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ENERGY EFFICIENCY IN URBAN AREAS BY INNOVATIVE PERMACULTURAL DESIGN

Stevovic Svetlana[1], Jovanovic Jovana[2], Djuric Dijana[3]

[1]*Innovation Center, Faculty of Mechanical Engineering, Belgrade University, Serbia, svetlanas123@gmail.com*
[2]*Faculty for Civil Engineering and Management, Belgrade, Serbia*
[3]*Faculti of Civil Engineering Subotica, University of Novi Sad, Serbia*

ABSTRACT: First two paramount problems of the world are food security and energy. Permaculture is a new interdisciplinary branch of the science, which has positive synergistic effects and solves both problems, including environmental care. The paper analyzed the holistic principles of permaculture design and possible application in the flats, gardens in the suburbs and/or in the countryside, the urban land, fields and plots, on rural estates and cottages, in commercial and industrial applications, as well as in educational institutions and in the abandoned land. Permaculture as a set of knowledge about designing sustainable human communities, is a connection of the old traditional techniques, enriched with new knowledge and technologies in the field of architecture, construction, agriculture and forestry, chemistry, biology, sociology, urban planning, ecology, economy, energy, water and waste management. Permaculture research answers on how to simultaneously grow food, build energy efficient dwellings and improve the functionality of urban communities while preserving the environment. Model of positive examples from international smart practice are presented.

Key words: *energy efficiency, innovative permaculture design, urban areas, environment*

INTRODUCTION

Energy efficiency is one of the imperatives of sustainable development today. In the broadest sense, energy efficiency can be discussed from the perspective of the manufacturer, then in the process of energy transport and from the consumer's point of view. In designing various energy facilities for the production and transport of electricity, with the aim of achieving the maximum energy efficient technical solution, they are using the appropriate optimization methods [1]. In the construction of buildings, there are various methods of realization of energy efficiency in the construction of buildings, ranging from the methods of rational energy consumption [2], through the use of solar panels in various construction combinations [3], to the use of rayon eco materials and the latest modern PCM materials in the walls of the buildings.

The research pedagogy in this paper is the modality of achieving energy efficiency using permaculture design in urban environments. Permaculture design is a specific form of designing energy-efficient building structures and architectural units, using different plant crops, which can also have aesthetic and dedicated function in nutrition. The term Permaculture is introduced in science and practice in 1978 by Bill Morisson and David Holmgrin. Early term of permaculture was related to "permanent agriculture", but with the advancement of science and practice it was made in "permanent culture", because social aspects were a key part of a sustainable system as a whole. Permaculture is sometimes

defined as many gardening tecniques together, but as a holisticly built philosophical view of life, which provides all life resources in one place, but protects the environment at the same time [4].

Providing food and energy are two biggest world problems of today. Permaculture is a new interdisciplinary part of science, which in practice has positive effects and sinergically resolves both problems. In the text below are holistically analized priniples of permaculture and their possible application in flats, suburbs, city soil, country houses, commercial and industrial space, schools and abandoned lands also [5]. Permaculture as a collection of techniques for designing sustainable communities is a mix of old tradicional techiques refined with new knowledges and technology from architecture, construction, agriculture, chemistry, biology, sociology, ecology, economy, energetics, water and waste disposal. Permaculture is finding answers to questions: how to grow food, build energy efficient homes and make functionality of urban community better by protecting the enviroment. These are examples of positive practice in the world.

Basic idea of permaculture is creating a system that satisfies people's needs using multiple natural elements and finding inspiration in natural ecosistems. Goals and priorities of permaculture are same as basic principles of sustainability. Its principles are constantly developing by the people from all around the world which live in different climat conditions and cultural frames.

Point of permaculture is creating an ecological lifestyle in households, gardens, urban enviroments and working activities. Principles and use of permaculture are available at any place: in flats, gardens, city soil, countryside, commercial and industrial space, unused soil. Permaculture is stimulising its own resources and local community development. Permaculture way of growing implies that the planting is done in all city zones, that way that the plants are compatible with each other, protecting each other from pests without use of any chemicals [6]. Easily said, permaculture is a method of designing sustainable communities using nature's example.

Many "grow your own food" projects started by permaculturists, today saves lives and making deserts green. Permaculture is also a bunch of ways to design a sustainable community. It started as a mix of traditional techniques, refined with new knowledge and technology from many sciences like: architecture, construction, agriculture, chemistry, biology, sociology, ecology, economy, energetic, water and waste disposal. Using this knowledge we can organize our resources more optimally, in order to make more balanced and sustainable habitat.

Permaculture is copying examples from nature and makes us reorganize spending of our resources, by taking care of environment and pollution [7]. Permaculture considers local culture [8], climate and local community habits. It offers basic knowledge of landscapes, climate, soil, plants and animals, water and insulation, because it unites them in one unique design for a user. In permaculture design, things that are taken care of are:

- people
- planet Earth
- resources [9]

Examples from nature are copied and implemented in order to optimally use all natures' potential, including solar energy [10], combining them into elements that support each other, meeting the needs of all people, without endangering the environment. 12 holistic principles of permaculture design that were published in the book by David Holmgren - "Permaculture: Principles and pathways beyond sustainability" (eng. "Permaculture: Principles and Pathways Beyond Sustainability") [7] are:

1. Observe and interact- By taking time to engage with nature we can design solutions that suit our particular situation
2. Catch and store energy- Ensure that collect resources when they are abundant, we can use them in times of need
3. Obtain a yield-Ensure that you are getting truly useful rewards as a part of the working you are doing

4. Apply self regulation and accept feedback- We need to discourage inappropriate activity to ensure that systems can continue to function well
5. Use and value renewable resources and services- Make the best use of natures abundance to reduce our consumptive behaviour and dependence on non renewable resources
6. Produce no waste- By valuing and making use of all the resources that are available to us, nothing goes to waste.
7. Design from patterns to details- By stepping back, we can observe patterns in nature and society. These can form a backbone of our designs, with the details filled in as we go.
8. Integrate rather than segregate- By putting the right things in the right place, relationships develop between those things and they work together to support each other
9. Use small and slow solutions- Small and slow systems are easier to maintain than big ones, making better use of local resources and produce more sustainable outcome
10. Use and value diversity- Diversity reduces vulnerability to a variety of threats and takes advantage of the unique nature of the environment in which it resides
11. Use edges and value the marginal- The interface between things is where the most interesting events take place. These are often most valuable, diverse and productive elements in the system
12. Creatively use and respond to change- We can have a positive impact on inevitable change by carefully observing and then intervening at the right time [11].

URBAN PERMACULTURE METHODS

Cities produce millions of tons of waste which is either piling up on landfills or being burnt, that way making toxic gases and sending them to atmosphere. High level of pollution by cars in the cities, combined with many other ways of pollution can severely harm people's health. Majority of world resources are consumed in the cities. Plenty of food and energy comes from afar. Citizens of the cities have a high demand for constant availability of all resources. Cities are taking huge amount of land. They actually remove the original green; cities are sort of islands of unnaturality in nature.

On first glance, in context of permaculture, big cities are ultimate evil. Is it really like that? More than 50% of human population lives in the cities. Many of those don't have financial possibility to buy a property in rural environment, to design a permacultural object, even if they wanted to. Additionally, it is unreal to expect that all those who have a possibility for it, could think of economical construction, which could cover their essential needs, and not depend on urban communities to sell their products(exp food) or services(rural tourism) [12].

Permaculture aims at sustainable design- to properties so as to communities. Permaculture also starts with an area closest to us. Regardless of our frequent urge to escape into the nature or in a process of building sustainable property or moving into one. Regardless of living in a city or countryside, permaculture is practised there where we live. There is no property without energy used in building it, or our transit period. That means that for most of us permaculture must be, at least partially, urban [10]. That aside, one more unexpected fact encourages us to step in urban permaculture.

At first glance unbelievable, but in more developed countries (developed consumer society) ecological footprint of cities per one citizen can be smaller than a footprint of a countryman. To reformulate, even in some megacities, which are unsustainable in every aspect, average citizens "use" less of the planet than average in the countryside. How can it be? Our ecological footprint does not grow with our food habits, holidays in distant lands or consumption in the markets. Big part of our influence on the planet goes to living and common infrastructure- streets, utilities etc. It is obvious that in a single house, typical for living in countryside we use more materials per citizen, because there is no shared walls, floors and celings, pipes, electricity… like in condo buildings common for the city.

It is not discussion about which lifestyle is more pleasant or more natural and acceptable for communities, but about that on a countryside property, even in an object entirely from natural materials, we spend more energy and resources to "live with nature", and usually we spend a lot more. Transport can't be neglected [13]. If we are not selfsustainable, and we are not, life on the countryside with all civilization benefits-schools, kindergartens, hospitals, etc. we need a lot more transport, and

commonly use of personal motorized transport. Worst thing we can do is lie to ourselves that it is sustainable to live in nature, tens of kilometres from our jobs and most of our food we still buy at supermarkets (which we need to drive to also) [14]. Solar collector on the roof and tomato in the garden would partially sooth that. On the other side, it isn't a rule that everyone who lives in the city live "sustainably", neither it's impossible to organize rural life with low ecological footprint- creating those is original job of permaculture, but reality is that even those who live on "permacultural" properties sometimes spend more energy than those that doesn't.

Pretty good indicator of ecological footprint is amount of accessible income, no matter if it is urban environment or rural. If we don't take a look at our influence in our environment, in every aspect, and drastically change our habits and reorganize the community where we live, that what we do is not going much further than increases our comfort at the expense of nature, and entire communities globally. We must not forget permacultural ethics [14]. Our pollution harms us and those who do not have the opportunity to move from urban hive, leaving a smaller overall footprint. Care for the Earth, care about people and the fair distribution of the food to return to think about inequality in human societies, and lead us to return to the city.

POSITIVE WORLD PERMACULTUR PRACTICE

Cuba Case Study

Cuba is a country that already went through the peak of its oil addiction (when you look at its environment and index of development) today is the only country with sustainable development. For years Cuba was depending on cheap oil and food from Soviet Union, but when the Soviet Union collapsed, in 90' Cuba faced itself with energy and food crisis at the same time. Citizens started growing vegetables and chicken on balconies and roofs, but that wasn't enough. Instead of copying typical third world economies by planting large amounts of coffee and sugar (cash crops) to sell on international market and get food for their hungry citizens, Cuba saw that they don't need megalomaniac sugar fields or huge profit, what they needed was food.

The system of planting gardens in the cities was launched, abolished the tax benefits in the urban ecological agriculture and within ten years or less not only the population was fed, but also the level of public health was at a high level. Havana, a city of about 2.5 million people and a much higher density than for example Belgrade, ménages to produce about 60% of fresh food inside the city for their own purposes. When something like this is achieved, there is no need for much transport and energy crisis is easier to bear [15].

Cuba is a great example of a country that found solutions in the middle of the crisis. Community is very well connected and the society, although their low standard is a really healthy society that functions well and solves two biggest problems of today: food and energy. Something like that seems impossible in richer countries where a lot of food and oil is.

Detroit Case Study

An example from North America shows that the countries with high standard, if it is high awareness and responsibility towards the environment, it is possible to make permacultural achievements in urban areas. While imperative sequence of permacultural is worth of attention. Detroit is a city that has evolved in parallel with the automotive industry and when that industry began to deteriorate (since oil prices jumped), city began to deteriorate too. Without regular income owners were no longer able to repay their family homes and they emigrated. As the houses were mostly older than 70-80 years and needed to be regularly maintained, and how no one bought them, they were starting to crumble, in the end, in most cases removed because they presented danger.

Finally the city bankrupt, and all public services stopped working. There was no waste disposal, public transport, and many poor citizens, were cut off in their ghost neighbourhoods, without ability to get

food nearby. People started to cope with a crisis, and started to use empty city spaces for food growing, not aware of perfect permaculture concept they were using.

Today, not only that individuals grow food in their backyards and on collapsed house sits, but also starting urban organic farms with fresh vegetables, fruit, even wheat, that supply local shops and markets and doing hose deliveries for people who can't afford to get to them. Soil is mostly clay, but projects of massive composting are started in Detroit's neighbourhoods because farms insist on ecological growing. Urban agriculture and connecting within community has caused a little local rebirth. For the first time in tens of years young people are moving into city and interesting things are happening, a local university has one of the best urban development schools in the world.

But not everything is ideal, because today's Detroit is another solution that emerged from problem. Regardless of individual footprint of living in the cities these examples shows us what is the cities weak spot-food. Modern cities are usually totally dependent on food supplying from outside, and really connect with local rural areas so the food comes from all around the world.

England Case Study

One of the many positive urban examples, but also of the very few that are permaculturaly designed and accessible to people with rather small capacity to pay, settlement LILAC (Low Impact Living Affordable Community) in north England's town of Leeds. Small village made of straw, with 20 households and a utility building are composed in a traditional neighbourhood, and neighbors are welcome. It is possible to adapt one of existing buildings by installing insulation, planting climbing plants on walls, as well as making green roofs.

Asia, Africa and America Case Studies

Historic fact is that food growing was attention ally integrated in early Middle East cities. Although urban agriculture wasn't later developed by plan but more informally and by the need, they knew that without food growing a larger amount of people on relatively small space is not sustainable in long terms. That aside many of the cities were formed on the most fertile land.

Urban gardens in some form has always existed and supplied residents with fresh fruits and vegetables as much as possible, and for other food products cities were connecting with rural areas close by. Many African and Asian megacities are almost self-organized to meet the need for fresh food. New Jersey still bears the nickname "Garden state" because it feeds hungry Manhattan for more than a century.

INNOVATIVE PERMACULTURE

There are ways to bring food growing closer to the cities, and to lower the entropy that cities produce as waste and pollution, so that through intelligent design, motor vehicles transport is reduced to a minimum to save much of the energy. Given the size and population density, cities are demanding but interesting and very promising training ground for building sustainable communities. Ways that we can make the cities more permacultural is to bring more nature into cities and amp the existing biodiversity, or in some way integrate the best from urban and rural, get cities in sort of their beginning form [16].

Healthier cities with less pollution, greener, with better food and better quality(not quantity) of content creates foundation for healthier community, healthier citizens and society. Although we can't achieve sustainability in city in terms of water and energy, little changes in our lifestyle can save us a lot- not only energy and water but money also. Also we can't forget that living in the city provides us a lot more choices in anything and it's easier to go for sustainable solution.

How permacultural design does not only refer to the design of the house or apartment, but on a design of our living routines, if you don't have ability to use public transport, or thus too far for walking or

cycling, it might make more sense to change the location of the apartment or change the job. Ife we can't agree a thing with our neighbors our lives will probably not be comfortable no matter how good the location is. Probably the biggest potential for the use of urban permaculture is in the community. Due to higher population density there is a much higher possibility that we will be able to find, gather, or connect to groups of people who aspire to the same goals and are ready to engage around their common goals. A lot more opportunities for public action exist, so a greater chance that we propose or apply can be visible. Those others will be able to get good ideas and apply them in their lives.

Cities are "hotbeds" of new ideas and social movements due to the greater prescience of authorities and institutions, the ideal location for activism and influence on changes in institutional practises, without which, unfortunately, collective social change is impossible- no matter what our personal ecological footprint is. There are numerous examples of the construction of sustainable buildings and sustainable neighbourhoods, however. In these neighbourhoods they collect rainwater and purify waste water, produce enough electricity for its own needs. Buildings are salary passive and growing food. It is also a form of cooperative housing (Cohousing): future residents pool their resources to design and build a sustainable village, and later get a flat to use.

RESULTS OF NEW IDEAS

Biggest problem and challenge for gardening in the city is finding adequate space. Not only there isn't much green surfaces, it is also important to make a big part of them into parks and recreational areas. At the same time, problem is that soil we used to build before (brown field) isn't healthy, or satisfies minimum quality for food growing. Also some materials that are common for countryside (straw, hay) are unavailable in the city, but there are solutions [17].

In the urban areas, it is possible to grow food on flat roofs and planted in green facades, balconies and window ledges, the garages and industrial buildings, and of course in the suburbs and neglected public green areas. The first step in designing any form of garden is to plan ahead. Therefore, the preliminary design is drawn in basis, applying the basic principles of permaculture and bio-garden criteria design. When creating conceptual design, the component which needs to be satisfied are:

- Shape and size of garden
- Source of light
- Source of water
- Plant selection
- Compost location

The gardens in the apartment: on the window ledges or in well-lit southern parts of the apartment, it is possible to plant herbs, spices, leafy vegetables, bulbs and plants that are self-fertilized. Peppers and tomatoes can also grow [18]. The gardens on the concrete are one of solutions in urban areas. Balconies, terraces, roofs, if they have good structural integrity, especially if there is a possibility to collect water, or any asphalt or paved area in front of the building, can be used as a space for a garden and get revived by movable slats.

If there is not enough light for the plants in the apartment, mushrooms can be grown. To do this, garages and cellars are also suitable, and in fact bathrooms are ideal, because it's warm and humid. In a relatively dark rooms in the apartment sprouted grains and beans can be grown, have your fresh salad in the middle of the winter. Vertical farming: on shelves, hanging installations, in the textile pockets. Vines can be grown on the balcony, metal balcony railings are ideal for beans or cucumbers.

The gardens within the institutions, schools, kindergartens, universities, hospitals etc. usually have a seedy lot belonging to the building, and management and employees may be happy to agree to start a garden on the land. Most of these institutions have organized kitchens or canteens and part of the grown food can be consumed on the spot. Ideal zones for food production and consumption in the city:

- Private urban gardens(gardens and terraces); discarded food that is good for consumption, but failed to sell; processing and preserving food at home

- Urban neighbourhood gardens in the public space
- Market: small neighbourhood shops of healthy food, preferably with the bulk (unpacked) goods
- Neighbourhood supermarkets
- Shopping centres and hypermarkets outside the city [19].

COMPOSTING IN THE CITY

About a third of the utility (solid) waste is bio waste, and one third goes to paper and cardboard, including one in final stage of processing, all this on the landfill of waste creates a dangerous, explosive methane gas, which is one of the six greenhouse gases. Unpleasant odours are spreading also. But it's still possible to compost; you just need to find right technical solutions. [20]. Permacultural solution is certainly composting at home because it solves the waste on site, produces its own hummus for growing plants, and no transportation is needed, so there is no bio waste "spoiling". Another great effect of bio waste is that thrash can never stinks.

If you have your own garden, it is best to make your compost pile on the ground, but can also be composted at home or on the balcony. It doesn't require any costly or complicated equipment. For buildings, rotating composters are advised, they can compost a lot of waste without the risk of anaerobic decay. Rotate or spin composters at each insertion of "fresh" material aerated mixture and accelerates the degradation. If, however is sometimes difficult to find a location or for some other reason cant compost at home, organized collection of bio waste could solve the thing- the neighbourhood composting or biogas production even in larger installations

PERMACULTURE IMPACT ON ENERGY EFFICENCY

Cultivation of crops, herbs and ornamental plants in urban areas, on the roof of residential and industrial buildings, as well as on the facades, increases the energy efficiency of existing buildings. Permacultural growing demands respect of the same criteria of standard installation of green roofs and facades. This is why effects are the same" improved thermal insulation and thus consequently reduced heat losses, reduce need for energy resources and increased living comfort [21]. Additional requirements and technical conditions that need to be fulfilled in order to have permacultural garden on the roofs and facades in urban areas are:

- Compost in organization
- Continuous irrigation (dew system or drop by drop)
- Stable structure that allows continuous access of technical stuff

Building temperature balance efect

Green facades and roofs act as thermal insulation and produce an outstanding cooling effect, i.e. maintenance of achieved ambient temperature. Green lining on facade produces cooling effect in summer, and enhances thermal insulation in winter – in fact, it has a favourable effect on indoor climate throughout the year. Inhabitants of green streets are more active, and consume less water. Air temperature is lower. Energy loss during winter is also possible to reduce by the same green lining.

Vegetation in front of facade acts as an important thermal insulation. Air cushion created between leaves and walls reduces the heat loss coefficient of the walls: air is an additional thermal insulation layer. 5 cm thick static air layer has a heat conductivity coefficient of approximately 2.9 W/m^2K, which corresponds to the one of double window glass. Protective effect is particularly high on the sides which are exposed to wind, because it reduces the cooling effect of the wind [22].

The basis for such a new approach is the important fact that leaves act as a live "solar collector". This "solar collector" achieves optimal follow-up with daily and annual cycles, providing the following advantages: in summer, when the sun is high, leaves spring up and behave as ventilation shutters,

acting as a partition between the plant and building, while cooling the air which enters the house. Conversely, in winter, when the sun is low, leaves of evergreen carpet – due to low hydrostatic pressure – press together and bend downwards, creating a layer of air insulation. Aerodynamic, physical and morphological properties of leaves define the passive capacity to retain the warmth of plant surfaces. Those are: leaf colour (ability to reflect), size and position of leaves, weight, density, aerodynamic properties, as well as wind resistance.

Heat loss in a house caused by wind may reach even 50% of total heat loss, depending on the position and structure of the building. It is very important to ensure maximum protection of facades against wind. Closed, evenly distributed vegetation on facade significantly reduces the cooling effect produced by wind. Thick, uneven leaf carpet in front of facade acts as "wind breaker". Besides, vegetation protects against heavy rains and prevents mortar wash off, thus considerably reducing the wall erosion. Temperature of classic facade which is not in shade during summer may reach up to 40-45ºC. This is extremely high temperature, which can be lowered by vegetation. Air temperature underneath green plants is much lower than in the same environment which is not exposed to sunshine.

The reason is not only the parasol effect, but also the special leaf structure. Leaves reflect approximately 10% sunshine – less if leaves have smooth surface, more if their surface is rough – and absorb about 70%, and accordingly, solar energy shall heat the surfaces shielded by leaves only 20% [23]. Luxuriant vegetation creates shade and reflects large quantity of sunshine and at the same time takes away the heat from surroundings by evaporation. Evaporation – produced by leaves of green plants – takes away the heat from surroundings, while air humidity grows. The larger the leaf areas are, the more intensive the process. On the other hand, vegetation contributes to reduction of air humidity where necessary, because the leaves absorb vapour, which drops condensed on the ground appearing as water drops. Thermally insulated flat roofs lined with bitumen layer may warm up to 60ºC during an averagely hot summer day in Central Europe, at air temperature of 25ºC, whereas under extreme circumstances this value may reach even 80ºC. The result is warm vertical air streaming, which further leads towards raising of dust specks from the street, thus creating pollution and vapour bell over the town [24].

Velocity of vertical air stream is much higher in front of facades compared to air movements over the roofs, so that large quantities of dust and particles transported by this air stream enter the flats through open windows. Vegetation lowers the air temperature, particles are stopped on leaf surfaces, and that reduces their density and velocity. Leaves are capable of sound reflection and absorption. Leaf structure absorbs and transmits – and thus reduces – a part of acoustic energy, and the rest gets reflected.

Noise reduction effect

The wind moves the leaves of green plants, they collide and emit even, calming rustle, which suppresses a part of irritating hazardous everyday sounds – this is the phenomenon of masking. The leaf layer in front of facade, particularly the thick and dense one, reacts to sound waves by motion. Efficiency of green facade protection against noise depends on the sort of plant, size of leaves and season of the year. Research has found that leaves reduce the noise quantity by about 5 Db [25].

Reaction of living creatures to factors of changes in environment depends on ecological awareness of subject living creature. Green facades may be created in various ways, and the plants used may possess various favourable properties. First of all, all characteristics of particular plants and local conditions must be harmonized, partly in order to use the advantages offered by green facades, and partly in order to avoid possible damage to both (buildings and plants).

Air purifying effect

Air purifying effect is often subject to scientists' disputes. The referent measure specified in literature is 0.5 kg dust specks per m^2 a year. Comparative measurement of dust and particle contents retained in the air was done in avenues with lines of trees and in greenless streets.

The results show that particle contents in avenues are by two thirds lower than in treeless streets, thanks to large leaf surfaces. Dust and particles of pollution remain on leaf surface, and then the rain washes them off to the ground. Leaf surface absorbs hazardous gases contained in the air. They remain on leaves also in autumn, when the leaves start to fall, and again end up on the ground. During 12 hours of daylight, the leaves produce about 4 litres of oxygen per square metre of leaf surface, at average. A man consumes 175 kg of oxygen a year at average, which is about 335 litres a day [26].

Based on specified data, oxygen production by green facade can be easily calculated. If ivy as facade plant forms leaves 10-15 cm thick, it means that there are approximately 3-5 cubic metres of leaves per square metre of wall. It comes out that ivy produces about 12-20 litres of oxygen per square metre of wall a day. Main issue in towns is not the low contents oxygen in the air, but high degree of its pollution.

From the viewpoint of an architect, the challenge is found in the possibility to underline the contrast between stability of structure and constant changes which are inherent to live plants: geometrical forms can be softened by mobile forms of vegetation, and structural elements can be shielded or emphasized by it. Tiny, large, sporadic or thick vegetation can emphasize powerful or subtle wall structures [19]. A layer of vegetation can fully or partly cover a building like a fur cloak. Using green plants, it is possible to form outfalls, circular structures and other interesting forms without intricate structural elements. On the scale of values of a human who lives in town, the fact that his residence is surrounded with agricultural vegetation or located nearby a park represents a special quality. This advantage raises the value of the building itself.

CONCLUSION

Permacultural design applied in urban areas, increasing the energy efficiency of buildings themselves and it is definitely in terms of sustainable development. “Towns keep expanding, which causes disturbances in the quality of environment, shortage in nourishment and energy. Instead of become familiar with nature and its laws, the man has started to degrade and pollute it intensively” [27].

One of the possible ways to increase energy efficacy, rebalance food supply, improve quality of environment in towns and return to the lost ecological balance, is construction of permaculture green roofs and facades. Nowadays, the increased number of various tended plant species offers large possibilities for covering of roofs, facades and terraces with different agricultural product, seasoning herbs and grape-vine.

The contemporary methods presented in this article show that growing of agricultural plants on architectural structures does not cause any problems, and in fact represents an advantage, considered from various points of view. Permaculture design in urban areas, permaculture green roofs and facades are one of the ways in which urban areas struggle against food shortage, energy deficiency and global climatic changes.

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