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Urban Harvest , and the Hidden Building Resources

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ABSTRACT

Within the URBAN Harvest approach, a strategy has been developed to investigate all possible harvest options within and from the urban environment. It can be seen as a positive contribution to a cities needs, complementary to reducing negative impacts.

Its should be studied how the urban organism –Orbanism- can organise itself to make maximum use of its own possibilities . It will require a high level or organisation, which in itself is available, but unexplored.

Its necessary to change our traditional look at a city, where people only live and consume resources, to a city where people (or activities) *produce* resources, as by-product of consuming.
The model is therefore entitled: Urban Harvesting. Harvesting all possible resources from within the urban environment.

The Urban Harvest approach focuses on 6 main sources and flows from and out of a Urban environment: Urban Rivers, Urban Forest, Urban Energy, Urban Quarry, Urban Space and Urban Farm .

Analysing potentials and maximum technical re-uses for quarry, space and energy, should lead to tools to manage building stock more effectively and reduce dependency on distant and non renewable sources. It will provide solutions for modern and non resource related solutions for sheltering.

KEYWORDS: Urban, Harvest, Resources, Building, Stock

1. Introduction

Today it becomes clear that our consumptive society can not be sustained over the years to come: scarce or expensive resources, limited availability of resources, climate change, and pollution require a new approach to secure the functioning of the built environment. [1]

Many initiatives have been taken over the past decades to reduce the needs of a the built environment, and to lower the impact of the resources used. Strategies for dematerialisation, energy efficiency, energy clearing houses, and many more have been applied, without so far having created any significant result in absolute reduction of resource needs . Energy , materials consumption and waste (better : residues) production are still on the rise. [2,3]

Most of these approaches in the built environment have addressed new buildings for instance, and by definition this is a slow process: The new additions to the stock, were efficiency measures are applied, are in the developed countries around 1 % of stock, (max 2) [4] With a demolishing rate of 0,25 % in the Netherlands for instance, this means that after 80 years only half of the stock is meeting standards from today or later: however in some cases that will be already 80 years old standards by that time… To create any significant form of result, on the level of society , the strategies have to be upscaled from building level to the level of management of the built environment .

We are now at the eve of change at the moment where the balance between need and provisioning will be broken due to unhealthy situations regarding air-quality in dense consuming urbanism, changing outdoor conditions due to climate change, and limits in distant provisioning due to limits in resources and energy for transporting these. The footprint of a city however has grown to a level where the relation between urban environments and hinterland can not be re-established in the old form.

The problem however has to be solved merely within the new system boundaries of the urban/ built environment. So far these solutions concentrated mainly on limiting negative effects (reduced footprints) However, with the massive balance disturbance in view, its unlikely that also these small scale improvements can help a city survive. Its necessary to concentrate on the enormous organism a city can be seen as, and to see in how far , as a system, the urban environment can provide in its own needs.

To create a sustainable situation to meet these needs, evaluation of the three elements of the total flow have to be addressed: the inflow of resources, the consumption and the outflow.

In a strategy for a sustainable situation, one that can be sustained over ages, this process has to become a closed cycle, where in and outflow are connected. The preferent approaches today are aimed at reduced consumption and lower inflow of resources, or the use of resources with a lower environmental impact. However few address the outflow of resources, or bending the linear output back into the system.

2. City as organism

Given the record of this century, an extraterrestrial observer might conclude that conversion of raw materials to wastes—often toxic ones—is the real purpose of human economic activity
Lester Browne, Linda Starke, in : State of The World 1999, World Watch Institute report.[5]

"Whilst many cities today have a linear metabolism, nature's own ecosystems have an essentially circular metabolism. Every output by an individual organism is also an input that renews the whole living environment of which it is part" [6]

Within all the above in mind, the URBAN Harvest approach has been developed. . A strategy to investigate all possible options for re-using the full output, and the potential sources within the system itself, within the urban/built environment. It can be seen as a positive contribution to a cities needs, complementary to reducing negative impacts of consumption, or limiting inflow.

It should be studied how the urban organism can (re-)organise itself to make maximum use of its own possibilities . (Urban organism : Orbanism) The focus is on the built environment, with materials, energy and water as the main sources and flows. It will require a high level or organisation, which in itself is available, but unexplored.

The city has to be seen as a true Urban forest, that maintains itself, like a tropical forest, where the trees are replaced by buildings and a human arranged internal ecosystem with many crops (C&D residues, radiation, rain, etc). Or for instance paper as an existing example:. The paper-industry is already collecting large amounts of used paper form Urban areas, and re-using it in their production. In fact , the volumes are so large it has become a main stream activity, and in the Paper-world they refer to this as their Paper Forest, part of the Urban Forest. Its not waste, it's a (re-)source, coming from human activity in a "buildings-forest. "

3. Harvesting the Urban Forest

Its necessary to change our traditional perception of a city, where people only live and consume resources, to a city where people (or activities) *produce* resources, partly as by-product of consuming. The potential is huge, if seriously explored and 'excavated'.

The strategy for this approach is: Urban Harvesting. The work so far carried out addresses the first explorations of the possibilities of this strategy, and the development of a first model to identify and manage the harvesting of all possible resources from within the urban environment.

The Urban Harvest strategy is defined to focus on:

1) make un-used resources and flows visible,
2) to develop a model and system approach
3) to inventorise the harvest potentials,
4) to investigate/develop if not available, technologies in the broad sense of the word to make them harvestable.
5) To study optimisation, adaptations of the urban environment to maximise harvests
6) To develop integrated approaches and organisational strategies to establish harvesting in many areas

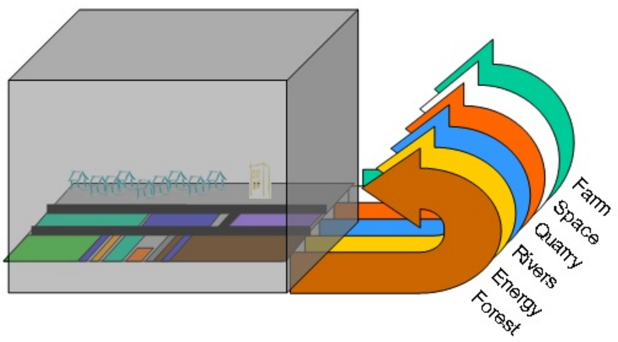
3.1 Urban Harvest strategy

To collect any renewable primary resource, or any secondary resource , within an urban environment system, and to (re-) use these within that urban environment system.

In this approach we have identified 6 different streams: Resources are sorted in topics, by the way they come available from the "Urban machine" at its borders :

Urban Forest : all solids from day to day consumption
Urban Rivers: all liquids from day to day consumption
Urban Energy: all flows containing energy
Urban Farm: all eatable resources from within the system
Urban Quarry: all solids form the Built/constructed environment over time
Urban Space: all space free available in the urban environment over time

This is a practical approach close to the perception of involved stakeholders . For scientific research and or educational reasons, these can be further detailed into organic/non organic, liquid/gaseous or solids, hollows, for instance.



The Urban/built environment as a closed system, and the 6 adressed flows from that system, Source: Author.

3.2 Principles with urban harvest

1) UrbanEnvironment: In general this is regarded as a built up environment of a city with its urban administrative boundaries, but can be adapted to a pre-defined tissue, a neighbourhood, a surface area, or else, to fit different purposes and use, as for instance research, implementation projects or education/assignments.
2) Re-use within the system: The urban harvest approach is based on closing the resource cycle on the output side of a linear system. You could say: Nothing goes out of the system anymore. Its intended to collect all these resources, and (re-)use these within that same system, to reduce the environmental load and resource burden, by limiting the need for virgin incoming resources. For different re-sources captured, the re-use can require different scales of urban environments for efficient treatment.
3) Urban Harvest and consumption: Urban Harvest does not address consumption, nor the need of resources. However important of course, for UH this is accepted as a given situation, (and should be addressed by other strategies). UH only focuses on the out coming sources from that consumptive system, and on possible unused first time harvest within the system addressed.
   In other words, the Urban environment is regarded as a impersonal productive area, which produces or can produce resources of different kinds, in different quantities and qualities. These are measured independent of their way of production, use or treatment.
4) Urban Harvest is applied in the built and un-built environment of an Urban system, without influencing or changing the working of that environment significantly. Buildings are not demolished to create space for biomass growing for instance. That built and un-built environment is however used to accommodate the harvest of resources. Adaptations will arise, and are accepted consequences, as for instance implementing wind turbines, growing biomass on un-used roofs , using roads as solar collectors, etc..

Note that Urban harvest addresses the output part of this system. How can this be captured and re-entered in the system. Urban harvest does not address non renewable (re-)sources . Its assumed that in a closing cycles approach, -which will lead to a resource use that can be sustained for ever, resources can only be those that can be renewed within a certain time frame related to that use.

4. Cascading

Sources can have different destinations: biomass can be used to produce building materials or serve for energy production. In general the Cascading principle is applied, the sequential exploitation of the full potential of a resource during its use . The use at highest quality level, before the loss of potential of functioning (potential of “ work”). A wooden beam serves as a new beam or planks, before being “down cycled” as chop-sticks, before being combusted to produce energy and total loss of potential. For each separate resource stream this has to be further detailed. Valuing this cascading is more difficult. For energy this approach is known as Exergy. However for materials there is not yet a useful hard definition. It is studied in quantifying this under “Massiveness” , For water under “dissolving potential’. Exergy specialist Goran Wall [lit 7] has suggested to use economical value as a parameter to measure cascading quality. However further research has to reveal the proper approach.

5. Application of Urban Harvest

A first impression of the potentials of this approach is shown by the materials flows through London, one of the best documented urban areas in the world, thanks to the progressive approach by its major, Ken Livingstone. (data available via : http://www.citylimitslondon.com/)

Table 2: A summary of material flows through London (Figures in '000s of tonnes)

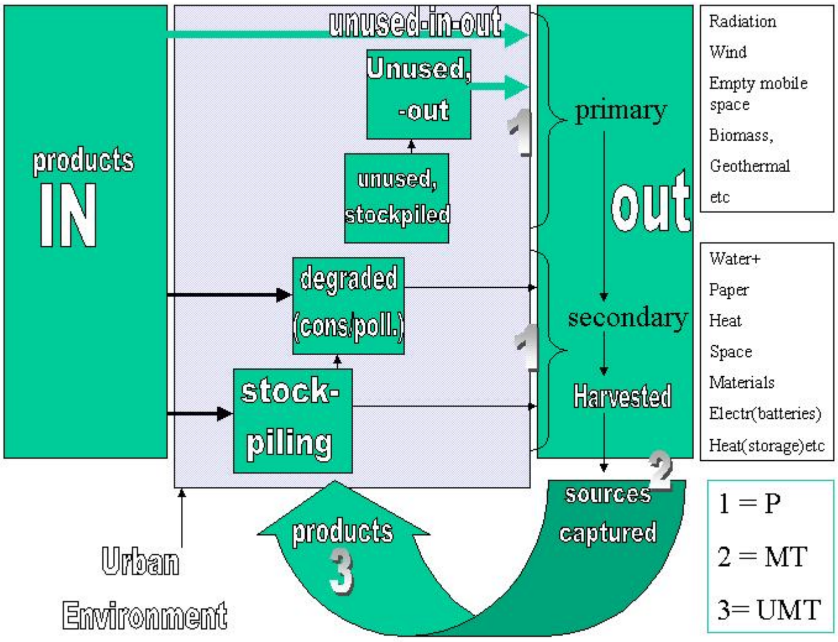
Material category	Production	Imports	Exports	Apparent consumption	Waste	Stock
Construction	24,067	8,143	4,430	27,779	14,756	13,024
Crude materials	884	462	183	1,163	595	568
Wood	102	2,565	255	2,412	574	1,838
Metals	830	451	307	974	642	332
Chemicals	312	820	287	845	462	383
Misc. manufactures	3,404	3,960	2,395	4,969	3,269	1,700
Misc. articles	6,424	3,043	5,458	4,010	2,051	1,958
Unidentified waste					3,361	-3,361
Sub-total (excl. food)	36,024	19,444	13,315	42,152	25,710	16,442
Food	2,076	5,585	761	6,900	562	**
Total (incl. food)	38,100	25,029	14,076	49,052	26,273	16,442

** Data was either not available or was confidential and suppressed Note: Due to the rounding off of figures, totals may not add up

London is one of the best documented cities in the world when it comes to resources. The table shows the data regarding Building and construction. Its obvious that London could theoretically cover its stock added (construction), by re-using the outflow on residues. [8]

Re-calculated per Hectare, London’s Construction residues are around 100 tonnes /ha -year. In Urban Harvest this is the Potential.
How to proceed from that potential, is that this potential has to be “captured”, and then transferred into ready products to re-enter the tissue. In these conversion steps some losses will be apparent.

Take for instance capturing the Solar radiation via PV panels, a efficiency of about 14 pct is available (under certain circumstances) , which decides for the technical potential as part of the overall potential , or the MT (Max tech potential). In re-entering the captured source into the Urban tissue, another reduction step will take place, since we will not significantly change that urban environment for this use. So for PV a limited space/surface is available, deciding on the maximum to be implemented. (the Urban Max Tech).

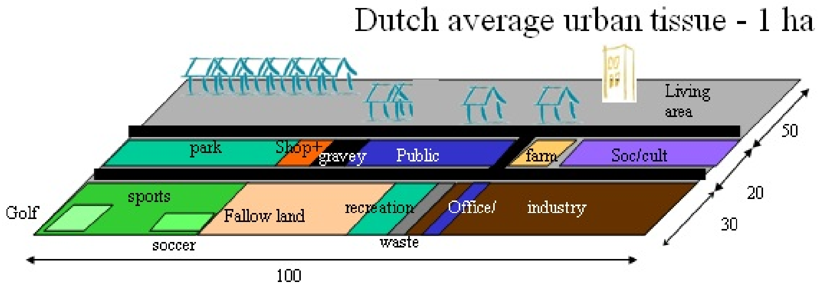


Basic model for the urban harvest approach: primary and secondary sources from the urban system, and 3 main measuring moments: The potentials (P), the captured and converted output (technological maximum-MT) and the maximum re-use in the urbansystem (UMT). .

6. The Urban average tissue

In order to have a first impression of the potential of a certain area, and to create a general benchmark for Urban Harvest it is needed to create a average tissue, or standard hectare. Due to the availability of data, as a first exercise this has been created on national Dutch level:
With the help of the abundance of statistical material (and definitions) available in the Netherlands, the “Dutch URban Average Tissue” was modelled, on a basis of 1 hectare. Called UrbAT-NL . All data were

brought back to m2 per hectare, and this creates insight in the division of activities, percentage wise and building wise. Illustration 1 shows this Tissue.



The Dutch Urban Area is about 11.4 % of the country. From this area, a average Urban hectare is compiled. With about 4600m2 living area, including 9,5 houses (4 in a row with 2 corner houses, 1,5 semidetached, 2 villas) and 4 apartments, and for instance ~80 m2 office space, ~1500 m2 road, 630 m2 fallow land etc. And for instance 123 m2 Golf terrain (largest part of recreation part)

Dutch Urban average Tissue, UrbAT-NL- source author.

From this UrbAT its clear that more detailed tissues can be compiled: The *average housing area tissue* for instance , looking only into the 46 % of living environment of the overall tissue. This opens the possibility to compare housing areas in real situations. Or any other cross section can be made of course.

To resume so far: Urban Harvest looks into the amount of (any)resources that are available and can be harvested from a urban area, looks into ways to capture these, to transform them in products that can be feed back again into that same urban area. This way closing the loop on the output side of a urban system.

7. Methodology

Developing a methodology for a practical and/or scientific approach for Urban harvest starts with defining the potential within the conditions described before. A first indication for the urban harvest potential for some resources in this urban average tissue is shown here: The Potential is the total of a resource or residue coming available from that tissue.

Some Potentials for UrbAT-NL

(Primary)

Rivers: 8,9 million ltr water/ha-year (rain)

Energy: 10 million kWh/ha-year (solar irradiation)

(secondary): (in UrbAT-NL)

Quarry : 50 tonnes/ha year C&D waste

Space: 10m2/ha empty office

Space: 4m2 /ha empty shoparea

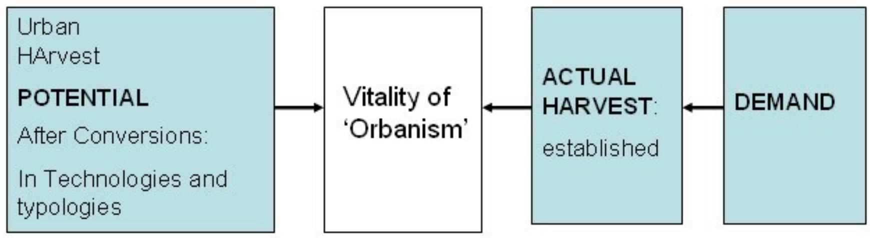
Forest: 17 tonnes/ha-year solid waste

Other outputs are being calculated by researchers at the moment, or are depending on the exact Urban typology.

A further detailing of the approach is illustrated by an example:
Solar energy is entering the urban environment, and most of it leaves the urban system unused. Now the total potential of a (full) 1 hectare tissue is about 10 million kWh /ha-year. (Depending location and climate) This can be captured and converted in electricity by a efficiency of ~10 pct (overall pv-solar system efficiency) , and provides a ready product to feed back into that tissue. The next step is to analyse how much of the urban area (which part of the hectare or urban environment) can be used for harvesting this potential. Since a condition is not to change the functioning of the urban organism significantly, we have to stick to modest adaptations.

Places were it does not interfere with day to day life. Roofs are a well known example. The available m2 roofs, suitable for Energy harvest in the UrbAT-NL, is calculated at 1980 m2. If we would use this potential, a 198.000 kWh can be harvested per year. (to compare: the consumption on average in this standard hectare from households is about 45.000 kWh electricity) Other available surface for energy harvests are roads for instance. Recent studies have shown the possibilities, and road energy potential will add to the total, (several technologies available) as well as its subsoil potential (geothermal, aquifer technology etc) or windpotential.

The total can be seen as the maximum potential energy harvest in a worst case scenario: If the urban organism (“Orbanism”) is cut of from its resource supplies, this is what it can supply itself maximum. If its more as it totally consumes, it could survive without adapting. If its to little, it has to find other resources or adapt its functioning. In this way, *the Orbanism’s “vitality” can be measured to overcome a crises, for each resource stream.*



Potential harvest versus demand and actual harvest gives Vitalty of Orbanism. source author

In a real day to day situation, a cities potential can be compared with its actual Harvest: that part of the sources which is already harvested. In the Netherlands for PV solar there is today 0,4 m2 panels installed , per UrbAT . So there is realistic room for improvement for about 1979,6 m2. Of course there is some competition for the roof surface, for instance from Solar heat collectors. A practical urban strategy has to be defined for analysing a optimal combination. In a research program by three universities in The Netherlands it is now explored how available Exergy- the quality of energy- within the system (urban or rural) , can be combined with a Spatial planning strategy, providing tools to make such optimisations [ref: 9] .

The example on Solar energy is one from a primary resource: a resource in the urban tissue un-used. The other form in UH are the secondary resources: resources that have been used and degraded or polluted within that tissue.

For example wood. Per UrbAT-NL 2.75 tonnes of wood comes available every year in the Netherlands. This can be captured an converted for re-use. Some at the same quality level, some as downcycled, or maybe upcycled with additional input of resources. And next to feed back into the urban environment. In the case of down cycling wood to chipboard: every kg harvested can be processed for chipboard with a 80 pct efficiency, thus giving 0.8 kg return into the tissue as board; or 2.2 tonnes of chipboard for the full resource Wood/ha: This is the theoretical basis. In real cases here also it has to be decide which combination of converting the source into products is most suitable for the analysed tissue, same as with energy.

In the case of secondary resources, 100 pct of converted resources can be feed back, since the Urban Typology has already been included in the level of output: This is the major difference with primary resources, since for these the urban typology , and since we agreed not to change this significantly, is deciding for the amount of place to install the panels. Or in general space need for all primaries.

Each of the 6 main streams in UH contains primary and secondary elements, as well as organic and non-organic fractions. Depending the use of the Urban harvest approach, a different categorising can be applied.

Most of these are obvious. For the ‘Forest’, where day to day harvest can take place, and Urban Rivers, that flow out of the city, are already captured and treated in most cases, and to a certain level, though not fully explored.

Space is a more hidden resource. Space in the from of buildings: these can be harvested, and re-used at the highest level of recycling: as buildings, as should be the main strategy in sustainable housing activities, to reduce the environmental load of materials consumption. [lit:10]
But also space in square meters. On average 10 m2 per UrbAT Office is empty. London is seriously exploring the SANE concept, (Sustainable accommodation for the New Economy), to combine empty spaces by IT, and combine dislocated office space to a new company, this way preventing more offices moving out of the city, and leaving the downtown area.[lit 11]

Urban Harvest, applied in a real urban/built environment, can make these resources visible, and quantifiable.
To recognise and estimate the potentials is at the basis of of a shifted approach and implementation. Analysing the urban Tissue with the Harvest approach shows many of these opportunities.

8. Time and scales

In the general approach of resources, there are differences in time scales of operation and use of these resources. Electricity is usually directly consumed and disposed of after generating it, while building materials serve decades in Buildings (“stockpiling”). However, this relates heavily to the scale of which the observation is perceived: Observed from an Urban level, there is a constant and real time stream of building resources going in and out of the system on a daily basis. And the opposite: by charging batteries the electricity is stored for longer time (though not decades) , and delays the normal real time approach of energy. Nevertheless, all resources can be calculated on a year to year base, with stockpiling having taken place before Urban Harvest is at stake!

Scales however therefore will play a major role in the further development of Urban Harvest, not only by the time parameter, but also by the regeneration-volume parameter: recycling of batteries will require a larger volume, and source area, to make it efficient at the highest available technical level, as for instance wooden beams from demolition, which can be processed on a very small scale.

9. In Practice

The general approach and theory have been defined now (though may change and improve still) , and the next steps are to detail many of the elements in the theory. Some have been mentioned already: How to quantify cascading for materials and fluids for instance, or developing a database with data sheets for resources, how much of one source can be converted in a useful product. This will form the basis for real case analyses, so called Urban Scans: A urban area is defined (a whole city or part of it) and a scan can reveal what's is the potential of this area, to improve performance , to develop policies and in the end sustain itself.

Urban Scan

Urban Resource Scan is the working title for the development of a tool to measure the cities potentials and performance in this resource management. (Or the "Vitality of the system"). It is meant to inventorise the outgoing resources and virgin harvest options (within the system) on one side as the potential, and on the other side to document the already actual established "harvest". (that is : what is already re-used and recycled, and what is already produced from within the system boundaries)

The Urban Resource Scan will be used for scientific study and education, but also to advise municipalities and stakeholders on the possibilities and potentials within their reach.

UH and Building and construction approach

With this Umbrella approach in Urban Harvest, it has become more easy to detail the possibilities of the management of the building stock, not at building level but at stock level. That is the level for the next decades to be addressed, in order to cope with our ever growing resource needs and impacts thereof. Concentrating on the output, not on input and consumption of the stock. However combining this approach with other strategies that address input and or demand is a obvious possibility

This task, for application in the built environment , can be defined as *to measure a cities performance and potentials in regenerating resources and harvesting inner city virgin resources for Building & Construction, from there to develop a practical tool for Urban management of Building & construction resources, as a steering mechanism, to organise and establish practical re-use and recycling of C & D secondary resources, reduce waste and save virgin (non renewable) resources, with limited transport needs.*

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