NBS Business Model – Green roofs and vertical greening

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Topic: ***SCC-2-2016-2017: Smart Cities and Communities Nature based solutions***

1. GREEN ROOFS AND VERTICAL GREENING BUSINESS MODEL

Green roofs are vegetative layers implemented on rooftops - especially in urban areas - with the aim to provide green space for different purposes and mitigate urban heat islands. Depending on the type of green roof installed, the plants may be modular or have drainage layers. However, all green roofs include a few important features, such as waterproofing and root repellent, to keep the structure safe and undamaged.

Several types of green roofs with varying coverings, complexity and scopes can be implemented on rooftops. Main positive effects associated with green roofs are for instance cooling and evapotranspiration, which lead to a reduction of the roofs temperature itself as well as of the surrounding air (air cooling). As a result, green roofs contribute to mitigating negative effects in urban areas, in particular caused by urban sealing, buildings and heat emissions.

Maintenance is the most important part of the green roof top for both the plantation as well as the building. A proper check is required once a while to see if the installation is perfect and no leakage is there.

Actors involved in green roof projects are usually engineers that give feasibility analysis report of the building with respect to green roof installation, experts on green roof installation guiding the installation process, gardeners physically working along with maintenance and office employees that manage accounts and the office work.

Green wall or vertical greening is used as the general term for any vegetation cover on vertical surfaces, no matter where the roots are located. Similar to green roofs vertical greening can be differentiated according to the level of technical support that is needed to sustain vegetation. However, since vertical soil itself has no model in natural settings, almost all types of vertical greening are "intensive" and therefore different characteristics are used to describe vertical greening. The main differences of vertical greening types are greening of facades (buildings), free standing living walls, moss walls, living plant construction and potentially vertical open spaces.

The following *Table 1.1* resumes main features, value proposition, conditions for implementation, main stakeholders involved, costs, financing options and limits of green roofs and vertical greening, considering the desk research, the analysis of the NBS implemented in Front-runner Cities and information provided in the *D5.1 NSB Technical Handbook*.

Table 1.1: Features, value proposition, conditions for implementation, stakeholders, costs, financing options and limits of green roofs and vertical greening

Features

• Green roofs are often associated with residential buildings, hotels or underground parking
• Higher installation, maintenance, management effort (regular irrigation and fertilisation) which leads to higher costs
• Intensive green roofs:
  ○ vegetation is often established on roofs that are accessible for public or recreation purposes and also for regular maintenance measures
  ○ Appropriate plants are mainly trees, shrubs and perennials
  ○ Different kinds of architectural elements (buildings, solar panels) can be established
• Extensive green roofs:

  - light weight systems, characterised by minimum maintenance and management
  - the installation and management/maintenance is less expensive than that of intensive systems
  - extensive green vegetation is often established on roofs that are not accessible or with limited access for public or recreation purposes (but annual maintenance) and partially characterised by steep slopes
  - Selected plants are generally well adapted to alpine environments/climate and tolerate different climate conditions (e.g. drought) and temperature fluctuations.
  - A limited number of different plant species
  - Smart roofs represent an extension of conventional green roofs because the system is equipped with a drainage system under the vegetation layer that retains storm water
- Vertical layering of soil/substrate which is stored in metal cages with supporting elements to create walls of up to 4 m.
- Fabric (organic or inorganic) is used to prevent the substrate/soil from eroding from the cages.
- Fairly heavy construction which rests on a simple strip foundation.
- Living wall needs to be constructed in two segments (minimum) that form a right angle in order to stabilize the living wall.
- Very flexible with regard to plant selection, as long as irrigation and fertilizer can be managed accordingly.

Value proposition/Benefits

- Enhanced biodiversity, human health and quality of life
- Public access to green recreation areas
- Storm water/rainwater management and quality increasing water retention
- Improved air quality (reduction of greenhouse gas emissions and pollution)
- Aesthetic value/visual attractiveness
- Additional space (intensive roof)
- Thermal performance/temperature reduction (air cooling and evapotranspiration)
- Energy reduction for buildings (heating/cooling)
- Reduction of noise/sound transmission
- Habitat provision for urban wildlife
- Reduced flood risk and slope stability
- Beneficial for selected species if respective plants are used
- Carbon storage capacity

Conditions for Implementation

- Site characteristics often depend on project objectives
- Solid, stable concrete buildings/bearing capacity
- Flat or relatively flat concrete rooftops and underground concrete structures
- Artificial irrigation but at least (rainwater) watering facility in critical/dry periods
- In some cases special plates to distribute pressure on the rooftop are needed (for planters)
- In the case of smart roofs: waterproofing surface/roof and sufficient roof load-bearing capacity
- Because of the thickness of the living wall, there is hardly any problem with central European frost periods
- Underground needs to be loadable in order to support the wall

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- Little risk of fire because of constant irrigation

Limitations/Barriers

- Limited development of undisturbed habitats because of human activities/public purposes
- Limited spread of flora and fauna because of regular maintenance and management
- Limited space for roots
- Irrigation is needed (summer and winter) but it should not rely on drinking water
- Supporting underground is needed
- Free standing living wall may act as a barrier for pedestrian movement
- Availability of an adequate location

Stakeholders/Beneficiaries	Costs
• Residents and citizens: people that live in the city will improve the quality of their life thanks to the enhancement of biodiversity and the reduction of heat stress. In particular families with children, older populations, students may benefit from the new opportunities for recreation available where the green roofs are open to the public. • Municipality and building/housing companies can finance the renovation. Building/housing companies will benefit from the increased value of the buildings. • Local businesses (e.g. hotels) may benefit from the increased attractiveness and improved aesthetic appearance of the city, which will have a diffuse network of carefully designed green façades and roofs. Offices: employees may benefit from the reduction of heat stress in the area • City users: people that do not necessarily live in the city but come regularly to the city for work or to use other services or amenities could benefit from the requalification of the city • Green builders and green roofs providers/developers together with maintenance and planning companies may new obtain business opportunities for planning, building and maintaining new green areas • Investors: houses with green roofs are a good investment; green roofs provide added value for residents and make houses more attractive	Costs vary significantly depending on a large number of variables such as the size, location and accessibility of the site, the types of plants that are going to be grown on it, the type of structure, the design, the distances for transport, the storage of materials on or off-site, the access for mobile cranes, access to goods lifts, the roof height, dimensions and load-bearing capacity, the roof construction, complexity of roof design including roof penetrations and the timing of project. • Material and Installation costs ≈ 100-200 €/m2 • Maintenance costs ≈ 3-12 €/m2 per year • Planning ≈20 €/m2 • Monitoring costs ≈ 15 000 € • Costs for the reinforcement of roofs, which may be necessary to withstand the increased load due to the installation of trees and vegetation ≈123 €/m2

Financing options

- Innovative municipal financing approaches
  - Municipal investment: municipality takes the lead in NBS financing by earmarking a share of public budget for the NBS implementation and maintenance.
  - Accessing external funding sources: for example regional, national and EU and/or other funds can be an important source of NBS financing
- Public-Private partnerships
  - Mobilising investment from municipal enterprises/utilities: Municipalities and municipal companies might want to co-invest in interventions that support achieving their strategic and political goals.
  - Tax increment financing (TIF): an anticipated increase in property tax assessed on the increase in property value due to a development project implemented in that area. For example the funds can provide partial reimbursement to commercial buildings that install green roofs.
- Mandatory Requirements and Tax Initiatives
  - Private sector financing: for example in Tampere private developers and building owners support the NBS implementation by setting up green roofs on their properties
- Incentive programmes
  - Private sector financing: for example in Tampere private developers and building owners support the NBS implementation by setting up green roofs on their properties
  - Grants to private property owners and community groups: Cities can provide money to private entities directly for green infrastructure practices or promote them indirectly through low-impact development competitions. For example programmes offering financial incentives to install green roofs on buildings.

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2. CASE STUDIES: BUSINESS MODEL OF GREEN ROOFS AND VERTICAL GREENING

1.1 Eindhoven experience - Green Roofs/Green Building Façades

Green roofs are vegetative layers implemented on rooftops for multiple purposes. They contribute to the mitigation of negative effects in urban areas, in particular caused by urban sealing, buildings and heat emissions. The idea of green roofs is based on natural processes of vegetation, such as water evaporation, temporary storage and buffering as well as sunlight absorption. Several types of green roofs with varying coverings, complexity and scopes can be established on rooftops.

Vertical greening is used as a general term for any vegetation cover on vertical surfaces, no matter where the roots are located. Similar to green roofs, vertical greening can be differentiated according to the level of technical support that is needed to sustain vegetation. *Figure 2.1* shows an example of green roofs and green building façades already installed in Eindhoven.

Figure 2.1: Examples of green building façade and green roofs (Eindhoven, Medina)[1]

1.1.1 Value Proposition

Green surfaces are often associated with residential buildings, hotels or underground parking. Main positive effects coming from them are for instance **cooling and evapotranspiration** (5-20% sunlight is used for photosynthesis, 20-40% is used for evapotranspiration 10-50 % transformed into heat 5-30% reflection), which lead to **a reduction of the temperature surface** itself as well as of the surrounding air (= **air-cooling**).

Plants, in fact, **reduce air pollution**, producing fresh air with low proportions of particulate and polluting gases (reduction of greenhouse gas emissions). Among the other benefits, green surfaces allow managing temperature and thus **decreasing the energy required for buildings heating and cooling.**

Green façades and roofs contribute to **enhance biodiversity and human health and quality of life** and create an **aesthetic value** and **visual attractiveness**.

Furthermore, green building façades and green roofs contribute to improving the **rainwater management and quality, increasing water retention** of 15-30%.

[1] Figure taken from the deliverable *D5.1 NBS Technical Handbook*

1.1.2 Key Beneficiaries and Stakeholders

The main groups of beneficiaries are:

- Inhabitants and citizens: people that live in the city will improve the quality of their life thanks to the enhancement of biodiversity and the reduction of heat stress.
- Offices: employees may benefit from the reduced heat stress of the area.
- Hotels may benefit from the increased attractiveness and improved aesthetic appearance of the city, which will have a diffuse network of carefully designed green façades and roofs.
- City users: people that do not live in the city but come regularly in the city for work or to use other services or amenities could benefit from the requalification of the city

1.1.3 Financing models

For the implementation of the selected NBS, funds come especially from the building owners that are responsible for the realisation of the project. However, in special situations the municipality may contribute to the greening of privately owned buildings.

1.1.4 Actors involved in the implementation and maintenance of green roofs and green façades

An active stakeholder's involvement has been essential to implementing green roofs and green building façades. The main actors involved in the implementation and maintenance of the selected NBS are reported below:

- Project leader and Policy advisor
- Designers, civil engineers, area coordinators
- Non-government organisations
- Building tenants/leaseholders/operators
- Citizens
- Municipality

1.1.5 Key activities

Table 2.1 identifies the key activities needed in Eindhoven to deliver the proposition of the project.

Table 2.1: Key activities foreseen for the implementation of the green roofs and green building façades

Key activities	Description of activities
Inform, inspire and involve stakeholders	Dissemination of the purpose, advantages and benefits of the selected NBS
R&D	Selection of the best solutions/design for green façades and roofs.
Installation	Higher installation of "green" that includes the choice of suitable plants
Procurement	Privately owned buildings are responsible for their own procurement. For some of the municipality buildings, there is a procurement for sustainable development for 15 years.

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Agreement	Obtaining an investor and design agreement to proceed into the project
Management and maintenance effort	Regular irrigation and fertilisation of roofs and façades

1.1.6 Key resources

Table 2.2 identifies the key resources needed in Eindhoven to fulfil the proposition of the selected NBS.

Table 2.2: Key resources for green roofs and green building façades

Key resources	Needed to/for…
Project leader, designers, civil engineer, maintenance and green experts	Procurement team planning specific knowledge and driving change and creativity
Construction/maintenance contractors	Green experts are in charge of the implement and maintain the project
Money and funds (Municipality budget, subsides/grants regional, national, European)	Design, implement and maintain the NBS
Municipality	Involve, inform, inspire residents/businesses through a communication plan

1.1.7 Cost structure

Costs for the implementation of green roofs and green building façades vary significantly depending on a large number of variables such as the size, location and accessibility of the site, the types of plants that are going to be grown on it, the type of structure (and any need for structural reinforcement), the design, the distances for transport, the storage of materials on or off-site, the access for mobile cranes, access to goods lifts, the roof height, dimensions and load-bearing capacity, the roof construction, complexity of roof design including roof penetrations and the timing of project.

However, according to a first estimation coming from the Municipality of Eindhoven, costs for installing and maintain a green roof or a green building façade are summarised in *Table 2.3*.

Table 2.3: Costs for the implementation of green roofs and green building façades

Type of costs	Cost for implementation
Manufacturing	To be determined
Installation	€ 40-50 /m2
Maintenance	Minimal (primarily just basic plant care)

Typical maintenance costs include irrigation water, fertiliser, replacement plants, weeding and pest and disease management. Periodic inspection and maintenance of the site, from the irrigation system to clearing drains to re-tensioning of cables or repair of loose wall fixings, will be needed.

Costs will be paid by the building owners. Privately owned buildings may be subsidised for the construction of green roofs by the municipality.

Figure 2 below summarizes the main sections of the Business Model Canvas developed for Green roofs/green building façades in Eindhoven.

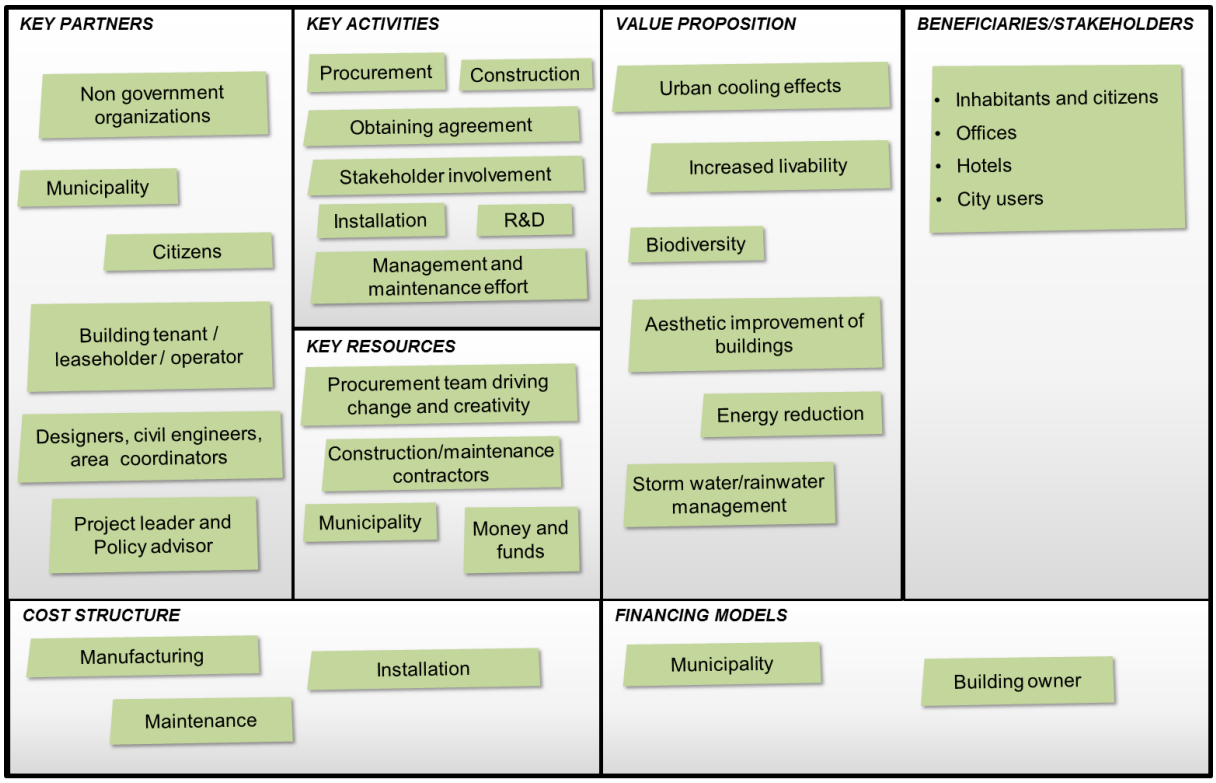

Figure 2: Business Model Canvas – Green roofs/green building façades (EIN)

1.2 Tampere experience – Green Roofs and walls

The implementation of green roofs and walls aims to manage water flows (storage) and their quality, with a particular focus on their performance during cold seasons. Suitable species of vegetation will be planted in order to resist in the sub-arctic climate with changing freezing-melting cycle and snow load as well as to support native species and enhance biodiversity.

The area involved in the implementation of a **green roof/wall** in Tampere is located in **Viinikanlahti**. Green roof and wall are planned into a new building (wastewater pumping station). Vegetation is selected from local species to support biodiversity and to ensure growth in harsh climate. Due to changed timetable of the pumping station, green wall is first built to a temporary location, where it is irrigated with lake water. *Figure 2.3* shows the temporary green wall.

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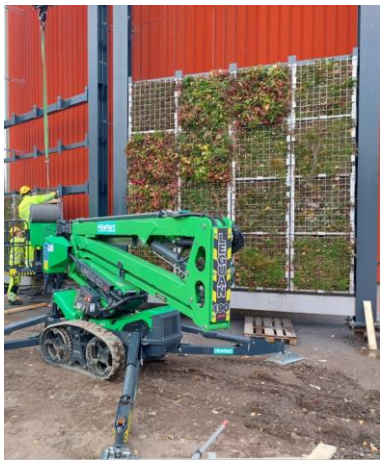

Figure 2.3: Green wall under construction in Tampere Viinikanlahti

1.2.1 Value proposition

The main environmental benefits expected from the implementation of green roofs are linked to **storm water management**. In particular, in Tampere, the main purpose of a green roof and wall is to retain storm water in dense areas. The nature-based storm water management system in Tampere is based on the decentralisation principle: green roofs and walls serve as a first step of the system. Water is retained in building plots, before they are led to a nature-based system in public green areas.

In addition, green roofs and walls can **improve biodiversity** especially in dense areas, providing **attractive green areas for citizens,** which will affect their **quality of life: in fact** in some cases, it will be also possible to open green roofs as public parks, thus increasing the **public access to the green recreation area.** This is important, as the city is growing and especially becoming very dense. Furthermore, **carbon storage capacity** obtained by installing green roofs is considered an interesting solution for Tampere, as its aim is to become a carbon neutral city by 2030.

Regarding biodiversity and plants, the main objectives of the city are:

- creating a high (rooftop level) green network (flora & fauna);
- availability of novel city green to support recreation and health of people;
- encouraging diversity in green roofs and walls (native species, bushes, shrubs, pollinators, etc.)
- testing the adaptation to heavy climate conditions
- increased knowledge of maintenance practices

1.2.2 Key Beneficiaries and Stakeholders

The main groups of beneficiaries are:

- Citizens and residents: people living in the city and Viinikanlahti/Hatanpää area will improve the quality of life thanks to the enhancement of biodiversity and the reduction of heat stress. In particular families with children, older populations, students may benefit from the new opportunities for recreation available where the green roofs are open to the public.
- Municipality: the Municipality of Tampere will own the building and finance the construction. The municipality will benefit from the carbon storage capacity obtained by installing green roofs and walls as its aim is to become a carbon neutral city by 2030.

- Green builders and green roofs providers/developers together with maintenance and planning companies may new obtain business opportunities for planning, building and maintaining new green areas
- Investors: houses with green roofs and walls are a good investment; green roofs and walls provide added value for residents and make houses more attractive.

1.2.3 Financing models

According to an estimation coming from the Municipality of Tampere, the dominant financing model is represented by building owners that fund green roofs and walls due to their interest in these solutions.

Public buildings such as schools and health centres are funded by public investments (municipality), while residential buildings are usually privately owned (first investor/construction companies and later housing companies) and so they make the investment.

Finally, funds come from the EU Commission for the demonstration of the selected NBS.

Recently a storm water fee (amounting in total 5,6 million €/year)[2] was introduced targeting the storm water management activities, and contributes to the funding of the implementation and maintenance of the selected NBS (Tampere Municipality, 2018).

1.2.4 Actors involved in the implementation and maintenance of green rrofs

In order to achieve a good implementation of the NBS in Tampere, public and private stakeholders have been widely involved. The main actors involved in the implementation and maintenance of the green roofs are reported below:

- The municipality of Tampere, involved in the project with the role of co-definition of demonstration aims, supervision and stakeholder engagement. Owner of the renovated/demonstration building and leader of Hiedanranta area development project, which includes “innovation platform” activities, are mainly involved.
- Ramboll has the role of green roof expert, stakeholder engagement and project management duties. The main activities performed are related to the planning stage.
- Construction companies (large companies/investors of apartment houses) have the role of guiding the demonstration and bringing in future investor viewpoints (important for replication), mobilisation of results.
- UNaLab project coordinator VTT is involved in the steering group. The main activities performed are communications between other UNaLab activities, especially indicator and monitoring development.
- The University of Helsinki is involved in the steering group. In addition, other research institutions involved in related and nearby located NBS/city green projects are being contacted. The main activities performed are bringing in the earlier research knowledge of green roofs.
- Associations (Green infra building, VYRA) are involved in the steering group. The main activities performed are bringing in green infra building expertise and mobilising results.

[2] Figures from Municipality of Tampere

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- SMEs are involved in the selling of new products and services needed. The main activities performed are e.g. growth media, plants, building materials, monitoring devices, maintenance and monitoring services.
- Builders (building and green) are involved in the construction of the NBS
- Citizens (co-creation participants, residents, students, NGOs) are involved in the co-creation, testing, maintenance and monitoring. The main activities performed are the participation in UNaLab and other co-creation activities, site visits to green roof demo, changing knowledge and iterating plans.
- The Tampere Region Central Wastewater Treatment Plant is a joint project of several municipalities and a public body involved in the project with the role of the building owner. The main activities performed are maintaining the building (in a change of green roof maintenance after the UNaLab project).

1.2.5 Key activities

Table 2.4 identifies the key activities needed to implement a green roof and reach the aim of the project.

Table 2.4: Key activities foreseen for the implementation of the green roofs and walls

Key activities	Description
R&D	Consulting previous R&D projects, setting monitoring program according to the aims, analysing results, measuring parameters/estimating results (e.g. temperature, water quantity and quality, biodiversity, effects to building structures, moisture)
Renovating/constructing the roof	The construction according to the aims requires new actors, products and services
Frequent maintenance	Learning new maintenance practices that again meet the aims, new actors are needed and heavy maintenance may not be feasible
Stakeholder engagement	To build a novel green roof that meets aims and is replicable, requires interaction with many internal (city units) and external stakeholders.
Promotion	Marketing and branding promotion involving stakeholders and mobilising results

1.2.6 Key resources

In order to implement green roofs and walls in a successful way in the Front-runner City of Tampere, a series of resources and activities is needed. The following *Table 2.5* identifies the key resources needed to fulfil the proposition of the green roofs.

Table 2.5: Key resources for green roofs and walls

Key resources	Needed to/for…
Planners (Ramboll+ steering group)	Plan the demonstration according to the aims
Money and funds (EU + municipality)	The construction phase for companies/investors

Marketing and advertising materials	Involve stakeholders and mobilise results
New knowledge	Achieve optimal solution and useful results

1.2.7 Cost structure

According to a cost estimation coming from the Municipality of Tampere, *Table 2.6* summarises the main types of cost to be taken into account for the implementation and maintenance of green roofs. Costs for maintenance include the costs for water control.

Table 2.6: Costs for the green roofs and walls[3]

Type of costs	Cost for implementation
Planning	20 €/m2
Material and Installation costs	70-250 €/m2 for sedum roof/"smart" solutions
Maintenance costs	3-12 €/m2 per year
Monitoring costs	15 000 €
The costs for the reinforcement of some roofs, which may be necessary to withstand the increased load due to the installation of trees and vegetation	123 €/m2

Figure 2 below summarizes the main sections of the Business Model Canvas developed for Green roofs in Tampere.

[3] Cost estimation coming from the Municipality of Tampere

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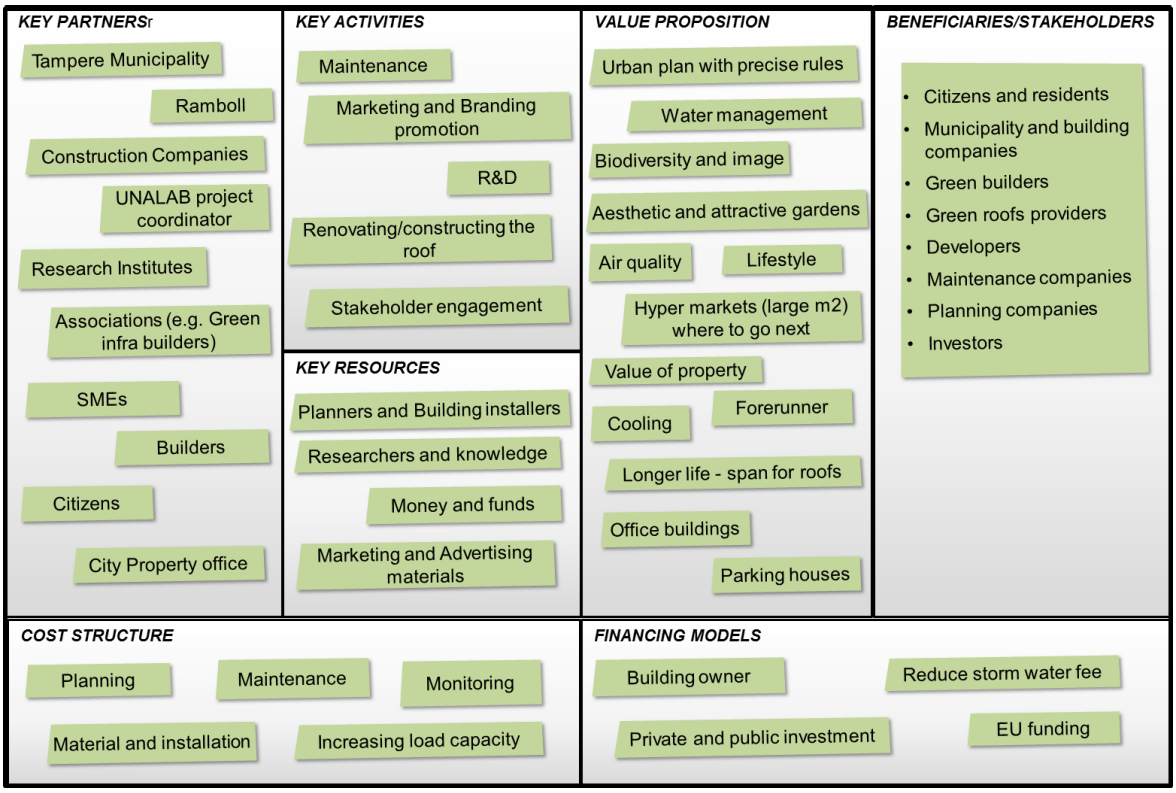

Figure 4: Business Model Canvas – Green roofs (Tampere)