CHANGING FROM LINEAR TO CIRCULAR METABOLISM: RE-DESIGN OF AN EXISTING NEIGHBORHOOD IN WAGENINGEN, THE NETHERLANDS

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Abstract

In order to explore the Urban Harvest theory, an urban neighborhood (tissue) in Wageningen was investigated in respect to Ecological Footprint and Urban Harvest. The work was conducted within the Urban Environmental Management course at Wageningen University. The main goal of the investigation was to explore the potential of an urban tissue in the light of evolution from linear to circular metabolism approach (Rovers, 2007; Agudelo *et al*, 2009). The work comprehends an environmental base line survey, assessment of the current consumption and calculations of the initial urban tissue footprint. Further an Urban Harvest Proposal was developed, taking into consideration the potential of onsite resources and planning principles. The proposed design includes harvesting of solar energy and water, production of local crop and fruit and the implementation of greenhouses. One of the major elements of the proposed design is the 'Life Gallery' where water storage, the bio-digester, the electric cars and their rechargers will be located.

1. Introduction

The present paper has been developed to meet the requirements as set out in the Terms of Reference of Urban Footprint and Urban Harvest Exercise within the Urban Environmental Management course, Wageningen University and Research Center, the Netherlands. The main goal of the present report is to explore the potential of an urban tissue in the light of evolution from linear to circular metabolism approach (ETE, 2009).

The paper begins with the environmental base line survey of a tissue, assessment of the current consumption: current use of on-site primary and secondary resources and calculations of the tissue initial footprint. Further, the report elaborates on Urban Harvest Proposal, taking into consideration the potential of onsite resources, planning principles and required interventions to accomplish the technical scheme. The proposal is complimented by a re-calculated ecological footprint of the tissue.

The tissue is an urban neighborhood located in Wageningen, a historical town in the central of the Netherlands, province of Gelderland. The total area of the tissue is 8,874m². It consist of 30 brick houses (2 levels houses), built in three rows, facing each other by the front or backyard. The backyard is mainly used as a garden, with much of the space left open for recreational purposes or children play grounds. Adjacent to every house there is a small garage which serves as a storage facility as well. Furthermore, there are places for parking in front of every house. The tissue is representative for an average Dutch neighborhood and can generally be described as being a pleasant place for leaving, well designed and maintained, with aesthetic attractive and colorful front yard gardens, quite and clean surrounding environment. The houses are located in the West-East axe and their South face is not really exploited. See figure 1.

The initial site visit and base line assessment of the tissue revealed the fact that the tissue represents a model of linear metabolism, where materials enter the system as artifacts and sooner or later leave the system as emissions to air and water and waste. However, onsite natural resources such as sun, rainwater, and waste streams (grey and black waste water, organic waste) can be captured/harvested and made use within the system. Furthermore, the process contributes to the reduction of the overall burden placed on the environmental components from urban neighborhood maintenance activities. In this context, the report elaborates technological and design interventions in the light of the modern circular resources approach.

2. Baseline assessment and current ecological footprint

The first step of the Urban Harvest project was to identify the current consumptions/generation of different resources within the neighborhood (Chambers, 2001). The average statistics for energy, water and food consumption as well as generation of waste and the passenger transportation were used as a base for the calculations. All the figures were averages per capita per year of Dutch or European resident.

The current footprint of the tissue is 3,47ha/cap/year (see table 1). As it is indicated in the table food makes the biggest contribution to the footprint, especially meat and milk consumption. The total footprint of food is 1,61ha/cap/year, which is about 46% of the total footprint. The second biggest contributors for the footprint are transport, energy (total 0,62ha/cap/year) and waste. The footprints of water and built-up area of the tissue do not make a big difference in the total footprint.

The baseline assessment was a good basis for evaluating the potential in footprint reduction of different methods. Nevertheless, even this was taken into consideration; it was not the main focus of the proposed interventions. Suitability for the current situation of the tissue was valued more in the choices of the solutions.

3. Urban Harvest Proposal

3.1. Planning Principles

As the starting point, it was decided to change as less as possible the main aesthetic characteristics of the tissue. Moreover, the 'Life Park' will be allocated in the space that is currently used for cars (street), freeing up this space and appropriating it for collective uses. In this new park of 875m², 25 fruit trees will be planted; also, there will be some places for other collective use such as place for disposal of waste, after segregation and leisure. See Figure 2.

In order to maintain the landscape, the urban harvest services will be placed in the underground of the park, the 'Life Gallery'. There, the water storage, the bio-digester, the electric cars and their rechargers will be located. It was also determined to build two greenhouses between the rows of houses, where currently walls are located. It will take the minimum space as possible from the gardens of the tissue. The total area of the two greenhouses is 1.276m². Each one will consist of two floors, the first for chickens and the second for tomatoes. In the underground of one of the greenhouses (located on East), another water storage will be placed. The greenhouses will feed the residents of the tissue and at the same time produce organic waste which will be converted by the bio-digester into energy. Furthermore, PV cells and solar pipes will be added in the houses roofs to make use of the solar source and reduce the external consume of energy.

3.2. Technical interventions

3.2.1. Energy

In the urban harvest project the energy interventions were related to both, on-site energy production as well as energy efficiency and saving. The energy production interventions introduced to the tissue were biogas and electricity production by solar panels. The biogas is produced in the anaerobic digester, where organic waste from the households is used as source for methane gas production. The biogas is used as a complimentary fuel in the existing heating system and the CO2-rich exhaust gas can be directed for the greenhouses. The electricity production takes place on the roofs of the residences, where three panels are set on both sides of the roof, covering total of 14,4m2. Energy saving is regarded as important aspect of urban harvest. Upgrading the insulation of the houses in the tissue has a high importance. The insulation measures include roof, wall and floor insulation as well as between the floors. Measures to increase energy efficiency involve applying energy efficient (EU energy label) electrical appliances in the houses as well as energy efficient lighting (CFLs and solar tube). Moreover, purchasing electricity from a company that provides electricity from renewable sources reduces the ecological footprint of energy consumption in the tissue. By taking these measures, the ecological footprint will be reduced by 20% in terms of energy.

3.2.2. Waste

The approach applied in the new design of the tissue is based on the concept that waste management is not a "carry-and-bury" process, but an integrated one that addresses human health, environment protection, waste prevention, reuse, recycling and recovery of materials and energy (Mels 2009).

The household waste prevention will be reached through the fact that a variety of vegetables and fruits will be grown on site. Harvesting of certain inflow site materials will be achieved through direct reuse (glass, plastic

packaging, textile, furniture). Because of healthy safety and economical reasons, certain waste streams will (i.e. plastic, chemical, hazardous waste, etc) will be treated off site.

The organic fraction of the household waste, together with the human feces, organic waste from the green space, green house and poultry farming will be treated on site via anaerobic digestion. See table 2.

The designed system will give a possibility to produce 28529,30m^3 CH_4/year that can be combusted to generate heat for the green house operation and living space heating. It is estimated that the green house operation will require only 4500m^3 CH_4/year, thus the rest 24029,30 m^3 CH_4 will be converted into 60073,25kWh/year or 3,0 kWh/per/day.

3.2.3. Water

In this study we approached water consumption by dividing it into categories and couple it to a certain quality. These categories are:

- First quality: water for drinking, hygiene and food preparation,
- Second quality: water for household use like toilet flush, washing machine, car wash, cleaning.

Each domestic water use requires a certain quality. For example: rainwater can have several domestic uses like cleaning and toilet flush and can be utilized beside drinking water quality. We made an inventory of all uses and made recommendations for more efficient water use. Examples of water saving equipments at household level are: No-mix toilets, water- saving shower, water tap with foot pedal, rainwater harvest and household filter system to produce drinking water on site. The implementation of these devices results often in both energy saving as water savings, for example when warm waste water is reused, there are gas savings.

After usage it is considered three categories of waste water that all serve a purpose in the urban tissue:

- Grey water: will be treated in the "living machine" and also used for toilet flushing
- Black wastewater: will be harvested for the digester
- Urine collection: will be used or sold for the nutrients

3.2.4. Food

As the basic human need, food is essential element in people's everyday life. It also contributes significantly to the urban footprint figure. In order to reduce the community urban footprint, food is the element that cannot be ignored. However, it cannot be done by simply changing people preferences towards vegetarian custom. In this study program, the local food consumption is carefully calculated in order to develop the potential of reduction. The proposed strategy is to construct a multiple-functional greenhouse in the open spaces of the neighborhood. Within the greenhouses, suitable vegetables will be grown together with meat-producing animals like chickens. All the organic waste generated from the greenhouses will be used to produce biogas. Besides this, another approach is to contact local organic meat producers and sign up long-term supply contract in order to ensure a stable supply. The final assumption of footprint reduction is about 20%.

3.2.5. Transport

The tissue is designed as car-free area, where 15 shared electric cars are reserved for the use of the residents (every two households share a car). The parking of the cars is organized in the underground parking space, which is on the site of the old road.

3.3. Re-calculation of ecological footprint – conclusions and discussions

The current urban harvest project comprehends a study concerning the present metabolic state of a neighborhood and reflects on best available techniques to convert the existing metabolism from a linear model into a circular one by using renewable resources, recovering materials and using materials within the regional scale. As a result, it was possible to decrease the footprint of the tissue from 3.5ha/capita to 2.4ha/capita, a reduction rate of 31% of the total footprint. See table 1.

The energy was divided into natural gas and electricity. The footprint of the natural gas has decreased from 0.25ha/cap to 0.04ha/cap due to the insertion of the bio-digester. Although the electricity footprint of the household has decreased, its total footprint has increased from 0.37ha/cap to 0.46ha/cap because of the electric cars. However, the transportation footprint has dramatically decreased from 0.64ha/cap to 0.04ha/cap.

The water footprint has dropped-off from 0.0045ha/cap to 0 due to the rain water harvest system.

The food was divided into cereal, meat, fruit, vegetables and milk. It was possible to achieve 0 footprints for the vegetables and fruits, because of the greenhouse and 'Life Park'. In addition, by introducing biological food into the tissue, the meat, milk, cereal footprints are able to be reduced by 20%.

Finally, there is a slight change in the built-up area due to the construction of the greenhouses.

4. References

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DEMAND		OLD CONSUMPTION (per capita/year)	NEW EXTERNAL CONSUMPTION (per capita/year)	OLD FOOTPRINT (ha/capita/year)	NEW FOOTPRINT (ha/capita/year)
ENERGY	NATURAL GAS	5639kWh	1054kWh	0.25	0.04
	ELECTRICITY	3611kWh	14432kWh	0.37	0.46
WATER		54969l	46355l	0.0045	0

Table 1- Comparison of the old and new consumptions and footprints

WASTE (paper, glass, plastic)		244.03kg	244.03kg	0.57	0.57
FOOD	CEREAL	82.85kg	82.85kg	0.18	0.14
	VEGETABLES	89.06kg	0kg	0.04	0
	MEAT	74.82kg	74.82kg	0.82	0.65
	MILK	328kg	328kg	0.49	0.4
	FRUIT	160kg	0kg	0.08	0
TRANSPORT				0.64	0.04
BUILT UP AREA				0.0069	0.007
TOTAL FOOTPRINT				3.5	2.4

Table 2 - Tissue potential in production of biogas/digestate:

Provenience of organic waste	Kg/year
Organic household waste	8803,08
Human faeces	2700,00
Green house organic waste	36000,00
Green space organic waste	9720,00
Poultry farming	1000,00
Total	**58223,08**
total m3 CH4	**28529,30**
digestate (compost)	**15526,15**

Figure 2- The tissue in the present days

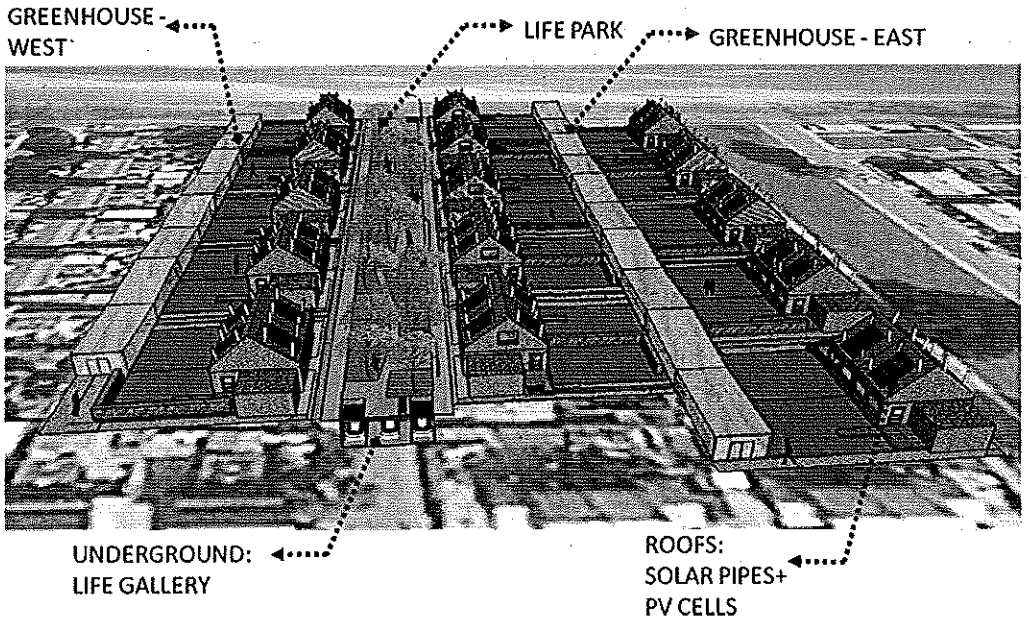

Figure 2 - Urban Harvest Proposal