International Journal for Quality Research 12(4) 803–822
ISSN 1800-6450

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**Article info:**
Received 10.08.2018
Accepted 16.11.2018

UDC – 633/635.017
DOI – 10.18421/IJQR12.04-02

# THE TRANSFORMATION OF WASTED SPACE IN URBAN VERTICAL GARDENS WITH THE CONTRIBUTION OF DESIGN TO IMPROVING THE QUALITY OF LIFE

***Abstract:*** *The main goal of this work is to propose a generic model of an urban vertical garden that can be folded and that can adapt to different types of spaces, taking advantage of the natural resources to the practice of urban agriculture.*
*The methodology of this research obeys five main ideas, the relation between wasted space, man, living space and sustainable design in the production of biological products.*
*The main findings are, improving the quality of life by promoting the practice of urban agriculture; the integrated management of sustainability components in a global market.*
*This case study is pioneer in the Portuguese researches about foldable urban vertical gardens. The authors believe that it can be useful in the creation of a Portuguese guideline for the integration of controlled plant foods production. It promises environmental benefits resulting from the design and development of a product that includes new technologies and the choice of reusable materials.*

***Keywords:*** *Sustainable development, Urban vertical gardens, Design, Product Development.measurement, Quality management, ISO 9001, Scientific research*

## 1. Introduction

The urban development, the growing population and rapid urbanization (Astee & Kishnani, 2010) have contributed to some of the challenges that cities face today. The consequent increase of urban buildings and public works makes evident the scarcity of local environmental resources, putting the biodiversity in question.

Various sustainability challenges including climate change and associated economic and environmental disturbances, with implications for ecosystem and human, and social order will increasingly challenge the society (Steffen & Hughes, 2013); (Huntingford, Mercado, & Post, 2013); (Rockström et al., 2009).

Cities are complex systems consisting of social, physical and informational layers which dynamically interact with one another (Batty, 2005).There are various reasons for this increased interest in cities in the context of sustainability and low-carbon transitions (Gaziulusoy & Ryan, 2017).

The degradation of these resources has raised considerable concerns in the scientific community, the political system and environmental associations.

Various cities are starting to recognize urban agriculture as an integral part of urban planning (Dubbeling, 2011) upgrading and design. Housing design can take into account (micro) farming requirements like designing

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houses in such a way that they can accommodate growing on exterior walls and window sills; designing balconies to maximize solar access or with growing containers already built into them; as well as so many possibilities.

Scientists warn of the harmful effects of human intervention on the planet, stressing that natural disasters are the result of a number of options taken.

The planet reacts as an organism to everything we do, because everything that surrounds us is inhabited by organisms essential to life on Earth. More and more, therefore, the criteria for planning natural resources, such as housing, are essential for the preservation of ecosystems and biological diversity, ensuring sustainable construction based on eco-efficiency, promoting environmental, social and economic awareness.

It is a characteristic of the human being to explore the world, extracting from it everything he needs to survive.

The problem is that many of the most productive forms use poisons and fertilizers to obtain higher yields, damaging biodiversity and the planet in general (Sorrentino et al., 2005). The concept of sustainable development implies respect for nature, looking at it as a resource of raw material aimed to the needs of the planet, but which must be explored rationally. Seeking this sustainability and the preservation of biodiversity, it seems pertinent to make use of the wasted space at the housing level, as well as of so-called transient places or "non-places" (Augé, 1994).

The scope of the problem is the promotion of occupation of wasted spaces, as a way to fill in the lack of spaces in urban habitations, which may enable the practice of agriculture.

The research questions are: (1) Will it be possible, within family routines, to contribute to a greater sustainability and protection of the planet, guaranteeing the rational use of natural resources? (2) How can one promote good eating habits and increase the supply of organic products to the urban population? (3) Is it possible to take advantage of the wasted spaces in a dwelling, through the design of devices for the practice and cultivation of urban gardens? (4) Will the applied technology create an incentive for the user to grow organic products? The findings are compared to those of other studies in the same context. The innovative forms of vertical urban gardens, normally, aim to combine food, production, design and the use of wasted spaces in urban homes.

The objective of this work is to contribute to the development of an urban vertical garden, for the practice of urban agriculture, with a focus on sustainable development to improve quality of life. This work aims also, to build the background for future studies in the context of the appropriation of wasted spaces of a dwelling, with the purpose of developing a product within the urban vertical gardens, with the objective of improving the existing design, that contributes for the promotion of sustainable practices and disseminate the best solutions within the industry.

## 2. Literature review

With the human population rising to 9 billion by 2050 (Griggs et al., 2013), definitions of sustainable development should be revised to include the safety of people and the planet. Defining a unified set of sustainable development goals is a challenge, especially when there is a conflict between individual goals such as energy supply and prevention of climate change.

So far, we can verify that urban agriculture can be truly useful in the strategy of the goals 1 and 2 of the Sustainable Development Goals (SDGs) and this is a point to discuss in a more detailed way. The emergence of successful entrepreneurs in urban agriculture has increased the global interest in this subject.

For instance, a survey with 386 urban participants in Berlin, Germany were found, which provided to identify the general

preferences for the productive use of urban space, the accessibility of different forms of urban agriculture and the demands and expectations regarding the products of urban agriculture (Kates, Parris, & Leiserowitz, 2005). The results show, firstly, that more than 80% of respondents prefer to have accessible systems such as public green spaces, intercultural gardens and roof gardens. In fact, land uses that do not provide accessibility, such as, aquaponic farms, meadows, or intensive agricultural and horticultural landscapes, showed less than 40% acceptance. Secondly, 60% of respondents expressed acceptance of rooftop agriculture, agriculture on the urban periphery or in the interior countryside of cities, while 65 percent rejected agriculture in multi-story buildings, or aquaponics. Thirdly, more than 50% are willing to buy vegetables, but reject intensive production systems products and animal husbandry mechanisms, with more than 70% rejection for animal products.

According (Kates et al., 2005) urban agriculture can have positive effects in the following areas: education, environmental improvement, diversification of leisure activity options, jobs creation, community building, and societal views of agriculture. Although these effects have not been studied in Berlin, perceptions of positive impacts are reported in other studies that describe similar urban agriculture impacts on other places (Anthopoulou, Partalidou, & Moyssidis, 2013; Caplow, 2009; Eigenbrod & Gruda, 2015; Pourias, Aubry, & Duchemin, 2016; Sanyé- Mengual, Cerón- Palma, Oliver- Solà, Montero, & Rieradevall, 2013; Specht et al., 2014). We believe that urban agriculture also offers social and environmental benefits in Berlin and that this model can be applied in another countries.

Conferences, scientific community warnings and conventions to promote better biological diversity have been shown to be the source of key indicators to improve the quality of the environment. Biological diversity and the sustainable use of its components is not a new topic on the diplomatic agenda.

Biodiversity as a natural heritage is an important element in the affirmation of its own identity in the context of European and world diversity, an historical and cultural heritage linked to it.

At the local level, many municipalities have developed action plans for the promotion of biodiversity, which include the increase of the green structure like the implementation of gardens and green leisure spaces, such as urban gardens. These plans allow the ecological maintenance of the spaces, increase the permeable area, restore natural ecosystems, elaborate management and regulation plans, and promote points for diversity and information sharing.

Urban gardens and community gardens have long been inserted in cities, urban gardens arise in an accumulation of information and knowledge to act in favor of biological diversity, as well as places of conservation of the local biodiversity, zones of cultivation of products for the human survival, zones that allow an extension of the permeable area, that form a space of convergence between local producers and consumers.

Urban agriculture may exhibit high levels of biodiversity, often exceeding that of other green areas within the city, the variation in plant cover, the diversity and structure will likely influence not only biodiversity in urban agriculture (Lin, Philpott, & Jha, 2015), but also the quantity and quality of the ecosystem services supported by such systems.

Biodiversity and the ecosystem services of urban agriculture can have major social and environmental benefits for cities, such as higher food security, air quality and water regulation.

In Portugal, urban gardens have been in the vanguard, attracting many practitioners, having been implemented in close proximity to cities, such as the urban gardens of Vila Nova de Famalicão, in Parque das Devesas, which can be seen in (Figure 1).

**Figure 1**. Vila Nova de Famalicão urban gardens in Parque das Devesas (Author's photo).

In many countries, private gardens are an important component of the urban green space and it can provide considerable benefits to biodiversity and quality of life, considering the global increase in urbanization and the fragmentation of the naturalnvironment, urban green spaces (Goddard, Dougill, & Benton, 2010).

These gardens can play an important role in improving the environmental impact of domestic curling, isolating houses from extreme temperatures. They can reduce domestic energy use, improve localized air cooling, help mitigate floods and provide a refuge for wild life (Cameron et al., 2012). The greatest benefit of home gardens is human health and well-being, but more work is needed to clearly define it within the broader context of green infrastructure.

An interesting concept is the one of urban community gardens (Ghose & Pettygrove, 2014) which are lauded as spaces through which residents relieve food insecurity and claim rights to the city, but also by the notion that citizenship participation is inherently transformative or empowering.

Rapid urbanization has substantially reduced the amount of viable agricultural land for food security issues (Guitart, Pickering, & Byrne, 2012), food security is bringing renewed academic interest to community gardens.

As a consequence of rapid urbanization, urban planning and landscape architecture level have gone through changes aiming at the conservation of biodiversity. Hence, urban sustainability is one of the most imperative and challenging tasks that humanity faces today, as cities are the main sources of major environmental problems, centers of economic and social development, and home to more than half of the world's population. The landscape ecology approach emphasizes the interrelationship between urban landscape patterns and ecological / socioeconomic processes (Wu, 2008) at different scales, as it is fundamental to encourage site-based research which integrates ecology into planning, design and other social sciences.

Due to the lack of sufficient space available and as an important part of the development of green areas in cities, the concepts of vertical gardens, green facades, roofs or garden terraces are innovative forms of urbanization (López-Rodríguez, et al., 2016). To reverse the trend of overconsumption, which compromises biological diversity in the medium and long term, and compromises the sustainability of the planet, there are aspects linked to the social responsibility (Santos, Murmura, & Bravi, 2018a). Design is a creative and innovative tool with a lot of knowledge that should meet the needs of people. It is fundamental to stimulate the designer's creativity, so that they can develop solutions and products capable of stimulating habits and a more responsible consumption of quality products (Santos & Millán, 2013) that respect the environment (Santos, Mendes, & Barbosa, 2011; Santos et al., 2014).

In this sense, design as an activity that projects goods and services, has a responsibility far beyond design, because it participates in the construction of spaces and environments, which can captivate people for their appropriation.

It is evident, therefore, that the design communicates with people, being able to alert and teach decisions about the consumption of products that promote healthier and eco-friendly habits.

In this sense, we are increasingly seeing the redesign of products for sustainability, with the use of more ecological materials, that is, biodegradable, recyclable and reusable.

Given the sustainability of the planet, there is now an increasing awareness of recycling and reuse.

Different Design for Sustainability (D f S) techniques have been found in the original literature that can help designers and managers (Arnette, Brewer, & Choal, 2014) through the design process and by contributing to future research.

The role of design in the development of sustainable products should take into account the Quality Management System (Santos & Barbosa, 2006; Marques et al.,2018) the Environmental Management System (Santos, et al., 2016; Rebelo et al., 2016) in the Individual or Integrated format, (Rebelo, Santos, & Silva, 2016; Ribeiro et al., 2017; Santos et al., 2017; Ferreira Rebelo, Silva, & Santos, 2017), as well as, the product life cycle (Bravi, Murmura, & Santos, 2017; Doiro et al., 2017) and market trends for a excellence in business (Santos, Murmura, & Bravi, 2018b; Santos, et al.,2018). The concern for the future is imposed by the haunted reality of the planet, which can see in design a salvation with the creation of new products that appeal to equity in the distribution of resources (Chiaradia & Pazmino, 2015).

At the urban level, wasted spaces have been object of concern by communities. Do It Yourself Urbanism and Tactical Urbanism are two of several labels of civic movements, aiming for short-term low-cost interventions in abandoned spaces, out of the scope of urban management authorities (Silva, 2016). In most of these cases, sustainability is also implicit, since communities use and reuse recycled materials.

The integration of natural materials into today's development of products gains more and more importance (Löwer et al., 2015). The Society's demand for environmentally-produced and sustainable goods is a key factor for scientists and material engineers to replace conventional substances such as metals or plastics. In addition, the entire lifecycle sets various requirements for product developers, involving reuse and recycling strategies. Most of these eco-design approaches are limited to selecting the right material and industrial processing to shape and manufacture the desired design. The goal is to minimize the conventional production steps and decrease the amount of resources for manufacturing.

Lately there has been a creation of products that contribute to the appropriation of spaces. Following a little of the ideologies proposed by several current designers, such as Werner

Aisslinger in (Figure 2) (Corboy, 2016), Francesco Codice (Codicè, 2016), among others. They have a vision of sustainability, creating design products in order to promote biodiversity.

**Figure 2.** Werner Aisslinger's 'house of wonder' envision the world of tomorrow (Corboy, 2016)

Francesco Codice presents a project designated Air Train, (Figure 3), (Codicè, 2016), which aims to improve the air quality and the natural beautification of the interior space of the carriage.

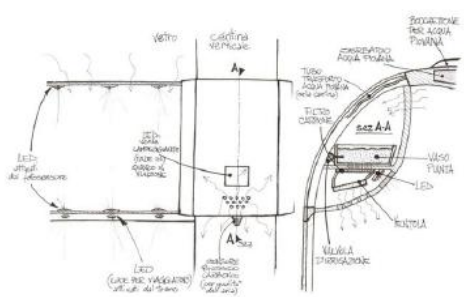

**Figure 3.** Air Train (Codicè, 2016)

The designer Benjamin Graindorge, (Figure 4), develops a floating garden on top of an aquarium which aims to use fish excrement to feed the garden and avoiding its maintenance (Graindorge, 2011).

**Figure 4.** Floating garden. (Graindorge, 2011)

In vertical urban gardens, we see a progressively professional creation developed by companies such as (Plantit, 2012), who developed their products, according to each need, as shown in (Figure 5), which show an innovative design and easy to assemble. (Plantit, 2012) privileges the dynamization of good environmental practices, namely the practices of organic farming, making the experience of this practice possible and bringing it closer to all people.


**Figure 5**. Products made by Plantit. (Plantit, 2012)

Populations are growing and cities too (Al-Chalabi, 2015) the concept of growing food indoors is evolving, and we have the vertical vegetable gardens as an example (Despommier, 2013), which has this name because the cultivation is done in a small area and in vertical layers. This concept is also associated with city farming and urban farming.

It is necessary to increase crop yields without increasing the area of land for crops. If we could get some of that from the countryside into the city and get some of that food production close to the high population concentrations, we could have a real impact.

Plants need lots of light for photosynthesis, and energy will be the biggest limiting factor for that. There are some examples of warehouses with vertical gardens that use

LED lights to make plants grow, but electricity will be necessary.

What will drive this technology (Davis, 2014) with it we can get enough light for the plants to grow (Figure 6) and recycle water and nutrients without the need to use soil more hydroponically. It is a clean way to control nutrients and water in a very efficient way. There are many opportunities for the biological control of pests and diseases.

**Figure 6**. Vertical farming overcomes a limited land area. (Davis, 2014)

Vertical farming is an industry with a lot of potential to change the way what we eat and how the quality of life can be improved. By economizing resources and producing local food, vertical farming can lighten many of the concerns that traditional agriculture faces. These products show how it is possible to make the appropriation of spaces to promote biodiversity and the production of vegetables towards improvement quality of life.

Aiming at this sustainability and preservation of biodiversity, it seems pertinent to make use of the wasted space at the housing level, as well as, the so-called transient places or "non-places" of Marc Augé (Augé, 1995). The theme "non-places" has been approached by several authors who have been dedicated to understanding the meaning attached to these same places, and which are proliferating everywhere due to phenomena such as, globalization in an increasingly modern society, but with a growing individualism. For Marc Augé (1995) "non-places" are transitory, non-historical, non-relational, non-identifiable spaces of people to space, that is, they are places of passage for some people and work for others, such as supermarkets, motorways, refugees, airports, etc. The author tries to understand what these places have in common to understand their proliferation in a world dominated by virtual reality (Augé, 1995).

## 3. Materials and method.

The study was developed as described by (Schwandt, 1994) "we invent concepts, models, and schemes to make sense of experience, and we continually test and modify these constructions in the light of new experience". Following this idea, the methodology used in this research has evolved with the exploration of the problem, being the main philosophical influence in the work, the belief that all knowledge is socially constructed.

For this reason, the methodology of this research obeys the five mentioned ideas, reminiscent of the relation between wasted spaces (appropriation), man (user), living space (local) and sustainable design in the production of biological products. For these purposes, the research begins by identifying transitory spaces at the level of a dwelling, collecting primary sources, such as visiting

horticultural gardens, questioning people, taking photographs, observing places where urban gardens are promoted, understand the use of space and the promotion of sustainable resources. It will also be part of this phase of the research the contact with companies related to outdoor furniture, collecting information on the best manufacturing processes and the characteristics of the materials. Data collection from another sources were carried out through research in works relevant to the area under study, mainly in the field of organic farming, sustainable development and product design.

In an initial phase of the project, we had the contribution of the people responsible for the urban gardens of Vila Nova de Famalicão in Portugal, gardens of Lipor and pedagogical gardens of Braga. With this information came the need to understand who practices this activity. A questionnaire was conducted, directed only to those who practiced urban agriculture in the vegetable gardens of Vila Nova de Famalicão, Lipor and Pedagogical Gardens of Braga. The sample was about 50 people. Information of survey was collected. They allowed us to gather information about their difficulties, the reasons and benefits of having an urban garden, as well as to understand the acceptance of new products that provide the practice of urban agriculture.

The product development method which was used is based on the recognition of a problem or question to be, which defines the scope of the problem. Before this definition, it is carried out a background investigation, i.e. a search of the state of the art to see the points that can be improved. If they do not exist, the research problem or issue will have to be revised, from a greater knowledge about the state of the art about the problem.

Following up the research, it is up to the researcher to define the problem, the concepts covered and goals to be achieved. To achieve the outlined objectives, the best way will be the spontaneous generation of ideas or sketches that can be improved or better suited to solve the problem. The selection of the concept allows us to identify the most promising one to solve the problem. In this way it is possible to build a prototype that can be tested, to see points of improvement, if it meets the outlined goals and if it can go into production.

This proposed methodology was adapted to the design of this product, allowing to identify the research question of the problem, and which path followed by the investigation.

In this way it was possible to generate a promising concept for the promotion of urban agriculture, which distinguishes itself from the competition and allows the users unique moments in his garden.

## 4. Results and discussion

The project consists of the development of a product that promotes a local biodiversity in the space of urban and dynamic gardens, allowing it to be somewhat vertical, as it fits the spaces of a dwelling, giving meaning and value to wasted places, taking advantage of the resources promoting the practice of agriculture and stimulating the production of horticultural foods of controlled origin. The results obtained from the survey were interesting, and progress was made to the next challenge, such as, taking the urban garden into the habitation.

In order to better understand the places where to install the product in a dwelling, it was fundamental to use works already carried out at the literature level and several studies on the transient places, in order to identify these spaces in the architecture.

It was selected at the level of family housing, a typical sustainable urban housing, with access to the garage and garden. These spaces (walls, terraces, access to garages and balconies) represent a housing area with potential to develop a new function, capable of bringing economic benefits, health, promotion of biodiversity and favoring the development of social ties. With the collection of this information at the level of spaces, it was pertinent to think of a design

for a product that fits the dwellings and the typology studied in this project respecting the requests and recommendations found in the questionnaires and interviews.

The information collected from the questionnaire showed that many people were willing to acquire equipment in which it would be possible to practice urban agriculture in their dwellings.

Given the possible stated requirements, which would be part of the product to enable the practice of urban agriculture in spaces that are destined to another function, the following expressions can be observed in table 1, according to the responses to the survey conducted on people, who have urban gardens.

**Table 1.** Concepts generated for a vertical vegetable garden. Source: Developed by author`s own method.

| | | |
|---|---|---|
| **- appropriation of walls**<br>**- framework with the housing** | - with composting plant<br>- do not look like a garden | - water collection<br>- humidity control |
| **- modular**<br>**- close to home** | - ensure the addition of organic compost<br>- drip irrigation systems | - horizontal<br>- dynamics |
| **- materials that do not affect the plants**<br>**- incorporated irrigation systems** | - vertical, but with solar exposure<br>- promote and facilitate pollination | - space for tools<br>- with plant information |
| **- controlled environment**<br>**- increased productivity** | - that allows resource savings<br>- resistant materials | - easy installation<br>- easy maintenance<br>- rotary system |
| **- enable recovery of natural resources**<br>**- do not waste humidity** | - facilitate the plantation and the harvest | - allows greater pest control<br>- be autonomous |
| **- to my measures**<br>**- nice** | - customized<br>- durability<br>- integration with nature | - adjustable to my availability<br>- automatic irrigation systems |
| **- possibility of interaction with information center**<br>**- vertical production** | - attractive<br>- ergonomic | - vertical<br>- vertical dynamics |
| **- provide single moments**<br>**- promote the enjoyment of cultivation**<br>**- relieve the stress** | - producing for my home needs | - that may include technologies<br>- well located |
| **- that can adjust to the spaces of my house**<br>**- that has a space for storage** | - run as a stove<br>- that allows to use a space that I do not have | - use hydroponic irrigation systems<br>- practical and easy<br>- clean |
| **- landless**<br>**- enable a biological agriculture** | - possibility of coexistence with the neighbors<br>- sharing | - that increases the space<br>- facilitate the production of various cultures |

With these initial requirements it was possible to develop a more comprehensive concept, such as product segmentation, technologies that could be associated for both irrigation control and information on each type of plant, in order to offer an improved range of this product. In the market study, it was possible to observe many gaps, manifested by urban agriculture professionals in the questionnaire, such as humidity control systems and

incorporated irrigation systems. The market for this product is a niche, with many similar products, but that do not satisfy the needs of some more demanding customers. Most of the materials used are treated pine wood and polymers or fabrics.

It is our intention that this product is beneficial to the production of vegetables and that it takes into account features that competition does not offer, such as humidity control, temperature, natural resource recovery and the use of wasted spaces.

Vertical gardens are spaces that have to be well controlled, in terms of humidity, drainage, soil height for the development of plant roots and their exposure to the sun because of the type of plant.

The irrigation system allows the controlled supply of water to the plants in sufficient quantity, being that when assured at the right time, and the necessary quantity, it allows a good productivity and the survival of the plants. The irrigation can be done by the crown of the plants or by the soil at the base of the plants.

In the case of urban gardens, it is recommended to water the soil only, to avoid pest development, and also, if possible, to do it at night to reduce the amount of evaporated water.

Drip irrigation was our option because this technique allows to conserve the environment and distribute water and nutrients evenly, with a high degree of utilization.

Data monitoring systems are being increasingly used in agriculture because they allow access to essential data such as temperature, organic matter levels, soil and atmospheric humidity. These data allow a better performance, which allows a reduction of costs associated with an increase in production. This monitoring system consists of several sensors that measure temperature, humidity and luminosity.

It began to form with the first drawing of a possible product to be created. All the models presented in this project are designed in a 3D format, with the support of the Solidworks program, which later facilitates the withdrawal of the drawings of the selected models for the final products.

For a dynamic garden, which allows a better use of space, with a larger production area, taking advantage of sunlight for all plants, the idea arises of a vegetable garden that had the possibility of horizontal and vertical production.

With the intention of making the most of natural resources and organic waste, it was pertinent to think of the creation of a deposit to store the rainwater to irrigate the garden, as well as to create a place where it would be possible to produce compost out of organic waste.

Many people claimed in the questionnaire that the lack of space in their housing was as a factor that prevented the practice of urban agriculture. In order to satisfy a greater number of people, aiming at a better appropriation of spaces, the idea is to adapt the equipment thought so far, pointing to the incorporation in the walls as a solution.

With these ideas, it is possible to develop a product that meets all the pretensions mentioned. Thus, it will be fundamental to study the type of urban vegetable gardens that best suits this aiming to achieve a high quality production with minimal production effort. In this way, the product to be designed was a dynamic vertical garden, as shown in (Figure 7).

This selection will allow the appropriation of spaces in horizontal and vertical and the introduction of technology that will allow a greater autonomy of the garden, meeting the greater number of concepts suggested in the questionnaire.

The selection of the technology to be applied to the equipment influences the choice of materials and the manufacturing process to be employed directly. As mentioned previously throughout this study, the technology (control systems, type of irrigation), when associated to the gardens, allows a higher production, a greater control over the pests.

For better efficiency of this product and pest control, the type of irrigation to be plunged will be drop by drop buried in the bibs, with the implementation of the Flower Power sensor, associated with a mechanical system to collect the vegetable garden.

With these systems it is possible to control the plant's needs and avoid moisture in the leaves and stems of plants, which is often responsible for the appearance of diseases in plants.

The selection of materials is an indispensable step, so the most accurate choice of material implies an analysis of the mechanical properties of each material that can be used in the construction of a garden, starting from the analysis of the materials that the competition uses, in order to produce.

The best combination of these factors will allow us to meet the wishes expressed, as well as ensure that the product presents good levels of quality.

**Figure 7**. Most promising models for space appropriation. (Developed by author`s own method)

In this way and for each material it is necessary to have an idea of the transversal area of each element that constitutes the equipment, as well as to establish the maximum number of shelves that can be safely placed in the equipment.

The materials and components to be applied in the equipment will be: treated wood, tank, submersible pumps, inverter motor, humidity and temperature meters.

With the purpose of adjusting the final model to be developed, with the pretensions expressed by the answers obtained in the questionnaire and the brainstorming, it was opportune to think of a model product capable of meeting all the demands of the collaborators.

On the other hand, the more complex product at the assembly level, shown in (Figure 8), shows a dynamic garden capable of favoring solar exposure, as well as greater protection against aggressive agents and greater control of all factors, such as temperature and humidity, which allows a high quality production.

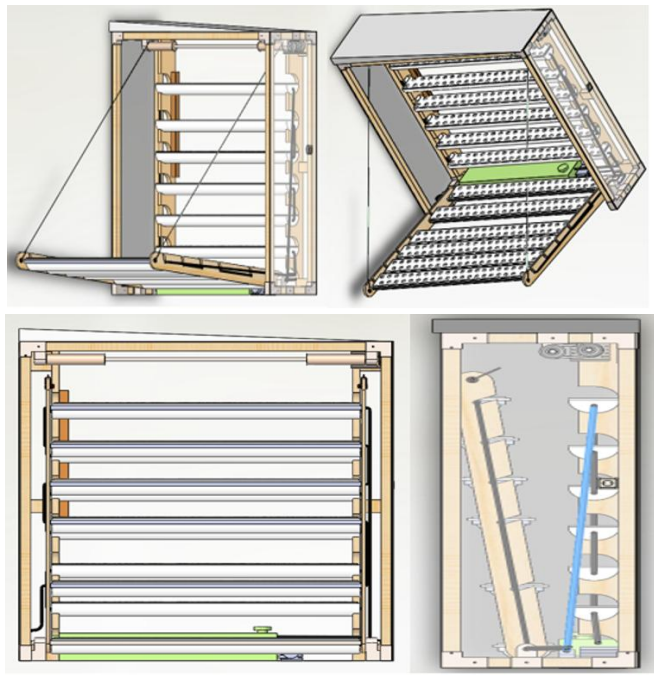

**Figure 8**. Dynamic vegetable garden. (Developed by author`s own method)

With this model, we understand that it will be possible to satisfy the desires expressed by urban agriculture practitioners.

With the elaborated renders we intend to make the concept behind the design of this product known. To insert the product into a work reality, the posters represented in (Figure 9) were drawn up, showing the product produced at scale, as well as the possible places of implementation.

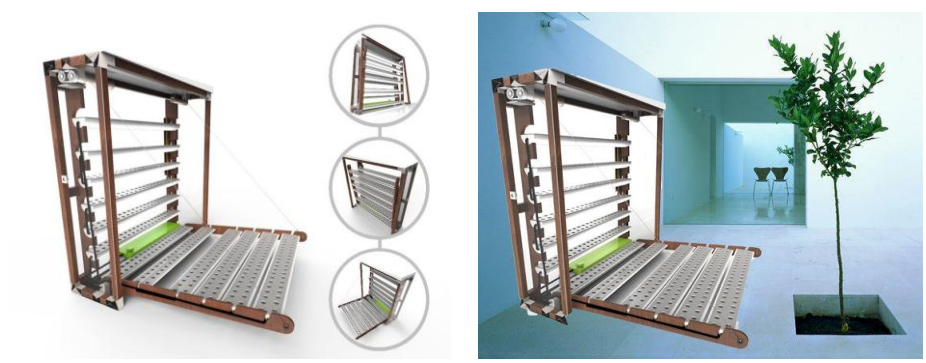

**Figure 9**. Product Posters. (Developed by author`s own method)

These simulations are important at the material level, as well as the most economical shape and profile for the development of a product. Thus, it is pertinent to show some simulations of sets of pieces that are part of the developed equipment, to understand possible future improvements. (Figure 10) shows the flower basket support assembly, with the application of the appropriate efforts, for which it was designed.

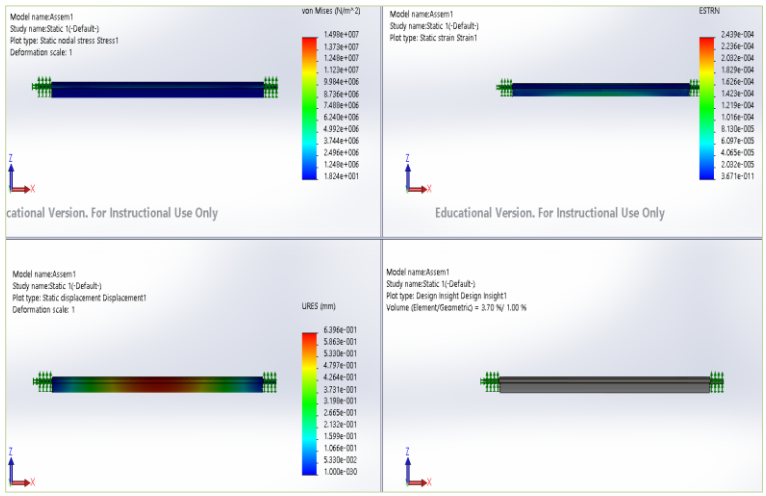


**Figure 10.** The flower basket support assembly (Developed by author`s own method)

(Figure 11), shows the efforts to which the equipment will be subject, which shows that the structure designed in wood withstands the efforts.

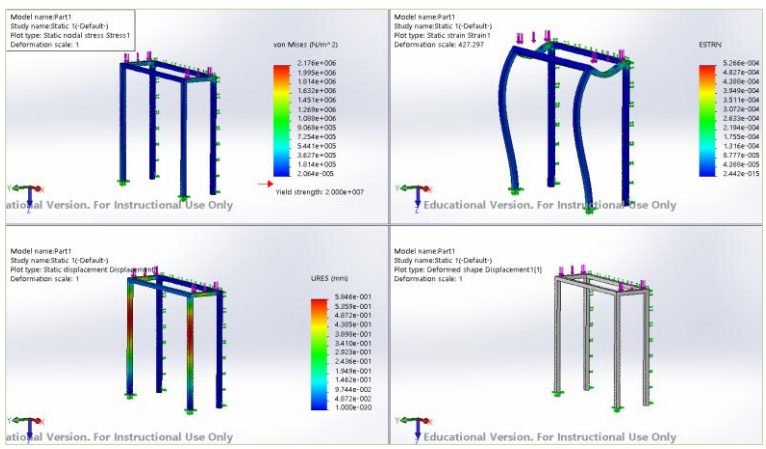


**Figure 11.** Simulation of the main structure in wood. (Developed by author`s own method)

Considering the static analysis of the structure, the chosen material will not collapse with the loads stipulated previously taking into account the respective coefficient of insurance. That is, this simulation reveals that the equipment will withstand the stresses it will be subjected to during its useful life, with an illustration of the possible fragile points of the equipment, which can be improved.

A way to reassess our initial intentions and try to understand the contribution that this project can make to the better occupation of housing spaces and the encouragement of better and environmentally friendly eating habits, it was our intention to see if it would be possible, within the family routines to contribute to a greater sustainability and protection of the planet, ensure the rational use of natural resources; contribute to the promotion of good eating habits by increasing the supply of vegetables to the urban population; take advantage of the wasted spaces in a dwelling through the

design of devices for the practice and cultivation of vertical gardens; study the best technologies to encourage the cultivation of vegetables was also a part of the research.

## 5. Conclusions.

The findings show that urban gardens have been implemented globally as part of the development strategy in cities, increasing the supply of horticultural foods, helping to meet the needs of the local market, and being a hobby for those who enjoy cultivating the land. For those who do not have access to urban gardens, a place not used for housing will be useful for growing vegetables or herbs, with the advantage of not requiring a large investment or maintenance time.

The objectives of this work were achieved with the development of a vertical, dynamic, fast to assemble, intuitive handling, low cost urban gardens category product which fits in several architectural typologies of a dwelling mainly in the occupation of the places such as access to garages, terraces and balconies. It is pertinent to think of offering solutions that are capable of profiting the wasted spaces of the vertical and horizontal living spaces, in a dynamic way, allowing a greater use of the natural resources and where it is possible to practice urban agriculture.

This product promotes the practice of healthy food and easy access to vegetables, which contributes to a greater sustainability of the planet and the stimulation foactivities that promote the physical and psychological well-being of the various elements of our society. In addition, it can contribute for collective engagement within members of communities, by learning gardening techniques, exchanging products developing these and other activities with impact also at the urban design level.

The association of technologies is important in this project of the garden, because it allows an increase in profitability and better control in the development of the plants, giving a greater autonomy to the garden, as it contains an irrigation system and a humidity, temperature, sun exposure and fertility of the soil control system, allowing to withdraw a greater benefit of production. In summary, analyzing the existing solutions in the market, as well as the ambitions expressed by the people questioned and that intervened in the investigation process, it all allowed to identify supply gaps.

The development of this equipment allows to improve the existing offer of products, that aim at the practice of an urban agriculture and to profit the occupation of the wasted spaces in a dwelling. For final product development and future improvements, material testing, reliability and usability of the equipment should be considered, eliminating possible gaps.

It will also be our intention to prepare a preventive maintenance plan according to the guarantees given by the suppliers. Afterwards it is our intention to make the product available to some users in order to contact the equipment and to register possible improvements, so that the contacts with the possible partner companies that are interested in commercializing the products can be developed.

Social advantages include improving family food security, reducing food waste and reusing unused space. For some applications, the necessary technologies are known, but have never been combined in this way before. This product will be seen as an innovative solution that has some potential, together with a population more and more aware and concerned about healthy eating habits. We have searched potential consumers and experts in Portugal for information on their preferences and acceptance of urban agriculture projects and products in particular in vertical urban gardens.

In conclusion, the results of our work suggest that urban vertical garden projects that are multifunctional and that combine ecological and social objectives can potentially reach the highest levels of social acceptance.

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