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ORNAMENTAL VEGETABLE GARDEN DESIGN POSSIBILITIES USING MODULAR RAISED BEDS

Ana-Maria-Roxana HANGAN, Mirela COJOCARIU, Doina-Mira DASCĂLU, Elena-Liliana CHELARIU and Vasile STOLERU*

Iasi University of Life Sciences, Faculty of Horticulture, Department of Horticultural Technologies, 3, Mihail Sadoveanu Alley,700490, Iasi, Romania; e-mail: roxanah@uaiasi.ro; mirelac@uaiasi.ro; doinamira@yahoo.com; julia@uaiasi.ro

*Correspondence: vstoleru@uaiasi.ro

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ABSTRACT. Ornamental vegetable gardens have many benefits. They are aesthetic, educational, ecological, economical, sanitary, and are a source of fresh food. Small allotments in urban and peri-urban areas do not allow the implementation of utilitarian gardens. Thus, ornamental vegetable gardens are the best choice. Raised beds can be used to enhance the decorative effect of the entire vegetable garden. This type of construction presents, in turn, several advantages both for the user and crop: reduced effort for maintenance work, early heating of the substrate, loose substrate, reduced volume of weeds, efficient use of space for plants, etc. Establishing ornamental vegetable gardens on raised beds is easily achieved using geometric modules, as they can be adapted to various designs. This paper presents several design options for a decorative vegetable garden on private properties. The case studies presented showed different methods of using modular raised beds depending on the property's area, the owner's wishes, and the desired area to be planted. Also, depending on the results obtained from the experimental batch, three other variations of modular layouts with different purposes were proposed: focal point, physically closed but visually open space, and relaxation space.

Keywords: edible landscape; vegetable garden; raised beds; design.

INTRODUCTION

Raised beds offer numerous benefits for gardening enthusiasts. For example, they allow for improved soil drainage, as excess water can quickly drain away from the plant's roots. Additionally, raised beds offer better control over the soil quality and nutrient content, leading to healthier plant growth and increased crop yields.

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Furthermore, they help to minimise the risk of soil-borne diseases and pests, which is particularly important in areas with poor soil quality or high levels of contamination. On the downside, raised beds can be more costly to set up initially and require more frequent watering than traditional gardens due to their tendency to dry out more quickly. Despite the potential drawbacks, raised beds offer a range of benefits that make them a practical and versatile option for both inexperienced and experienced gardeners alike (Santos and Wall, 2023; Hangan *et al.*, 2021).

The attractiveness and value of landscaped areas are generated by their ability to satisfy urban comfort and quality of life needs. The value of harmonious landscaping also resides in its educational effect because the design environment can help shape the inhabitants' aesthetic sense (Cojocariu *et al.*, 2022; Dascalu and Cojocariu, 2016).

Landscape design is a process of viewing and planning objects, systems, buildings, plans, etc., which are user-centred. To design a landscape, the designer must first know what is to be designed: a system, object, or garden. In other words, the design aims to create solutions for people with the help of physical objects or abstract systems or plans (Filor, 1994).

A simple way to design an object or, in the case of this research, an ornamental vegetable garden is by using modular raised beds (Deveza and Holmer, 2002). Modular design involves planning complex systems using blocks (modules) with the advantage that they can be combined in various ways to create a practical, versatile, and easy-to-maintain garden (Rizzo *et al.*, 2015). These modules can be easily repaired, replaced, or removed without affecting the overall design (Tseng *et al.*, 2018). They can be used on straight and sloping terrain (Hangan *et al.*, 2021).

Understanding the origins of garden design is crucial to exploring ornamental gardens' cultural and historical context. A study by Majid Amani-Beni *et al.* (2021) revealed that cultural and historical setting is significant in designing ornamental vegetable gardens, highlighting the potential for incorporating traditional elements and design principles from historical gardens to create visually appealing and culturally relevant urban edible gardens. Designers can use these findings to create attractive and practical ornamental vegetable gardens incorporating historical design elements.

Raised bed ornamental vegetable gardens are a common technique used in vegetable gardening and are a suitable option for those with limited outdoor space, such as private gardens, schools, and kindergartens, and can also serve as an educational tool for younger generations (Hangan *et al.*, 2021; Wells *et al.*, 2018; Graham *et al.*, 2005). This option offers many advantages including easy maintenance of plants, faster heating of the substrate in the spring, loose substrate, and the possibility to use most of the space intended for plants by using an intercropping system (Hangan *et al.*, 2020; Ramjan and Chanu, 2020; Deveza and Holmer, 2002).

The presence of heavy metals in urban soils due to human activities, especially road traffic, poses a significant risk to the health of both plants and humans. The accumulation of contaminants in soil, water, and air can

also affect the quality and healthiness of plants, which can have adverse effects on human health. Therefore, it is essential to consider factors such as pollution absorption capacity and potential sources of pollution when designing and implementing urban horticultural gardens (Oprea *et al.*, 2022; Hangan *et al.*, 2020; Timofeev *et al*., 2019; Vittori Antisari *et al*., 2013).

Stoleru *et al.* (2015) showed that using raised beds for vegetable cultivation in urban and peri-urban areas is a beneficial technique to mitigate the risk of contamination from heavy metals and pesticides that may have accumulated in the soil over time. In the research made by Whitzling *et al.* (2010), raised beds were used in urban community gardens to mitigate the risks of lead-contaminated soil and were particularly effective in reducing lead exposure by providing a barrier between the contaminated soil and the crops. Moreover, adding clean soil to the raised beds allowed for the cultivation of safe crops while minimising the risk of lead exposure.

Similarly, Paltseva *et al.* (2022) also suggested raised beds to reduce the risk of lead exposure in urban gardening. Their study found that raised beds could decrease the amount of lead uptake by plants, thus reducing the risk of lead exposure to gardeners and consumers.

It is crucial to design and plan a little urban vegetable garden since, in this way, the space allotted to it is used to its fullest potential to give enough production and beautification for a family's usage. To improve the aesthetic effect, flowering plant species are blended with aromatic, spice, and vegetable species in these gardens. Additionally, ornamental varieties of plants used for practical purposes are used (Hangan *et al.*, 2021).

This study aims to explore the design and implementation of ornamental vegetable gardens using modular raised beds. The study provides case studies of different design solutions for ornamental vegetable gardens and evaluates the feasibility of using SketchUp Pro (2022) 3D modelling software in designing the raised bed types. Finally, the study's results simulate a vegetable garden implemented in an experimental field. The paper seeks to guide garden enthusiasts, designers, and educators in creating practical and visually appealing ornamental vegetable gardens.

MATERIALS AND METHODS

The present study employed a documentary research approach to investigate various methods for designing and constructing raised vegetable beds. The case studies analysed in this research encompassed a range of design solutions for decorative vegetable gardens on raised beds intended to benefit private garden owners.

A feasibility study was conducted utilising SketchUp Pro (2022) 3D modelling software to examine the selection and design of raised bed types. The information gathered during this investigation was subsequently applied to simulate a vegetable garden, implemented in the experimental field of the "V. Adamachi" Farm from Iasi. Different types of ornamental vegetables

were planted, and their growth and development were monitored.

The materials used in this research included SketchUp 3D modelling software, soil, compost, raised bed kits, gardening tools such as trowels, spades, pruning shears, watering cans, gloves, and a camera for documentation purposes.

RESULTS AND DISCUSSION

Case studies

To create a decorative vegetable garden, rigorous documentation is essential before it is designed. At the first meeting with the client, it is recommended to ask as many questions as possible regarding their needs, preferences for colours and plants, the time available for maintaining the garden, the purpose of the garden, and the allocated budget. In addition, the pedo-climatic conditions of the area as well as the ecosystem of the property will be studied very carefully.

Figure 1 shows a design solution for an individual garden in which the client wanted an area with a lawn, a layout style with sinuous shapes, an extension of the terrace, a relaxation area, storage space, and a raised beds vegetable garden to provide decoration, to be a hobby area and a potential source of fresh food.

All client requirements were considered, and the vegetable garden was positioned in an area that benefitted from as much light as possible and protected from likely children's games.

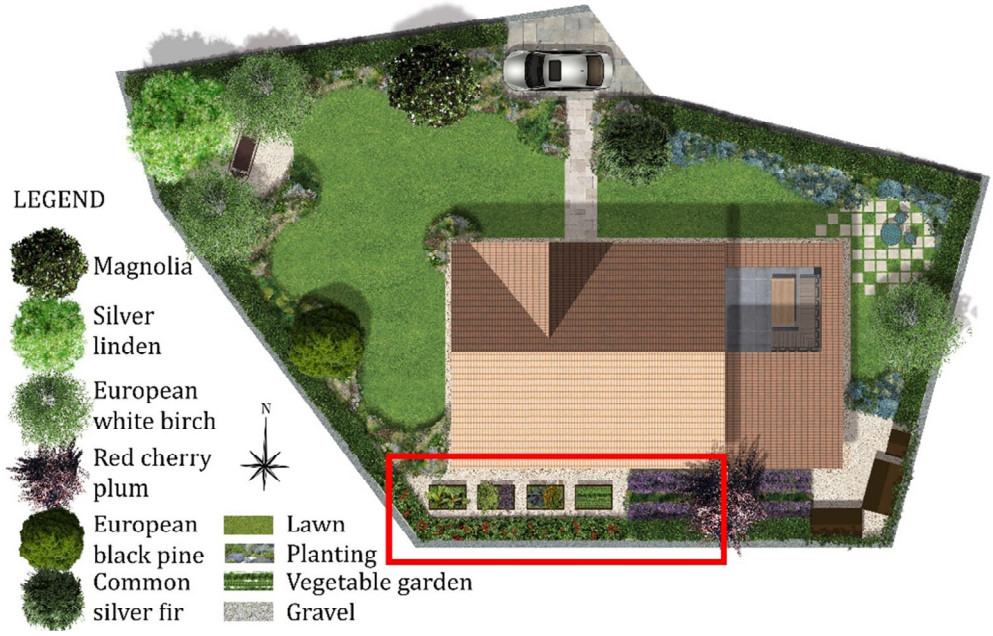

Figure 1 – Case study 1 Master plan

Figure 2 – Case study 1 Vegetable garden simulation

The material proposed for their construction was the autoclaved aerated concrete (AAC), durable over time. The recommended number of beds is four in order to apply the principle of crop rotation. The recommended height was at least 40 cm for easy plant maintenance. To be easily integrated into the entire design, the finishing material was proposed as that of the building.

Since the clients do not have much free time for careful maintenance of the vegetable garden, it was proposed that the surface of a module be 90 × 120 cm. *Figure 2* shows how to integrate these modular raised beds into the property using a simulation of an existing picture.

Figure 3 shows another option for designing an ornamental vegetable garden using modular raised beds.

In this case, the clients wanted a raised bed vegetable garden for easier maintenance and to give the feeling of an orderly space. Although the green area of the entire property is much smaller, the primary purpose of this vegetable garden is to offer fresh produce. The proposed surfaces for a square module were 100 × 100 cm, and for a rectangular module were 100 × 300 cm. The height of the modules was also 40 cm.

In *Figure 4*, the visual impact offered by the modular raised beds can be seen. The material proposed for their construction was wood (treated adequately against UV rays and weathering) to blend in with the overall planned design. Both the building and the desired annexes (gazebo, storage space, and play space) contain wood.

Figure 5 shows another way of designing a vegetable garden on a modular raised bed. In this situation, the clients wanted the vegetable garden only for relaxation. Thus, only two modules were proposed. The raised bed was positioned close to the house and the summer kitchen but in an area as sunny as possible. The submitted material for the construction was wood because it presented the lowest-cost solution.

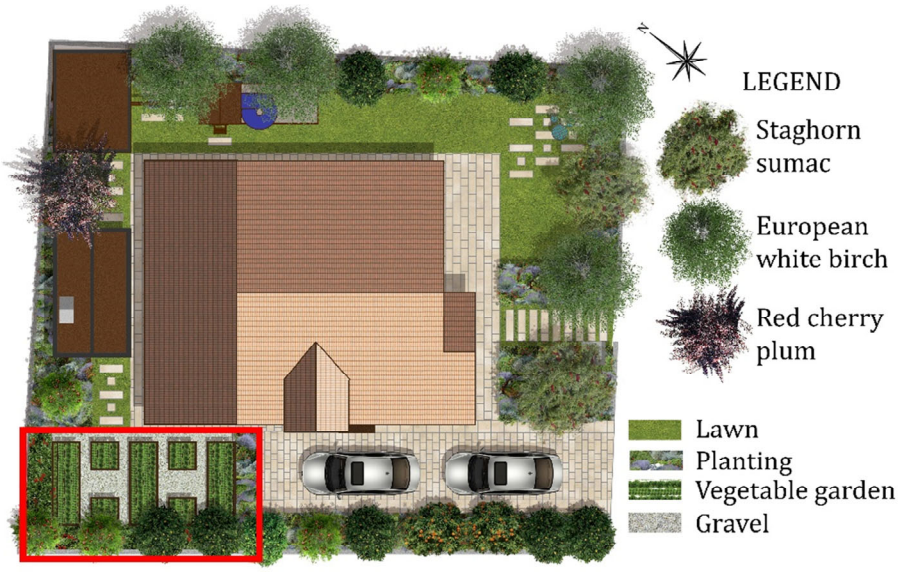

Figure 3 – Case study 2 Master plan

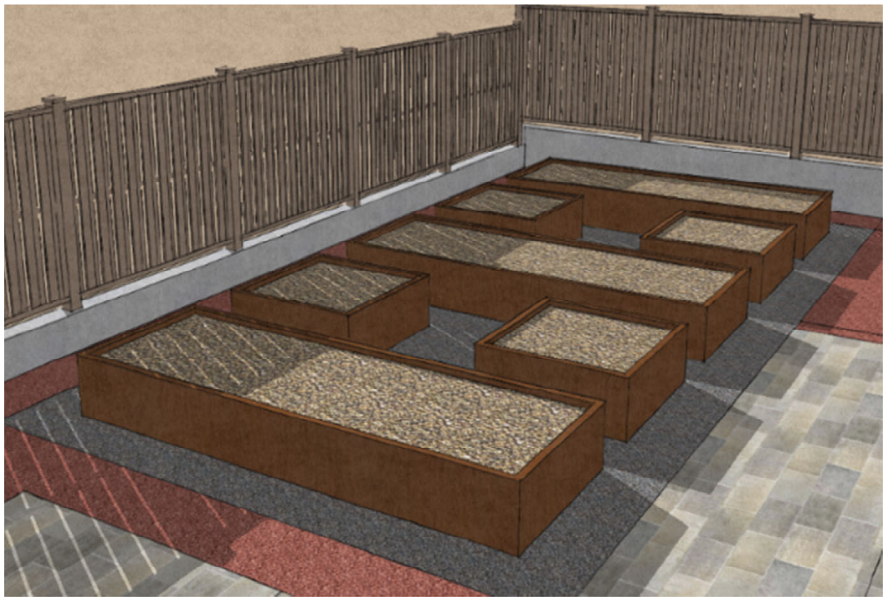

Figure 4 – Case study 2 Modular raised beds 3D simulation

With the terrain having a slight slope, the proposal of raised beds was the best solution because they are much more convenient to maintain, and the substrate from them does not risk being carried away by rainwater in the lower areas of the property. *Figure 6* shows a 3D simulation of the modular raised beds and how they are inserted into the overall design.

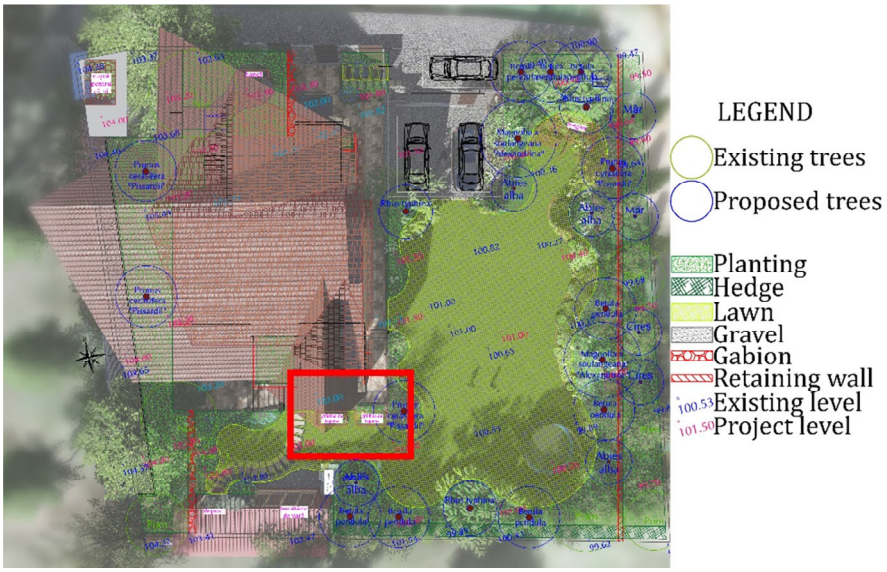

Figure 5 – Case study 3 Master plan

Figure 6 – Case study 3 Vegetable garden 3D simulation

Research design

The raised bed types and layouts were designed in the 3D modelling program SketchUp. Two shapes were designed, rectangular and L-shaped, and their dimensions are shown in *Figure 7*. The orientation and repetition of beds in the study plot was evaluated and a simulation was created in the experimental field, as seen in *Figure 8*. These shapes were positioned to create the garden shown in this research and

the design of the entire layout can be seen in *Figure 9*.

The modules are arranged symmetrically about an imaginary axis, with equal distances between them. Thus, secondary alleys were created between the modules to provide access to the side alleys, and a free space took shape in the centre of the arrangement, which can be used for relaxation purposes.

The research plot was divided into three experimental versions, each with the same plant species planted using the same design. V1 had 40 cm high raised beds, V2 had 20 cm tall raised beds, and V3 had ground-level beds. The crop technology applied was basic, with crop rotation used for ecological control of pests and diseases according to organic farming principles. The substrate used in V1 and V2 was a mixture of garden soil, peat moss, peat, and leaf compost, amended yearly with poultry manure. Due to its high organic matter content and pH of 6 - 6.5 the soil in the trial field was suitable for horticultural crops. The plants water needs were ensured by an automatic drip irrigation system.

The selection of plants was made with great care, considering their specific ecological needs, such as light, water, and soil requirements, as well as their decorative qualities, including their height, shape, and colour of leaves, flowers, and fruits. In addition, their ability to provide a decorative effect throughout the year was also considered. The plants that were ultimately chosen for the garden included a variety of vegetables, such as kale, chard, leek, cucumber, eggplant, tomato, sweet pepper, and herbs like parsley, basil, oregano, and mint. Additionally, decorative plants, such as French marigold, silver ragwort, fountain grass, butterfly bush, Russian sage, New York aster, lavender, rosemary, lamb's ear, and woodland sage were also included (Hangan *et al.*, 2021).

In general, the three versions of the experiment showed significant differences in average yield, with the V1 version (40 cm raised bed) producing 41.04% of the average yield. The average yield results for V2 (20 cm raised bed) and V3 (at ground-level) varied depending on the plant species, with a percentage of 30.52 % and 28.44%, respectively. V1 generally produced good yields for most species, specifically for *Solanaceae* species and kale. Leeks had higher yields in V2, and celeriac and peppermint had better results in V3 due to the high moisture content (Hangan *et al.*, 2021).

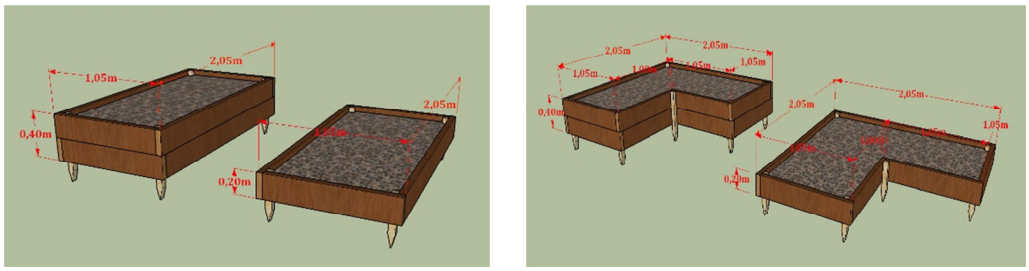

Figure 7 – 3D modelling of rectangular and L-shaped beds for V1 and V2 variants

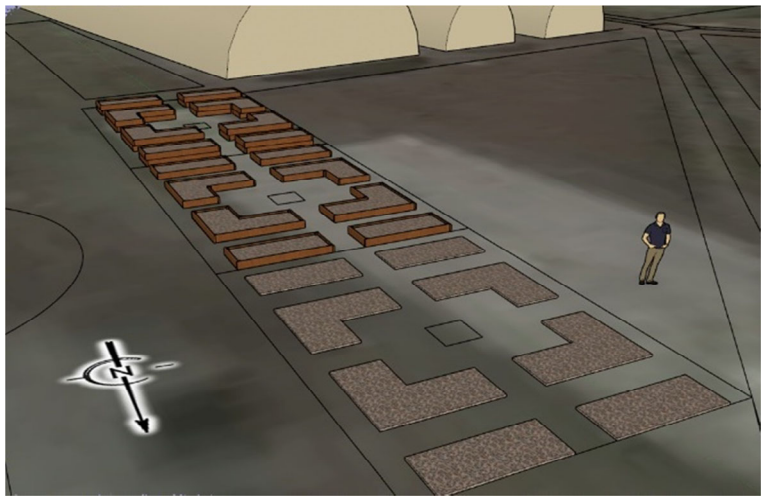

Figure 8 – 3D simulation of experimental variants in the experimental field

Figure 9 – Aerial view of experimental variants

Approach possible designs

Based on the research design, three possible layouts were developed using the same number of modules (four rectangular and four L-shaped), thereby allowing for the principle of crop rotation.

In *Figure 10*, a geometric design in an informal style was proposed. Plant compositions of decorative shrubs were proposed, and a point of interest was considered at the design's centre. In their research, Khalilnezhad and Tobias (2016) explore the productive landscape features of Persian gardens, which have been traditionally used for agricultural purposes in addition to their ornamental value. One of the critical features of these gardens is the central water feature, which provides a focal point for the garden and helped irrigate the surrounding vegetation. This design element can be adapted to modern urban edible gardens by incorporating a water

feature in the centre of a modular raised bed system. This would add an aesthetic element to the garden and provide a practical solution for irrigation, especially in areas with limited water resources.

Another way of positioning the modules is proposed in *Figure 11*. They form a closed space to give the feeling of a room without interrupting the field of vision. The access to this garden is through an archway that can be covered with vegetable species that need support: bean, tomato, pepper, or even pumpkin. Opposite the entrance, in the background, fruit trees are proposed to accentuate the view and the desire to enter this vegetable garden.

A design and beautification model of the outdoor dining area has been proposed in *Figure 12*.

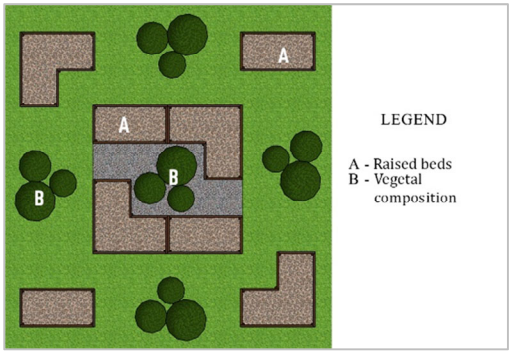

Figure 10 – Design proposal: focal point

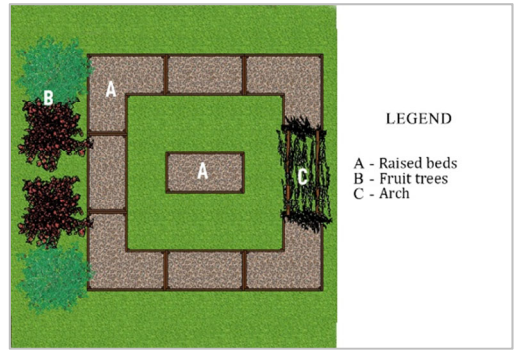

Figure 11 – Design proposal: physically closed space but visually open

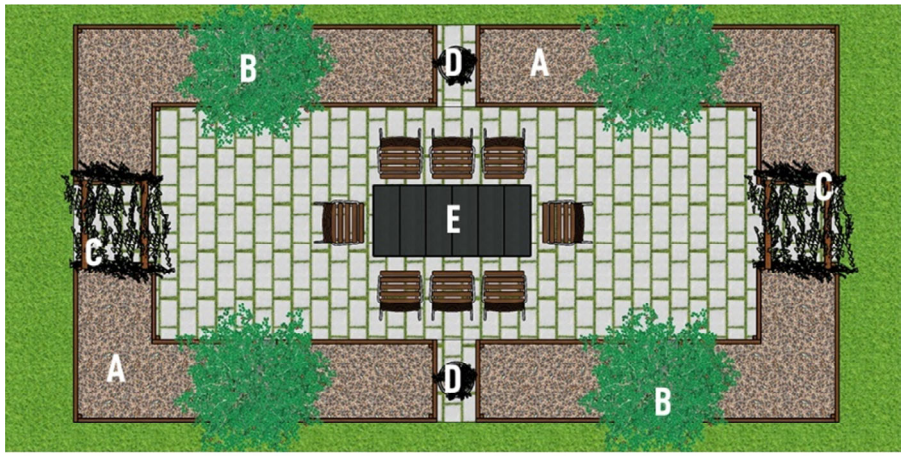

Figure 12 – Design proposal: dining and relaxation area

Delimitation of the terrace was achieved by using modules. Access to this terrace is through two points highlighted with arches that can be covered with vegetable species. On the sides of this terrace, fruit trees were proposed to provide vertical decoration and other species of decorative plants suitable for pots. The primary purpose was to create an intimate, pleasant, functional, and comfortable area for spending time outdoors.

In recent years, there has been a growing interest in urban gardening, with more and more people looking to incorporate green spaces into their homes and communities. With the increasing demand for urban agriculture, it is important to explore various design techniques and principles to help make the most of limited space while providing an attractive and productive garden. One popular gardening method is modular raised beds, which offer numerous benefits such as easy maintenance, efficient use of space, and versatility in design. By incorporating principles from different gardening styles, such as Persian and other historic gardens, designers can create unique and visually appealing spaces that serve practical purposes (Khalilnezhad, 2017).

The use of modular raised beds in ornamental vegetable garden design presents several advantages for both the user and crop, including reduced effort for maintenance work, early heating of the substrate, loose substrate, reduced volume of weeds, efficient use of space for plants, and a decorative effect. The case studies show that this gardening method can quickly adapt to various designs. Additionally, using raised beds can address concerns about urban soil contamination and lead exposure, as highlighted in the studies by Whitzling *et al.* (2010) and Paltseva *et al.* (2022). Another study demonstrates that modular raised beds are viable for ornamental vegetable garden design, providing sustainable, aesthetic, and productive use of urban and peri-urban spaces. Further research can explore the feasibility and scalability of this method for large-scale urban agriculture initiatives (Thomaier *et al.*, 2015).

CONCLUSIONS

This research investigated various methods for designing and constructing raised vegetable beds for decorative gardens. The feasibility study utilising SketchUp 3D modelling software helped to examine the selection and design of raised bed types, which were subsequently applied to simulate a vegetable garden in the experimental field. The case studies analysed in this research presented different design solutions for private garden owners, considering their needs, preferences, and available resources.

This study showed that modular raised beds are an efficient and versatile solution for designing a vegetable garden in a decorative style, with easy maintenance and fresh produce. The proposed materials for their construction varied from AAC to wood, depending on the available budget and aesthetic preferences.

Furthermore, the experimental results showed that the height of the raised beds significantly affected the growth and development of vegetable

plants. The 40 cm high raised beds produced the highest yields, while the 20 cm high raised beds and the ground-level produced higher yields for plant species with high water demand.

Overall, this research contributes to designing and implementing decorative vegetable gardens on raised beds, providing helpful information for garden owners and horticulture practitioners. Three-dimensional modelling software and experimental field tests can help optimise the design and performance of raised vegetable beds, leading to sustainable and healthy food production in urban areas.

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