

VERNACULAR ARTIFACTS FOR PLANT CULTIVATION: A SUSTAINABLE DESIGN

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ABSTRACT

Purpose: this paper aims to present vernacular artifacts produced to aid the domestic cultivation of plants and discuss its sustainability.

Methodology: research using the digital universe to gather market and vernacular products for cultivation and field research through visits to the residences of people who practice some type of planting with the same objective.

Research Limitation/implication: compare the product research with bibliographic research with references from social design, co-creation, sustainability, and innovation, used to support the proposal to compare homemade products with market analogs (if any) presenting as many possible justifications for the consumer's decisions to create their own products instead of buying them, representing a potential opportunity for design.

Results: the creation of vernacular artifacts is independent of design quality projects. Most likely they will always exist, as interests go beyond those related to the need for a specific product. But for the designer, observing these initiatives is a way of understanding the users desires.

Originality/Value of paper: presentation of sustainability precepts and the reuse of materials and products from the perspective of sustainable design, also the potentialities for working in this field.

KEYWORD: product design, domestic cultivation, vernacular artifacts, plants, urban context.

ARTEFATOS VERNACULARES PARA CULTIVO DE PLANTAS: UM DESIGN SUSTENTÁVEL

RESUMO

Objetivo: o presente artigo mostra artefatos vernaculares produzidos para auxiliar o cultivo doméstico de plantas e discute os aspectos de sustentabilidade desta ação.

Metodologia: foi feito levantamento pelo universo digital para reunir produtos de mercado e artefatos vernaculares de cultivo e pesquisa de campo com visitas a residências de pessoas que praticam algum tipo de plantio, com o mesmo objetivo.

Limitações: comparação dos produtos levantados com referências do design social, cocriação, sustentabilidade e inovação para embasar a proposta de comparar produtos caseiros com os análogos de mercado (quando há) apresentando tanto possíveis justificativas para a decisão do consumidor em criar os próprios produtos em vez de comprá-los, representando uma oportunidade potencial para o design.

Resultados: a criação de artefatos vernaculares independe da qualidade de design nos projetos. Muito provavelmente sempre existirão, pois os interesses vão além daqueles relacionados à necessidade de um produto específico. Mas para o designer, observar essas iniciativas é uma forma de entender os desejos dos usuários.

Originalidade: apresentação de preceitos da sustentabilidade e o reuso de materiais e produtos pelo viés do design sustentável e as potencialidades de atuação neste universo.

PALAVRAS-CHAVE: design de produto, cultivo doméstico, artefatos vernaculares, plantas, contexto urbano.

1. INTRODUCTION

The domestic cultivation of plants is a frequent activity in residences in urban centers (Chalmin-Pui et al., 2021; Gyurkovich & Gyurkovich, 2021; González-Ball et al., 2022). In contrast, even living in reduced spaces with little natural light and also having arduous work routines, people and families continue to cultivate plants in their domestic environments. At the same time that societies develop, homes diminish and become expensively priced (Park, 2017). Despite this paradox of urban centers, cultivation activities persists. Given that, there are several obstacles to the cultivation, many of those who practice this activity create strategies so the insertion of plants in their residential environments becomes an easier, practical, and pleasurable activity, or even instructive, with specific aesthetics.

Despite the ample work of architects, designers, and decorators planning and developing products and residential interior atmospheres, there are people without academic education in these areas who choose to create their products applied to plants. “There are social environments in which the access of these goods can not be possible for various reasons. There, the spontaneous practices of self-production and consumption of material goods are contextualized [...]” (Riul et al., 2015). Design by Non-Designers (DND) (Ibarra & Ribeiro, 2014; Liedtka et al., 2017; Hernandez et al., 2021) is the term that refers to the development of material solutions that are unrelated to the academy, that is, artifacts that are produced and designed by people who do not have formal knowledge in the field of product design.

The term DND is related to the trend of the *Do It Yourself* (DIY), the practice of self-production that has been gaining strength among users around the world (Sarpong et al., 2020; Roßmann et al., 2021; Hernandez et al., 2021). Nunes (2010) also relates this type of production to a sustainability bias by bringing greater awareness to the use of artifacts regardless of the reason that generates the individual conception, which can be financial, functional, or seeking certain independence from the market. In DIY “the experience of consumption makes room for a user experience, desire is transformed into affectivity, the object and the way we use it gain meaning in the natural cycle of life” (Nunes, 2010, p. 45).

An assortment of homemade solutions is available for plant maintenance. At first, these resources may seem impromptu, with low durability and no adequacy to the domestic environment, but this will depend on each cultivator and the function the product is intended for. Its sustainability bias occurs through the idea of reusing materials, having their time of use extended, thus delaying the disposal of products that gain new appearance or materials that obtain new functions. It is also essential to evidence the social significance of self-production activities, which can contribute to generating income or be a therapeutic activity.

The Maker culture is an important topical aspect of society as it is currently considered an attitude. Self-production has the potential to generate conscious consumption, with a certain autonomy from those serial products available on the market. The one who produces becomes aware of the production costs, thus prolonging the use of their creations, being an important factor for sustainability (Franzato & Celaschi, 2017).

Cultivation activities are important because since the beginning of 2020, Brazil, like almost the whole world, practices social isolation due to the pandemic caused by SARS-CoV-2. According to the philosopher Slavoj Žižek, the pandemic has confronted two different sides of society. The first of those who deal with extreme exhaustion, such as healthcare professionals and caregivers. Second, people dealing with tediousness, due to confinement (Žižek, 2020).

One of the results of confinement was some alterations in the habits and routines of families, which can lead to several changes in mental health among the population of all ages (Reis et al., 2020). “This time we are the ones in the cage” (Dohmann, 2020). Access to green areas, such as parks and squares, was limited and could seriously worsen the physical and mental health of those who were away from any contact with nature at that moment (Reis et al., 2020). From this position,

the residence and the objects inserted in it are now part, almost uninterruptedly, of the everyday experiences. It is important to emphasize that one of the conditions for satisfaction with the residential environment is the presence of internal components (products) that allow residents to accomplish their activities (Pezzini et al., 2018).

The quarantine intensified the demand for cultivation activities, as shown in several news reports about the subject. Sillva (2020) and Inouye (2022) also calls this increase in demand for plants during quarantine as “green wave”, by giving examples of people who turned their homes into urban jungles during social isolation, as a way of having a daily activity, while compensating at home for the lack of contact with green areas.

Own production of artifacts unites the opportunity to use the free time with a purpose. Both the time spent on the production of the artifact and the use of the artifact itself, can bring satisfaction and learning to the producer. If the focus of the design is to serve the user, observing the DIY proposals as a way of understanding habits and preferences can bring opportunities to the area. The present paper investigates the vernacular products for plant cultivation manufacturing, through an imagery survey and interviews with the purpose to describe users habits presenting potential opportunities to the design field.

2. METHOD

This paper is part of doctoral research in design about cultivation activities in residential spaces in urban areas and design performances in this context. The study focuses on the presence of vernacular devices that are inserted in domestic environments to help the contact of the inhabitants with their plants. The question that this work seeks to understand is: “why do people create their own cultivation devices?” and “Is this a sustainable creation?”. After all, there is a wide range of products available in the market at affordable prices. This study reinforces the design proposal for sustainability and social innovation presented by Franzato & Celaschi (2017, p. 101) which says that the idea of proposals in this area should strengthen “a new idea of well-being widely shared by society”.

This work is exploratory and qualitative research, which uses the bibliographic method for the collection of data. News about plants cultivation during the pandemic, books, and academic works that address topics such as design, sustainability, and plant cultivation were selected, in addition to the search for practical self-production initiatives for the cultivation of plants in search websites. The references were schematized according to their theme and origin in Table 1.

Table 1: *Study References*. Source: the authors (2022).

Reference source type	Reference	Theme
Books	Zizek, 2020	Life in pandemic
	Park, 2017	Architecture
	Leite, 2009	Design and economy
Academic papers	Chalmin-Pui et al, 2021 González-Ball et al, 2022	Gardening
	Dohmann, 2020	Life in pandemic
	Gyurkovich; Gyurkovich, 2021 Pezzini; Schulenburg; Ely, 2018	Habitations
	Bloder; Jäger, 2021 Franzato & Celaschi, 2017 Inouye, 2022	Sustainability
	Rei; Reis; Nascimento, 2020	Cultivation in pandemic
	Hernandez, 2021 Ibarra; Ribeiro, 2014 Liedtka; Salzman; Azer, 2017	Design by Non Designers
	Riul et al, 2015	Spontaneous design
	Sanders; Stappers, 2008	Co creation
	Lepre; Santos, 2008	Sustainability
	Benatti et al., 2014	Customization
Reportage	Sillva, 2020	Cultivation in pandemic
Academic work and papers	Nunes, 2010 Roßmann et al., 2021 Sarpong et al, 2020	Do It Yourself

The second stage is focused on searches for vernacular products for cultivation. To attain the results, the term DIY plants was searched, which generated approximately 77,900,000 results, in a search carried out on google.com, on 23/09/2020. “The pandemic accelerated many years the transition from physical to electronic retail, forcing online consumer experiences” (Dohmann, 2020, p. 2). Diverse experiences that also focus on consumption, not specifically retail, including proposals for own production were also intensified.

Visits were made to twelve residences in the cities of Juiz de Fora and Belo Horizonte, in the state of Minas Gerais/Brazil to record forms of cultivation, thus completing the survey of vernacular resources used in the activity. The research method was approved by the Research Ethics Committee of the University of the State of Minas Gerais on July 17, 2018.

For analysis, the proposals that help the cultivation were registered as being grouped by the similarities of functions. Then, analogous products from market were sought for comparison. The final stage consisted of analyzing the data and writing the paper.

3. VERNACULAR ARTIFACTS FOR CULTIVATION

In a survey made by Ibarra and Ribeiro (2014), vernacular artifacts are developed for five reasons: the cultural representation of a locality, the lack of resources that encourages creativity, the contribution to sustainability, the new uses that users give to industrial artifacts and the contribution

to the academy. From these areas, the DIY proposals found on the internet that relate to the cultivation of plants indoors were concentrated.

3.1 Cultural Representations

This item includes artifacts whose creations have a specific aesthetic function. “Plants are cultivated for their desired aesthetic and/or sensory characteristics” (Reis et al., 2020), so their containers also follow these characteristics. It concentrates artifacts such as vases that have their visual created to decorate or compose the surroundings (figure 1). “Customization makes it possible to improve satisfaction with the use of the product or service, since it will have been built to adapt to your profile, fulfilling your needs, both functional and emotional” (Benatti et al., 2014).



Figure 1. Decorated vases. Source: left – Mari Oliveira in roteirobaby.com.br (01/202014), center – www.casapraticaaqualita.com.br/noticia/5-maneiras-de-reaproveitar-a-garrafa-pet-no-seu-dia-a-dia_a697/1 (09/23/2020), right – Auana Sonsin in depoisdosquinze.com (09/10/2015).

The representations show vases with figurative faces for the inclusion of children into cultivation activities, as well as customization with lace (on the right) so that the artifact attains a specific aesthetic profile, for example, the revitalization of something old. In several proposals available for itself the vase production, issues related to the decorative aspects of the products are widely addressed. As much as simple surface changes, such as painting, for example, do not modify the way of cultivation, they can allow strategies for different contexts of use.

“Design is an important agent in the product customization process since its tools highlight the importance of inserting the user in the process of the product thinking and in the promises that will be delivered by companies” (Benatti et al., 2014). Therefore, companies allow customization according to customer needs or show diversified possibilities for selection.

It is important to highlight the wide range of suggestions for DIY products with proposals for the inclusion of children in cultivating activities. This point is important because bringing children closer to plants can help to create environmental awareness since the first years of life.

Decorated vases, whether with a children's theme, figurative, or with textures, colors and images are widely offered in the market, but few are effectively customizable by the users. Figure 2 (left) shows an example in which personalizing the artifact is done through the selection of the photograph to be inserted, as well as the plant species. On the right is a ceramic vase sold with a pen for differentiation. This last proposal was found in one of the house visits. It is interesting to note that the user of the product liked the typography made for the basil plant planted there so much, that even after changing the plant species, kept the initial design.



Figure 2. Left: picture frame with vase. Source: loja.imaginarium.com.br/porta-retrato-com-vaso-amor-que-cresce (06/14/2020). Right: crockery vase for drawing. Source: authors collection (2021).

In addition to the decorative representations, the products can promote the meeting of people who exchange gifts for example. Reis, Reis, and Nascimento (2020) pointed out that the interaction between humans and plants helps to build stability through contact with nature, mediating relationships with other people, and building the aesthetics of environments.

3.2 Lack of resources

Fits here creations that solves common problems in cultivation. In particular, suggestions were found for the production of systems that allow irrigating plants without the need for direct action by the user. For the practice of gardening at home, it is important to consider several aspects, mainly providing conditions for the development of the species in question (Reis; Reis & Nascimento, 2020). Therefore, these systems are often used in cases such as travels, in which the residents will not be able to water the plants, so they continue their development, even without watering. “The various ways of materializing a solution to a problem establish differences and mark identities” (Ibarra & Ribeiro, 2014, p. 10).

There are alternatives for plant hydration using the passage of water from a container to the earth through porous materials, which allows the water to flow by capillarity. As capillarity is a physical property of water due to its structure and surface tension, this type of system allows it to follow a specific path even against the force of gravity. There are systems, for example, that uses fabrics to connect the land to a water reservoir (figure 3).

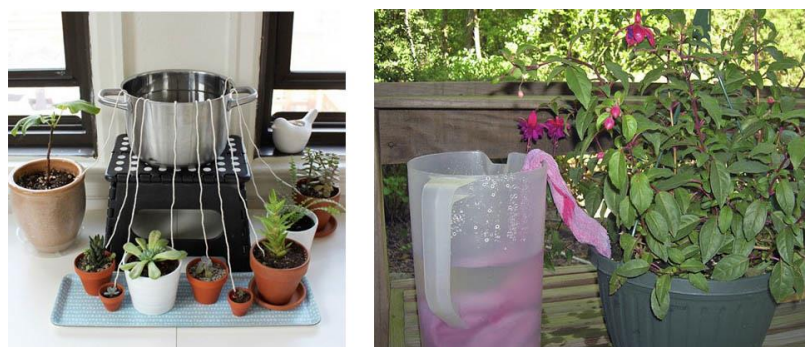


Figure 3. Watering strategies using string (left) and towel (right). Source: dcoracao.com (01/05/2016).

It was observed, in one of the visited houses, the use of a laboratory pipette (figure 4) to slowly hydrate a plant. The pipette, a work tool used by the residents, was the resource found to irrigate the plant over a few days, thus making it possible to be away for trips.



Figure 4. Product reuse for slow irrigation. Source: authors collection (2021).

Self-watering pots, also known as self-irrigating, such as those shown in figure 5, are systems that resolve the problem of standing water accumulated in the dishes that collect the excess liquid from common vases. These products are built for maintaining a passage through lining, fabric, or textile geomembrane for capillarity of water positioned below the vase, in a closed system. It is popular to reuse PET bottles for this type of construction.



Figure 5. Homemade product with PET bottles (left) and self-watering market vase (right). Source: left – Bianca Alvarenga in vivadecoora.com.br (09/04/2017). Right – plantei.com.br (09/23/2020).

It is also mentioned that cultivation with the use of pots is a low cost alternative that also has the flexibility to move around the environment (Reis; Reis; Nascimento, 2020). This movement allows the use of the aforementioned strategies. The figure 5 shows a self-watering pot available for purchase in the market. It proposes to work in the same way as using the PET bottle. Conversely, in the previous example, customization is hardly offered by companies. In this scenario, the commercial proposal for a self-watering pot is similar to the proposal for self-production, with the main value attributed to this scenario (besides possible customization) being the low cost.

The appeal of the economic aspect in this case allows the user to have a much larger amount of pots with plants than investing in new products.

“The artisan production of artifacts is related to the human need to facilitate the performance of everyday tasks” (Riul et al. 2015, p. 63). The decorative issue also joins the functions of vernacular products, there are ways of simplifying industrial products so that an idea is transposed to products made by hand and with accessible materials.

3.3 Sustainability

“In the orthodox view of what Design is, the sustainable design presents itself as a paradox to the final results of the Designer's professional activity” (Lepre & Santos, 2008). If the creation of new products no longer fits a vision of sustainable design, the reuse of products can be an interesting strategy to delay its disposal.

Many of the DIY proposals concerning growing plants involve the reuse of products, with a special focus on the use of PET bottles. Despite being a material that can be considered in wide demand for recycling, according to the PET Recycling Census in Brazil, in 2015, the material recycling rate was 51% (ABIPET, 2016). Even with its widespread use, effective recycling still does not approach its totality in use.

In this reuse, there are alternatives whose goal is the gradual release of water to the plant, however, applying it directly to the soil, without the use of tissues as presented above. Unlike capillary systems, in the gradual release of water, there is no passage through a porous material, but direct dripping into the earth, thus relying on the action of gravity. The figure 6 presents three alternatives for the reuse of materials. The first one is burying a PET bottle with holes in the ground, and the second alternative is to use the application of a bottle with a hole in the lid positioned inverted in the vase.



Figure 6. DIY alternatives for gradual watering. Source: left – www.dcoracao.com/2015/09/como-molhar-as-plantas-quando-voce.html (09/24/2020). Right – www.youtube.com/watch?reload=9&v=6zaATfT_euw (09/24/2020).

For this type of gradual release of water, there are market drippers (figure 7). It is interesting to note that, in the same way as the aforementioned vernacular artifacts, the reuse of bottles is also necessary for the use of the product. It can be considered a facilitator to structure and determine the drip velocity.



Figure 7. Dripper. Source: isla.com.br/produto/gotejador-rega-facil/6721 (09/24/2020).

After all, is the reuse of plastic bottles a sustainable option? PET is a recyclable material and in turn, could become new market bottles again, would not the removal of its consumption cycle bring the need to use more raw material?

Sustainability issues rarely have a simple answer, and sometimes the lack of knowledge and resources makes coherent proposals difficult. The concept of sustainability has several biases: “In the modern vision of sustainable design, the focus remains on full customer satisfaction” (Lepre & Santos, 2008).

The reuse of a plastic bottle can delay its disposal, but if during its use the material is contaminated, cut, painted, etc., even if discarded correctly, it will hardly return to a cycle. However, even if the bottle is disposed correctly, it may still not be directed to recycling, after all, many industries are not responsible for the collection of their products, and in several cities, there is no redirection of urban waste. There is no way to determine, in this situation, a simple solution to a complex problem.

The reuse of products, in addition to being an alternative that can generate savings and creativity, is directly linked to the sustainable aspects of cultivation activities, by delaying the disposal of materials, but in the visits made, products that supported themselves in this aspect were not observed. Even if the cultivation activity itself is a way of expanding the proper use of nature, in general, the products involved do not have a low environmental impact, with wide use of plastic for example.

Avoiding the plastic material, in the visits to the residences, it was observed both people using miniature tools to care for the soil in their pots, the use of the traditional watering can (also on a small scale) and the spray, as well as the use of instruments from the house itself as milk jugs, bottles, and cups to water the plants. In general, the reuse of products to serve as vases was observed, both as a way to reduce expenses and even as a decorative strategy (image 8). Bottles and crockery can be used as a cheap and unusual way to contain plants, or pots considered beautiful also help in the decoration of the environment. One of the interviewees reported having used a planned piece of furniture that was discarded by a neighbor to support the plants on her balcony.



Figure 8. Examples of product reuse for cultivation. Source: authors collection (2021).

Concepts related to sustainability are still confusing (Lepre & Santos, 2008) and the lack of knowledge generates more difficulty for the general public to have sustainable actions. Regardless of its sustainability (or not), the numerous proposals for the reuse of plastic bottles shows that users understands this action as positive concerning its sustainable aspect. It is therefore worth emphasizing point of view of Franzato & Celaschi (2017), that following simple rules of

sustainability (reduce, reuse, recycle), without profound changes in consumer behavior, makes products more sustainable but not effectively sustainable.

3.4 New use

A relevant part of DIY proposals involving plants is the reuse of products that would be discarded. The products can simply be transported for a new use or undergo through alterations that improve their new function or appearance (figure 9), thus conquering a new space in the residential environment and meaning for the user.



Figure 9: product reuse for plant cultivation. Source: casinhaarrumada.com/2015/08/diy-20-vasos-de-flores-feitos-com-materiais-reciclad.html (10/05/2020).

For Nunes (2010) the designer still does not fully insert the user in the project, so it becomes difficult to attend to specific needs. Methodologies such as Human-Centered Design, for example, offer tools to correct this lack, but they are still focused on developing mass products, so it will not be enough for specific demands. “We are all different and therefore have different needs. These differences mean that not all objects adapt to our needs and sometimes users have to do it themselves” (Nunes, 2010, p. 67).

During a visit to the residences, it was possible to observe (figure 10) the new use of snack box and cups indoors (left) and also sanitary ware (right) for use outdoors. Both used as vases.



Figure 10. Assignment of new use to household products. Source: authors collection (2021).

If in Brazil it is common to reuse plastic bottles for the production of vases, internationally some companies bet on the reuse of glass bottles for the commercialization of herbaria. In Portugal, the company My Little Garden, produces and sells the Bottle Kit (figure 11). The product consists of a kit for growing herbs on self watering vases made from used wine bottles. Includes bottle, soil, expanded clay, seeds, natural fiber wick, and instruction manual.



Figure 11: My Little Garden bottle kit. Source: www.greenstore4u.com/en/product/my-little-garden-window-bottle-kit-2/ (10/06/2020).

In this case, there may still be some cost saved, since it is about the reuse of packaging that can be purchased for less or even free, depending on the form of acquisition and partnerships of the producer. However, in the case of a company, the savings will hardly be reverted to the user, as it will still be a new product.

It is then observed that the reuse of materials for the development of marketing products coexists alongside DIY actions. The fact that there are proposals that allow users to buy products with reused material does not eliminate the search for their production. The question then follows: if the designer effectively inserts the user into the development of projects, would DIY initiatives end?

For Riul et al. (2015) while industrialization offers easy access to material goods available in the market, spontaneous creations will continue to emerge, which can overcome the lack of resources and bring greater flexibility “through the artisanal and symbolic manipulation of waste and other products of the industrial culture” (Riul et al., 2015, p. 70).

3.5 Contributions to the Academy

For Ibarra and Ribeiro (2014) in recent years, the appreciation of vernacular artifacts is being increased, which represent the expression and culture of a locality.

As much as the market serves to different needs, self-production is still reflected “in an exercise of decentralized construction, through artisanal methods and imperative conditions, and symbolizes a rupture with the inflexibility of the material world produced by the industry” (Riul et al., 2015, p. 70).

The academy has turned its eyes to vernacular expressions to refer to the productive forms that characterize individuals. A product can gain new functions, the reuse of materials can be considered sustainable, and the scarcity of resources can generate creativity.

Using strategies of incorporation of local and/or vernacular elements in design works, it is possible to create stronger bonds between the user and the context, achieve coherence with the cultural circle in which they are inserted, and make a more human and more diversity open design, less globalized (Ibarra & Ribeiro, 2014, p. 10).

Researchers who work with the idea of participatory design can achieve an emotional connection between products and their users, through greater participation in their design (Nunes, 2010). Participatory thinking goes in the opposite direction to consumerism, after all, in a participatory conception, happiness is equated with the purchase and consumption of material goods (Sanders; Stappers, 2008).

4. CONCLUSIONS

Design can no longer be defined as an activity of product development for industry, because in a complex scenario the actions are multiple. “The skills required of the designer today transcend what has become conventional as his usual universe” (Leite, 2009, p.30).

As Nunes (2010) exposes, if the user develops their products, at some point, the designer does not serve them. The understanding is that the problem must be beyond the need to grow plants. The objectives can relate to several aspects, among them can be pointed out:

1. Willingness not to discard a specific material, feeling the need to reuse;
2. Appreciate handcraft activity, and satisfaction to construct;
3. Consume without additional costs. Possess products with minimal monetary expenditure;
4. Instruct and teach someone to build/cultivate;
5. Part of developing an environmental conscience;
6. Using product modification as income generation.

It is then concluded that the creation of vernacular artifacts is independent of design quality projects. Most likely they will always exist, as interests go beyond those related to the need for a specific product. But for the designer, observing these initiatives is a way of understanding the users desires.

For authors such as Sanders and Stappers (2008), participatory design actions, such as co-creation methodologies, would be considered the evolution of design. Thus, regardless of the project, the user should be included in the stages of generating ideas and making key decisions for product development.

The examples presented in this article demonstrate homemade solutions, starting from the reuse of materials and products for the construction of growing plants devices in domestic environments. The wide dissemination of these proposals reveals some of the cultural aspects, such as making an effort to reuse materials, the attempt of using manual skills, and the constant search for proposals that help to maintain the activity of cultivating.

Just as the study of vernacular artifacts has been adopted by design, the cultivation of plants is demonstrated as an activity worked in several academic disciplines. Gardens can be implemented relatively quickly and serve different groups of people, including children, the elderly, and people with disabilities. A regular dose of gardening can improve physical, psychological, and social health (REIS; REIS; NASCIMENTO, 2020). Combining cultivation with self-production proves to be a focal point for materializing an environmental conscience. Even if in practice it does not result in comprehensive solutions to the problems of excess waste in our society, it shows the initiative of people who seek conscious consumption and can be understood as a point to be explored in initiatives to promote ideas of sustainability.

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DECLARATION OF CONTRIBUTIONS TO THE ARTICLE - CRediT

ROLE	LBenatti	BMayeta	ASilva	Mdias
Conceptualization – Ideas; formulation or evolution of overarching research goals and aims.	x			x
Data curation – Management activities to annotate (produce metadata), scrub data and maintain research data (including software code, where it is necessary for interpreting the data itself) for initial use and later re-use.	x	x	x	
Formal analysis – Application of statistical, mathematical, computational, or other formal techniques to analyze or synthesize study data.	x			
Funding acquisition - Acquisition of the financial support for the project leading to this publication.	x			
Investigation – Conducting a research and investigation process, specifically performing the experiments, or data/evidence collection.	x		x	
Methodology – Development or design of methodology; creation of models.	x	x	x	x
Project administration – Management and coordination responsibility for the research activity planning and execution.	x			x
Resources – Provision of study materials, reagents, materials, patients, laboratory samples, animals, instrumentation, computing resources, or other analysis tools.	-	-	-	-
Software – Programming, software development; designing computer programs; implementation of the computer code and supporting algorithms; testing of existing code components.	-	-	-	-
Supervision – Oversight and leadership responsibility for the research activity planning and execution, including mentorship external to the core team.	x			x
Validation – Verification, whether as a part of the activity or separate, of the overall replication/reproducibility of results/experiments and other research outputs.	x		x	
Visualization – Preparation, creation and/or presentation of the published work, specifically visualization/data presentation.	x	x	x	x
Writing – original draft – Preparation, creation and/or presentation of the published work, specifically writing the initial draft (including substantive translation).	x	x	x	x
Writing – review & editing – Preparation, creation and/or presentation of the published work by those from the original research group, specifically critical review, commentary or revision – including pre- or post-publication stages.	x	x	x	x