characteristics such as high population densities, areas prone to flooding or areas devoid of green infrastructure.

It is often the case that relying on one's voluntary action for the implementation of a technology is not a realistic option especially if financial benefits are not immediately apparent. As such the installation of green roofs could also be imposed on the size of roof areas of newly proposed buildings or the activity which is housed by the development. Such schemes are nothing new; In Linz, Austria, policies required that flat roofs over 100m^2 should include a green roof and in France any industrial/commercial building should be covered by a green roof or PV panels. Such schemes could differentiate between residential, commercial and industrial buildings.

Demonstration and leading by example

Leading by example is a means of gaining thrust and demonstrating shared responsibility. Uniformity in policy through the various policy institutions and implementing technology in-house would increase thrust and increase a sense of accountability.

Both central government and local governments could lead by example and commit themselves to develop a green credential. By introducing green roofs on public buildings an example is set. Public entities such as educational institutions, government offices as well as commercial buildings could support demonstration green roofs with the aim of allowing public access on to them. Other structures particularly suited to be retrofitted to install green roofs should be encouraged to do so.

Showing consistency in policies by government and other public bodies is important to ensure a clear message. Different ministries, local councils and agencies need to ensure that relevant policies are encouraged which would popularise green roof technology. Green roofs could be included into existing policies and strategies and most importantly installed on public buildings through retrofitting and proposed on new buildings. In North American cities policies and commitments by Councils see to the inclusion of green roofs on new public buildings and building upgrades (City of Melbourne, City of Stonnington, City of Yarra, City of Port Phillip, State of Victoria, Univeristy of Melbourne, 2014).

11. Awareness

A scheme, however beneficial will not be upheld unless there is proper awareness. Awareness is one of the LifeMedGreenRoof Project's aims however this must be extended well beyond the project completion. Awareness can be raised through different media sources, special events, competitions and demonstration projects. Associated media coverage is particularly important as green roofs are generally not readily visible from street level or easily accessed by the public. Special events can be organised to highlight these roofs and illustrate the benefits that green roofs pose to both the owner and society.

To reduce the possibility of failed green roofs due to bad construction practices which could damage the reputation of green roof technology, it is important that any incentives offered are linked to green roof construction standards. It is for this reason that the LifeMedGreenRoof Project has foreseen the publication of a Green Roof standards for

Malta. However, whereas the standards document highlights issues pertaining to the construction of green roofs, there must be more defined quality standards and conditions imposed within any proposed green roof funding Programmes and compliance inspections.

Pushing green roofs forwards should not be seen as a means of further expanding the urban boundaries or increasing building density. Green roofs are a means of mitigating the issues experienced in urban areas, which impact on the quality of life of urban dwellers. This document provides a review of options which policy makers can uphold so as to increase the number of green roofs on a national scale. It should be understood that the larger the surface area covered by green roofs the greater are the benefits. By adopting policies outlined in this document, it is likely that attitudes are influenced resulting in the uptake of green roof technology. Generally speaking, it would be beneficial if more than one policy option is implemented and such policies should support and reinforce each other. Government and their agencies would do well to work together to establish an effective way forward which would help in the implementation of green roofs over a wide territory to combat climate change and meet energy targets.

12. Conclusion

Green roofs offer many benefits and are one of the main features within sustainable urban environments. They are considered by both planners and academics as an adaptation to combat climate change and are effective in mitigating urban related problems including pollution, flooding, the urban heat island as well as mental health and allergies. The benefits are such that many municipalities and countries worldwide have incentivised green roof technology to increase the quality of life in urban areas and reduce urban related problems. Central European countries have introduced policies to increase green roof coverage since the second half of the 20th century. Unfortunately, in Malta green roof technology still lags behind other European countries due to general misconception and the mentality concerning green infrastructure. The LifeMedGreenRoof project has illustrated that green roofs can be easily constructed over a building without water leaks and plant failure and can also provide effective insulation in summer, reducing the carbon footprint of buildings. The project has also demonstrated that green roofs are effective at reducing water run-off from roofs, mitigating flooding.

So as to encourage the dissemination of green roof technology, it is important that it (green roof technology) is encouraged over a wider territory through grants, policies and incentives. Incentives can be both direct- and indirect-financial depending on the target audience. Policies should be tailor made to focus on different aspects of the urban fabric and could be both voluntary and imposed. The different levels of government should also be seen to be doing its part through exemplification. The installation of demonstration green roofs on government and other public buildings will help to encourage the uptake of the technology by corporate bodies as well as by the general public. For green roofs to be effective, there needs to be a combined effort at all levels of government. A clear plan should be set which would include clear objectives and a long term strategy which would address general goals and determine specific actions.

The intention of this document is to kick-start the process of dialogue and action for incentivising green roofs and has looked at various foreign examples which were successful in terms of increasing green roof cover and in terms of reaching the required goals.

It is hoped that the effort made through the LifeMedGreenRoof Project is upheld by the relevant authorities and pushed forward to creating more habitable urban areas and to meet environmental and energy targets.

References

Edwards , P. & Tsouros, A., 2006. *Promoting physical activity and active living in urban environments,* Copenhagen: WHO .

Zhao, M. et al., 2014. Effects of plant and substrate selection on thermal performance of green roofs during the summer.. *Building and Environment,* Volume 78, pp. 199-211.

Austin, G., 2014. *Green Infrastructure for landscape planning.* 1 ed. Abingdon: Routledge.

Berndtsson, C., 2010. Green roof performance towards management of runoff water quantity and qualtiy: A review.. *Ecological engineering,* 36(4), pp. 351-360.

Brickhill, D., 2015. *Ecosystem Services and the Environment. In-depth Report 11,* Bristol: European Commission, DG Environment.

Burszta-Adamiak, E., 2012. Analysis of stormwater retention of green roofs. *Archives of Environmental Protection,* 38(4), pp. 3-13.

Carter, T. & Fowler, L., 208. Establishing Green Roof Infrastructrue Through Environemntal Policy Instruments. *Environmental Management,* Issue 42, pp. 151-164.

City of Copenhagen, 2012. *Green roofs, Copenhagen,* Copenhagen: Københavns Kommune.

City of Melbourne, City of Stonnington, City of Yarra, City of Port Phillip, State of Victoria, Univeristy of Melbourne, 2014. *Growing Green Guide - Green Roofs, Walls and Facades Policy Options background Paper.pdf.* [Online]
Available at:
http://imap.vic.gov.au/uploads/Growing%20Green%20Guide/Policy%20Options%20Paper%20-%20Green%20Roofs,%20Walls%20and%20Facades.pdf
[Accessed 12 December 2016].

City of Toronto, 2006. *Making Green Roofs Happen.* [Online]
Available at:
http://www.toronto.ca/legdocs/2006/agendas/council/cc060131/pof1rpt/cl020.pdf
[Accessed 12 December 2016].

City of Toronto, 2017. *Toronto facts.* [Online]
Available at:
http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=57a12cc817453410VgnVCM10000071d60f89RCRD
[Accessed 01 March 2017].

City of Toronto, n.d. *Toronto Environmental Progress Report 2015,* Toronto : City of Toronto.

Dearborn, D. C. & Kark, S., 2010. Motivations for Conserving Urban Biodiversity. *Conservation biology,* 24(2), pp. 432 - 440.

Dunnett, N. & Kingsbury, N., 2004. *Planting green roofs and living walls.* 1st ed. Cambridge: Timber press .

EEA, 2009. *Ensuring qualtiy of life in Europe's cities and towns: 5/2009,* Luxembourg: EEA.

EFB, 2015. *2015 White Paper: Greener Cities in Europe,* Vienna: European Federation Green roofs and Walls.

EPA, 2016. *Heat islant effect.* [Online]
Available at: https://www.epa.gov/heat-islands
[Accessed 17 Oct 2016].

European Commission, 2013. *Communication from the commission to the European Parliament, the Council, the European Economic and Social Committee and the Commitee of the Regions (COM(2013)249 final),* Brussels: European Commission.

European Commission, 2016. *Green Infrastructure.* [Online]
Available at: http://ec.europa.eu/environment/nature/ecosystems/
[Accessed 07 October 2016].

European Environment Agency, 2009. *Report 5/2009, Ensuring quality of life in Europe's cities and town,* Copenhagen: EEA.

European Environment Agency, 2013. *Air pollution fact sheet 2013: Malta,* Copenhagen: EEA.

European Environment Agency, 2015. *Air quality in Europe — 2015 report (5/2015),* Luxembourg: EEA.

European Environment Agency, n.d. *European Climate Adaptation Platform.* [Online]
Available at: http://climate-adapt.eea.europa.eu/metadata/case-studies/green-roofs-in-basel-switzerland-combining-mitigation-and-adaptation-measures-1
[Accessed 14 Nov 2016].

Eurostat, 2013. *File:Causes of death — standardised death rate.* [Online]
Available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Causes_of_death_%E2%80%94_standardised_death_rate,_2013.png
[Accessed 17 Oct 2016].

Green Roof Technology, 2016. *History of green roofs.* [Online]
Available at: http://www.greenrooftechnology.com/history-of-green-roofs
[Accessed 07 October 2016].

Green Roofs For healthy Cities, 2016. *Green roofs for healthy cities North America.* [Online]
Available at: http://www.greenroofs.org/index.php/about/aboutus
[Accessed 09 Nov 2016].

greenroofs.com, 2016. *greenroofs.com.* [Online]
Available at: http://www.greenroofs.com/Greenroofs101/industry_support.htm
[Accessed 10 10 2016].

Howarth, T., 2010. *Toronto, ONTARIO, CANADA.* [Online]
Available at: https://www.britannica.com/place/Toronto
[Accessed 01 March 2017].

Ichihara, K. &. C. J. L. S. R., 2011. New York City property values: what is the impact of green roofs on rental pricing?. *Letters in Spatial and Resource Sciences,* 4(1), pp. 21-30.

Jia, Z. et al., 2016. Small scale green infrastructure design to meet different urban hydrological criteria. *Journal of Environmental Management,* Volume 171, pp. 92-100.

Kaplan, R. & Kaplan, S., 1989. *The Experience of Nature: A Psychological Perspective.* 1st ed. Cambridge UK: Cambridge University press.

Lawlor, G., Currie, B. A., Doshi, H. & Wieditz, I., 2006. *Green roofs, A Resource Manual for Municipal Policy Makers,* s.l.: Canada Mortgage and Housign Corporation.

livingroofsworld.com, 2013. *Green roof policy in Denmark.* [Online]
Available at: http://livingroofsworld.com/page21.php
[Accessed 11 Oct 2016].

M.D. Velardea, G. F. M. T., 2007. Health effects of viewing landscapes – Landscape types in environmental psychology. *Urban Forestry & Urban Greening,* 6(4), pp. 199-212.

Madre, F., Vergnes, A., Machon, N. & Clergeau, P., 2014. Green roofs as habitats for wild plant species in urban landscapes: First insights from a large-scale sampling. *Landscape and Urban Planning,* Volume 122, pp. 100-107.

Malta, Government of, 2012. *Rainwater flood relief project.* [Online]
Available at: https://mti.gov.mt/en/Pages/WASD/PROJECTS/Rainwater-Flood-Relief-Project.aspx
[Accessed 07 October 2016].

MEPA, 2015. *Strategic Plan for Environment and Development,* Floriana: MEPA.

Michael Krause, P. L. A. S. P., 2010. Green roofs mean jobs. *Planning*, 1 April, pp. 16-18.

Ministry for Tourism, the Environment and Culture, 2012. *National Environmental Policy, February 2012,* s.l.: Ministry for Tourism, the Environment and Culture.

Nagengast, A., Hendrickson, C. & Scott Matthews, . H., 2013. Variations in photovoltaic performance due to climate and low-slope roof choice. *Energy and Buildings,* Volume 64, p. 493–502.

Ngan , G., 2004. *Green Roof Policy: Tools for Encouraging Sustainable Design.* [Online]
Available at: http://www.gnla.ca/assets/Policy%20report.pdf
[Accessed 18 Oct 2016].

Oberndorfer, E. et al., 2007. Green Roofs as Urban Ecosystems: Ecological Structures, Functions, and Services. *Bioscience,* 57(10), pp. 823-833.

Rowe, K. L. G. &. D. B., 2006. The Role of Extensive Green Roofs in Sustainable Development. *Hortscience,* 41(05), pp. 1276-1285.

Schmidt, M., 2000. Dachbegrunung als Ausgleichs- und Ersatzmasme zur Flachenversiegelung.. In: *Proceedings of Infoforum Regenmanagement: Regenwasserbewirtschaftungssystems in Berlin und Brandenberg.* Berlin: GeoAgentur, pp. 46-56.

Stovin, V. V. G. &. K. H., 2012. The hydrological performance of a green roof test bed under UK climatic conditions. *Journal of hydrology,* pp. 148-161.

T. Van Renterghem, D. B., 2014. Influence of rainfall on the noise shielding by a green roof. *Building and Environment,* Volume 82, pp. 1-8.

Tiwary, A. et al., 2016. Development of multi-functional streetscape green infrastructure. *Environmental Pollution,* Volume 208, pp. 209-220.

Tolderlund, L., 2010. *Design guidelines and maintenance manual for green roofs in the semi-arid and arid west USA.* [Online]
Available at:
https://www.epa.gov/sites/production/files/documents/GreenRoofsSemiAridAridWest.pdf
[Accessed 15 October 2016].

Tomalty, R. & Komorowski, B., 2010. *The Monetary value of the soft benefits of green roofs,* Montreal: Smart Cities Research Services.

Toronto, C. o., n.d. *Toronto Environmental Progress Report 2015,* Toronto: City of Toronto.

UK National Ecosystem Assessment, 2012. *UK National Ecosystem Assessment.* [Online]
Available at: http://uknea.unep-wcmc.org/EcosystemAssessmentConcepts/EcosystemServices/tabid/103/Default.aspx
[Accessed 7 November 2016].

Ulrich, R. et al., 1991. Stress Recovery during exposure to natural and urban environments. *Journal of Environmental Psychology,* Issue 11, pp. 201-230.

van der Linde, D. &. P. S., 2010. Green Roofs IN THE PUBLIC SPHERE. *PM. Public Management,* 92(11), pp. 18-19.

Velarde, M. D., Fry, G. & Tveit, M., 2007. Helath effects of viewing landscapes: Landscape types in environemntal psychology. *Urban Forestry and Urban Greening,* Issue 6, pp. 199-212.

Vijayaraghavan, K. & Joshi, M. U., 2014. Can green roof act as a sink for contaminants? A methodological study to evaluate runoff quality from green roofs. *Environmental Pollution,* Volume 194, p. 121–129.

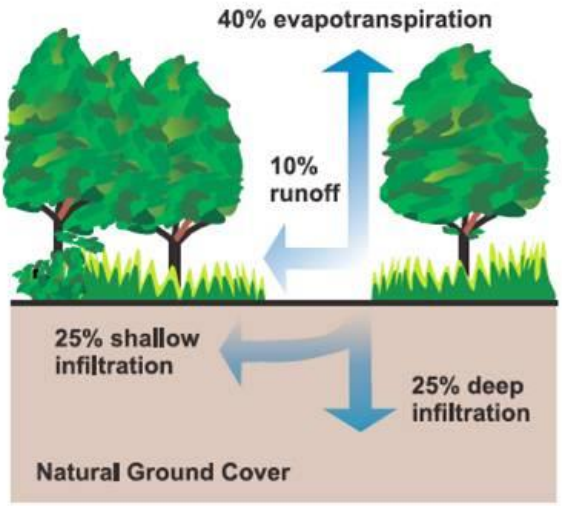
Annex 1

Bolzano Italy - The R.I.E. Index (Riduzione dell'Impatto Edilizio)

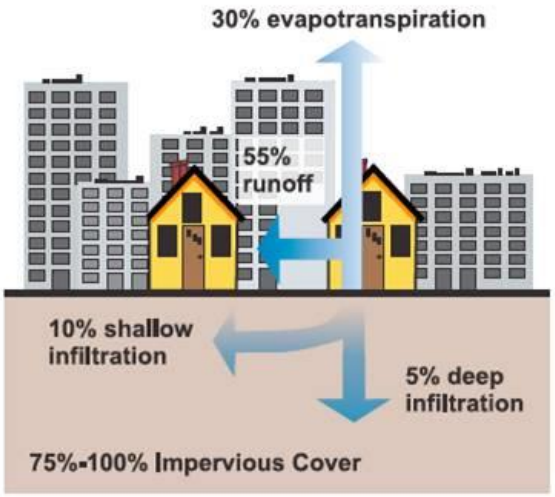
R.I.E. is an index of environmental quality which serves to certify the quality of any building intervention with respects to the permeability of surfaces.

In part the degradation processes of environmental macro- and micro-climate is caused and fed by the sealing of the earth's surface. Sealed surfaces encourage the heating up of the air column above it and the resultant air circulation transports particulate matter into the atmosphere. Hard surfaces absorb and reflect solar energy back into the atmosphere resulting in the increase in air temperatures within urban areas. This is exacerbated by the lack of green infrastructure in urban areas. Green infrastructure is able to mitigate such urban issues through shading and evapotranspiration. Increased run-off from precipitation into water courses due to the reduced natural infiltration through soil horizons, distorts the natural water cycle.

Considering the above, it would be worth adopting mitigation and compensatory measures which manages and collects precipitation and water runoff at source. Such technologies include permeable surfaces and similar systems which encourage water infiltration, green roofs, geotechnical engineering and green infrastructure including traditional gardens.



Soil surfaces allow the infiltration of water into the ground leading to ground water recharge and reduced flooding.



Impervious land cover results in increased surface water run-off and flooding.

Adapted from U.S. Environmental Protection Agency. 2003. Protecting Water Quality from Urban Runoff. EPA 841-F-03-003. Washington, D.C.: United States Environmental Protection Agency, Nonpoint Source Control Branch. Online available at http://www.epa.gov/npdes/pubs/nps_urban-facts_final.pdf. Last accessed 7 February 2017

The City Council of Bolzano has commissioned a study on the problems faced by urban areas and possible mitigation and compensatory measures which could be adopted. The

study resulted in the “R.I.E. index” to calculate the impact of urbanisation with the drawing up of a definite and practical proposal to be utilised as an urban planning tool.
The City of Bolzano approved the "R.I.E. index" in February 2004. This tool is applied to all new building and urban projects subject to planning permission within the municipality and include both new housing developments and renovations. The R.I.E is a numerical index applied to each specific plot proposed for development or building requiring intervention. This tool compares the permeability of a green areas to that of a developed one.

The R.I.E index ranges from "0" to "10". A value close to "0" refers to completely sealed areas lacking greenery and permeable surfaces. Such surfaces contribute to high surface water run-off and negative effects on the urban microclimate.

A values of "10" corresponds to properties with abundant green spaces and without sealed areas. Such areas provide the highest performance in terms of water management, recharging of the groundwater and improving of urban microclimate.

Urbanized lots are characterized by intermediate R.I.E indices. The index achieved depends on the built area, the types of surface materials, their permeability defined by the coefficient of discharge and the area of soft landscaping.

Coefficient ψ	Category
0.10 – 0.20	Gardens, meadows, vegetable gardens, agricultural, woodland, uncultivated land
From 0.10 to 0.70	Green roofs
0.40	Permeable surfaces with vegetation
From0.30 to 0.70	Permeable surfaces laid on sand or with unsealed gaps
0.7	Roofs with gravelled surface
From 0.90- 0.95	Metal roofing
0.90	Roof tiles and similar surfaces
0.90	Macadam, concrete and other sealed surfaces

Figure 7: Coefficient of discharge

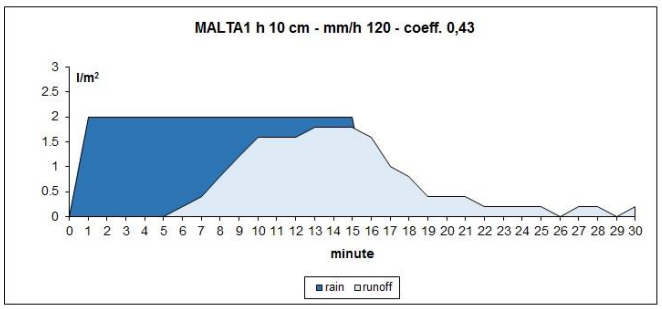
Coefficient of discharge of various surfaces (adapted from Procedura RIE Valutazione dei risultati ottenuti nel primo periodo di applicazione; http://www.comune.bolzano.it/UploadDocs/3856_Bolzano_Rie_Paolo_Abram.pdf)

Annex 2

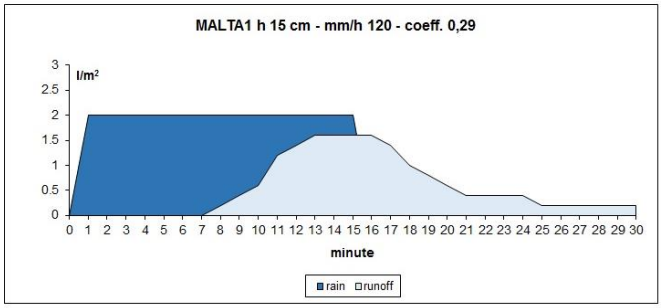
Coefficient of discharge (established under laboratory conditions)

Following are graphs showing the results for run-off tests carried out in a rain chamber on the Malta 1 mix. This substrate is one of two mixes used in the Maltese case study. Tests are conducted using saturated substrates which are left to drip for 24hrs prior to commencement of the tests.

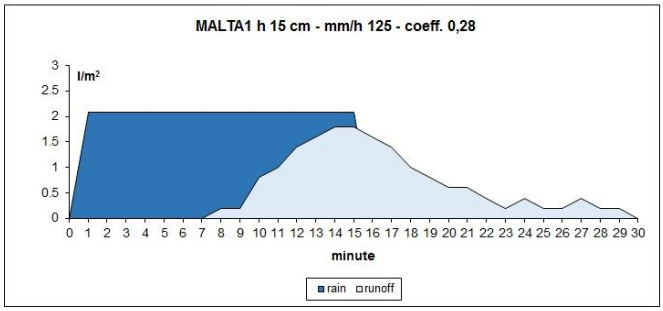
The coefficient of discharge is defined as the quotient of run-off volume and rain volume during block rainfall and would give a good indication of the amount of water which drains from a surface or material.



Run-off test results:
Substrate Malta1
Depth of substrate: 100mm
Rain intensity: 120mm/hr (from saturation)
Coefficient achieved: 0.43



Run-off test results:
Substrate Malta1
Depth of substrate: 150mm
Rain intensity: 120mm/hr (from saturation)
Coefficient achieved: 0.29



Run-off test results:
Substrate Malta1
Depth of substrate: 150mm
Rain intensity: 125mm/hr (from saturation)
Coefficient achieved: 0.28

Figure 8: Run-off test results

Graphs illustrating the rain events conducted (in dark blue) and the resultant run-off (in light blue). It is clear that the substrate absorbs a significant amount of precipitation, reducing run-off and peak flows. The deeper the substrate the more effective is storm water management.

Annex 3

Insulation properties

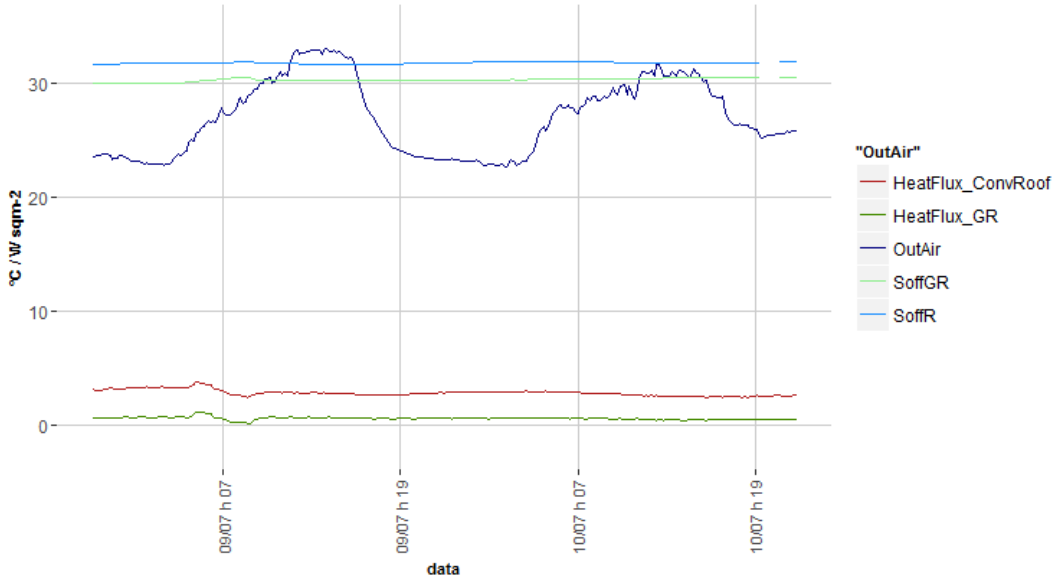


Figure 9: Heat Flux and temperature readings

Heat Flux and temperature readings comparing a conventional roof with green roof. Initial readings confirm that green roofs insulate against solar energy during the hot summer months keeping the underlying rooms cooler and reducing energy consumption for cooling (09-10th July 2016).

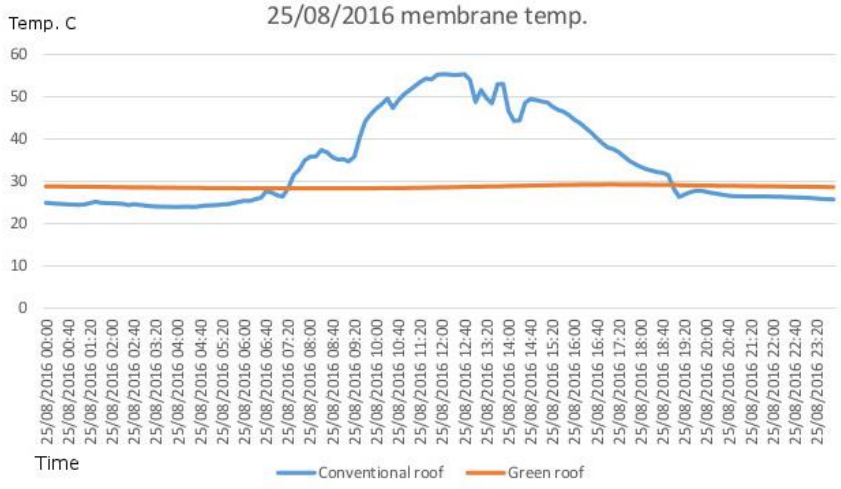


Figure 10: Diurnal temperature cycle for the damp-proof membrane.

Membrane temperatures beneath the green roof (in red) are much more stable as opposed to the tempe of the membrane on a conventional roof (in blue). This results in less damage to the membrane and unde structure due to the reduced exposure to the elements and volumetric change associated with temperatu fluctuation.

LifeMedGreenRoof Project

MEETING ENVIRONMENTAL TARGETS

UNIVERSITY OF MALTA
L-Università ta' Malta

MCCAA
MALTA COMPETITION AND CONSUMER AFFAIRS AUTHORITY

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Fondazione Minoprio

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