Garden towers as vertical landscape elements for community-based urban food production in Indonesia

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Abstract: Rapid urbanization has reduced the availability of agricultural land and limited access to fresh vegetables in many urban areas, particularly in developing countries. Urban agriculture, including vertical farming systems, has emerged as an adaptive strategy to enhance food availability and strengthen social–ecological resilience in densely populated environments. This study evaluates the performance of a garden tower (GT) system as a vertical landscape element for community-based vegetable production in urban and peri-urban areas of Bogor, Indonesia. The research employed a descriptive–evaluative approach involving 105 GT units distributed to 21 women farmers groups (WFG). The GT system utilized tarpaulin-based cylindrical containers filled with a soil-based growing medium composed of soil, rice husk charcoal, and organic manure. Data were collected through field observations, photographic documentation, online questionnaires, and WhatsApp group communication, focusing on plant growth performance, pest and disease occurrence, container effectiveness, and community participation. The results showed that all GT units were successfully established and produced harvestable vegetables. Tomato (*Solanum lycopersicum*) exhibited the highest growth success rate (92.59%), while leafy vegetables such as water spinach (*Ipomoea aquatica*) and bok choy (*Brassica rapa*) demonstrated rapid growth and frequent harvests. In contrast, red lettuce (*Lactuca sativa*) and celery (*Apium graveolens*) showed lower survival rates. Pest and disease incidence in the GT system was comparable to that in conventional vegetable gardens, indicating good integration with local agroecological conditions. Social factors, particularly active participation and collective management by WFG members, were identified as key determinants of system performance and sustainability. The study concludes that the GT system represents a practical and adaptable form of vertical green infrastructure that supports community-based urban food production. By integrating locally available materials, efficient spatial use, and strong social organization, the GT contributes to urban food and nutrition security and offers potential for wider application in rapidly urbanizing landscapes.

Introduction

Rapid urbanization has become a major driver of global urban landscape change, with significant implications for spatial structure, ecological function, and community lifestyles. The expansion of built-up areas often occurs at the expense of urban green spaces, reducing public access to green spaces and weakening the connection between urban residents and local food production systems (Mcdonald et al. 2020; Seto et al.

2012). This landscape transformation has a direct impact on urban food systems, particularly in the declining availability and consumption of fresh vegetables, which play an important role in maintaining human health and nutritional balance (Springmann et al. 2020). Several studies have shown that low vegetable intake is strongly correlated with an increased risk of non-communicable diseases, such as cardiovascular disease, type 2 diabetes, and several types of cancer, the prevalence of which is relatively higher in urban areas (Aune et al. 2017).

In many developing countries, including Indonesia, the challenges of urban food systems are becoming increasingly complex due to the ongoing conversion of agricultural land to residential areas and urban infrastructure. This land-use change limits local food production capacity and increases cities' dependence on external food supplies, thus increasing the vulnerability of food systems to social, economic, and environmental disruptions (d'Amour et al. 2017; van Vliet et al. 2017). In this context, urban agriculture is increasingly seen as an adaptive strategy that has the potential to increase local food availability, strengthen household food security, and support socio-ecological resilience in urban environments (Artmann and Sartison 2018; Evans et al. 2022). Various forms of urban agriculture, such as yard gardening, vertical farming, and container-based cultivation, are widely used to produce food in limited spaces, especially in areas with high population density.

Among these approaches, vertical farming systems are an innovation gaining increasing attention for their ability to use vertical space for crop production in urban environments where horizontal land is scarce. This system allows for efficient use of space while maintaining crop productivity, thereby reducing pressure on open land conversion in cities (Al-kodmany 2018; Kalantari et al. 2017). From a landscape ecology perspective, vertical farming structures can be understood as small-scale green infrastructure elements that contribute to various urban ecosystem functions, including microclimate regulation, increasing connectivity of green elements, and strengthening social interactions and environmental awareness of the community (Haase et al. 2014; Russo et al. 2017). However, the success and sustainability of vertical farming systems are not only determined by technical aspects, but also depend greatly on their suitability to local environmental conditions, the availability of materials, and the social and institutional capacity of the community in managing the system sustainably (Camps-Calvet et al. 2016; Tornaghi and Dehaene 2020).

The garden tower (GT) is a vertical farming system developed using simple technology and local materials to support vegetable cultivation in limited urban spaces. Unlike commercial vertical farming systems, which generally rely on high technology and large capital investments, GT uses tarpaulin planting containers and conventional soil-based growing media, making it more accessible, affordable, and replicable by the community (Goldstein et al. 2016; Weidner et al. 2019). This approach is in line with the principles of community-based landscape management, which emphasizes the role of local knowledge, social organization, and collective participation in shaping and maintaining productive landscapes that are adaptive to local conditions (Camps-Calvet et al. 2016; Cohen and Reynolds 2014).

In a social context, Women Farmers Groups (WFG) play a strategic role in the development of community-based agriculture in Indonesia, particularly at the household and neighborhood levels. Various studies have shown that the involvement of women's groups in local food systems not only contributes to food production but also strengthens knowledge exchange, capacity building, and social empowerment at the community level (Doss et al. 2018). Women's participation in agricultural systems is closely linked to improved household food security and community-level development outcomes. In implementing the GT system, WFG could serve as early adopters and primary managers, thereby playing an important role in diffusing vertical farming innovations to the wider community.

Although numerous studies have addressed vertical farming and urban agriculture from both technical and ecological perspectives, studies specifically evaluating the performance of community-based vertical farming systems using simple technologies and integrating ecological and social aspects within the context of urban landscapes in developing countries remain relatively limited. Therefore, this study aims to evaluate the performance of the GT system as a vertical landscape element in a community garden managed by a WFG. Specifically, this study examines plant growth and productivity, the occurrence of pests and diseases, the effectiveness of tarpaulin-based planting containers, and the willingness of the women farmers' groups to continue and expand the GT program. By filling this knowledge gap, this research is expected to contribute to the development of community-based vertical farming as an important component of sustainable urban landscapes in areas experiencing rapid urbanization.

Materials and Methods

Study Design

This study employed a descriptive-evaluative research design to assess the implementation and performance of a community-based GT system as a vertical landscape element for urban food production. The research focused on evaluating plant growth performance, pest and disease occurrence, container effectiveness, and community participation in managing the GT system. Data were collected through field observations, documentation, and an online questionnaire survey.

Study Area

The study was conducted in Bogor City and Bogor Regency, West Java, Indonesia. GTs were installed in gardens managed by 21 WFGs, located both within and outside the IPB University campus (Figure 1). On-campus locations included gardens associated with several faculties at IPB University. Meanwhile, off-campus sites were situated in urban and peri-urban villages surrounding Bogor. These areas are characterized by relatively higher population density compared to rural settings and, in many cases, have limited space available for conventional agriculture due to ongoing urban development.

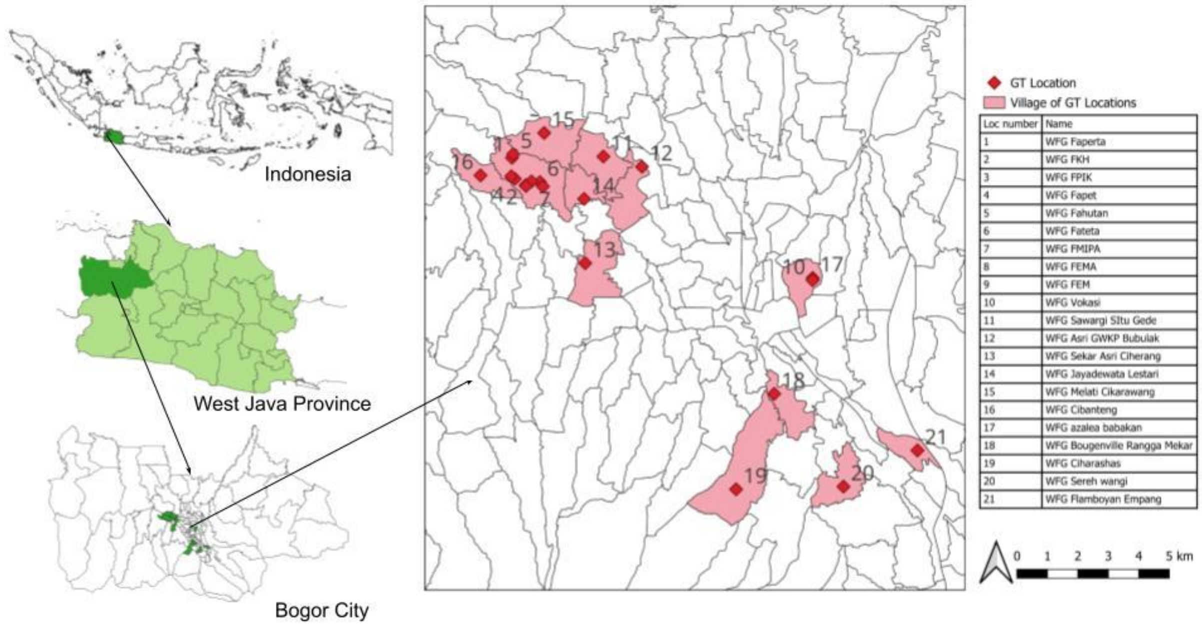

Figure 1. Location of garden tower (GT) sites
1. ábra. A vertikális ültetőtornyok (garden tower – GT) lokációja

GT System Description

The GT system used in this study consisted of a cylindrical tarpaulin container measuring approximately 1.0 m in height and 0.5 m in diameter (Figure 2). Planting holes were evenly distributed across the tarpaulin container. The GT system demonstrates a distinct spatial configuration compared to conventional horizontal planting systems. The physical footprint of a single GT unit is approximately 0.2 m^2, while the effective growing area may expand to 0.6–0.9 m^2 due to canopy development. In conventional planting systems, vegetable cultivation generally requires approximately 0.04–0.09 m^2 per plant, depending on crop type and management practices. Vertical farming systems, including GT configurations, are widely recognized for their potential to optimize space use in land-constrained environments (Beacham et al. 2019). Within an equivalent area, this corresponds to approximately 7–22 plants. In contrast, the vertical configuration of the GT allows a greater number of planting points within a relatively small ground footprint, suggesting its potential to increase planting density per unit area. However, as no direct experimental comparison was conducted, this advantage should be interpreted as a structural characteristic rather than a quantified measure of productivity.

A perforated PVC pipe (approximately 7.6 cm in diameter) was installed vertically at the center of each tower to facilitate water distribution throughout the growing medium (Figure 1). The planting medium was composed of a mixture of local soil, rice husk charcoal, and organic manure derived from commonly available livestock sources (e.g. poultry manure) in a 1:3:3 ratio. This composition was selected based on material availability and suitability for vegetable cultivation under local conditions. The tarpaulin-based design was chosen to ensure portability, ease of assembly, and cost efficiency, allowing the system to be easily replicated in community settings.

Figure 2. The model of garden towers (GT)

2. ábra. Példa a vertikális ültetőtorony alkalmazására

Plant Materials

Vegetable species cultivated in the GT system included green spinach (*Amaranthus* sp.), water spinach (*Ipomoea aquatica*), celery (*Apium graveolens*), green lettuce (*Lactuca sativa*), red lettuce (*Lactuca sativa*), bok choy (*Brassica rapa*), choy sum (*Brassica rapa* var. *parachinensis*), tomato (*Solanum lycopersicum*), and chili (*Capsicum frutescens*). Seedlings were typically raised in trays before transplanting into the GT system. However, selected leafy vegetables, such as green spinach (*Amaranthus* sp.) and water spinach (*Ipomoea aquatica*), were directly sown into the GT.

Implementation Procedure

A total of 105 GT units were distributed to the 21 WFGs, with each group receiving five units. The GT units were assembled at each WFG site with technical guidance from the research team. After assembly, seedlings were transplanted into the planting holes, while regular maintenance activities included watering through the central PVC pipe and surface irrigation as needed.

Harvesting was conducted based on the growth characteristics of each vegetable species. Leafy vegetables were harvested approximately four to five weeks after planting, whereas fruiting vegetables such as tomato and chili were harvested repeatedly over a longer period.

Data Collection

Data collection was carried out using multiple approaches. Field observations and photographic documentation were conducted to record plant growth conditions, pest and disease incidence, and structural performance of the GTs. In addition, an online questionnaire distributed via Google Forms was used to gather information from WFG representatives. The questionnaire covered respondents' identities, the condition of each GT, the occurrence of pests and diseases, the effectiveness of tarpaulins as planting containers, their willingness to participate in the second phase of the GT program, and their expectations regarding program development.

WFG representatives served as key informants because they were directly responsible for the daily maintenance and monitoring of the GTs. Supplementary data on harvesting activities were also collected through regular communication via WhatsApp groups.

The questionnaire respondents included at least one representative from each WFG participating in the program. In total, 23 respondents were included in this study, representing all active groups involved in implementing the GT systems. Selecting group representatives as respondents was appropriate because they had direct operational knowledge of the establishment, maintenance, and performance of the GT units within their respective groups. In community-based agricultural research, key informant responses from responsible group representatives are commonly used to capture collective experiences and management practices, thereby providing reliable insights into group-level implementation and outcomes.

Data Analysis

The collected data were analyzed using both qualitative and quantitative approaches. Descriptive statistics were applied to summarize plant growth success rates, pest and disease occurrence, and levels of community participation. Qualitative data obtained from observations and open-ended questionnaire responses were analyzed thematically to identify key patterns related to system performance, management challenges, and community perceptions. The combined analysis provided an integrated evaluation of the GT system as a component of community-based urban landscapes.

Results and Discussion

All GT units installed across the 21 WFG sites were successfully established and used for vegetable cultivation. Vegetables grown in the GT system were harvested and utilized by WFG members and, in several cases, shared with surrounding households. Field observations indicated that the overall performance of the GT system was strongly influenced by active community involvement in assembly, maintenance, and harvesting. Sites with higher levels of collective participation generally exhibited better plant growth and system maintenance.

Effectiveness of Tarpaulin Containers and Irrigation System

This study was conducted as part of an initial project implementation; therefore, WhatsApp groups were established and managed by the research team to facilitate coordination and data collection. Each Women Farmers Group (WFG) was represented by one designated member responsible for monitoring the GT units and completing the questionnaire, indicating that responses were collected at the WFG level rather than from individual members. The total number of respondents corresponded to the number of participating WFG representatives (n = 23), which is specified in the revised manuscript.

Of the 23 respondents, 13 (56.52%) reported that the tarpaulin-based Garden Tower (GT) structure functioned effectively as a planting container, maintaining its form and adequately supporting plant growth. Although several Women Farmers Groups (WFGs) observed that some GT units tended to lean due to the weight of the planting medium, this condition did not lead to structural damage and was generally resolved through reassembly after harvesting. The overall structural performance indicates that the tarpaulin material provided sufficient mechanical stability to support the GT system under field conditions.

Regarding irrigation performance, 55.56% of respondents considered the central PVC pipe effective in distributing water throughout the growing medium. However, 33.33% reported uneven water distribution, with some planting areas receiving insufficient moisture. These findings suggest that while the irrigation system was generally functional, design refinement – particularly in pipe diameter and perforation configuration – could improve water uniformity. Overall, the results highlight common trade-offs in low-technology urban agriculture systems, where simplicity and affordability are balanced against technical performance and maintenance requirements (Specht et al. 2014). Incremental design improvements could therefore enhance system stability and irrigation efficiency while maintaining the low-cost and easily replicable nature of the GT system.

Vegetable Growth and Survival Rates

Based on questionnaire responses and field observations, most vegetable species cultivated in the GT system showed satisfactory growth. Leafy vegetables such as water spinach (*Ipomoea aquatica*), bok choy (*Brassica rapa*), and green spinach (*Amaranthus* sp.) showed high survival rates and rapid growth. Among all crops, tomato (*Solanum lycopersicum*) exhibited the highest success rate, with 92.59% of planted seedlings growing and producing fruit (Table 1).

Table 1. Percentage of Vegetable Growth in GTs at Each WFG

1. táblázat. Az egyes termesztett növébyfajok növekménye

Vegetable commodities		Growing Well (%)	Grow But Dwarf (%)	Growing but affected by pests (%)	Not growing/failed in the nursery (%)
1.	Green Lettuce	62.96	14.81	11.11	7.41
2.	Red lettuce	44.44	11.11	3.7	37.04
3.	Spinach	62.96	18.52	7.41	3.70
4.	Water spinach	66.67	18.52	7.41	3.70
5.	Celery	55.56	14.81	3.70	18.52
6.	Bok choy	77.78	3.70	11.11	3.70
7.	Chilli	74.07	11.11	3.70	3.70
8.	Tomato	92.59	3.70	0.00	0.00

In contrast, red lettuce (*Lactuca sativa*) showed the lowest growth performance, with only 44.44% of seedlings growing successfully, while 37.04% failed to establish. Celery (*Apium graveolens*) also displayed relatively low survival rates, with a notable proportion of seedlings failing to grow. These variations indicate species-specific responses to the vertical planting environment and the soil-based growing medium used in the GT system.

The results showed variation in growth and survival rates among vegetable species cultivated in the GT system. Leafy vegetables such as water spinach, bok choy, and green spinach generally showed high survival rates and rapid growth, indicating their compatibility with short-cycle cultivation in vertical systems. Tomato exhibited the highest overall success rate, which may reflect its relatively robust growth characteristics. However, these differences may also be influenced by management factors, particularly irrigation practices and planting methods. Leafy vegetables are typically more sensitive to water availability, and variations in watering consistency, as well as the use of direct sowing for some species, may have affected their performance. Therefore, the observed differences should be interpreted with consideration of both plant characteristics and system management conditions.

In contrast, red lettuce and celery showed lower establishment success and higher failure rates. These differences reflect species-specific sensitivities to root-zone volume, water availability, and microclimatic conditions, which are often amplified in container-based and vertical systems. Similar patterns have been observed in urban horticulture studies, where physiological traits and adaptability to constrained growing environments strongly influence crop performance (Orsini et al. 2013). The Results, therefore, indicate that careful crop selection is essential to optimize productivity and reduce failure rates in the GT systems.

Harvesting Patterns and Household Food Contribution

Harvesting of leafy vegetables generally began four to five weeks after planting, depending on the species. Water spinach and bok choy were the fastest-growing crops and could be harvested repeatedly within a short period. Fruiting vegetables, particularly tomato and chili, required longer cultivation periods but allowed multiple harvests over time (Figure 3).

Figure 3. Bok choy vegetables were harvested from the GT system

3. ábra. Bordáskel termesztése vertikális ültetőtornyos rendszerben

In this study, the success of the GT system is primarily defined in terms of system establishment, functionality, and the ability to produce edible crops, rather than quantitative yield performance. Although systematic quantitative measurements of total yield were not conducted in this phase, reported harvests from WFG representatives indicated that all groups were able to obtain edible produce from the GT units. The harvested vegetables were primarily consumed by WFG members, suggesting a potential contribution to household food availability. However, in the absence of quantitative yield data, these findings should be interpreted as indicative rather than conclusive.

Harvesting patterns reported in the Results indicate that leafy vegetables can be harvested within four to five weeks, whereas fruiting vegetables such as tomato and chili require longer cultivation periods but allow repeated harvesting over time. These observations suggest differing production cycles between crop types within the GT system.

Taken together, these findings suggest that the GT system has the potential to support both short-term and sustained household food provisioning. Rapid harvest cycles may contribute to immediate food availability, while repeated harvests from fruiting crops may help sustain household consumption over time. Such multifunctional production patterns are commonly associated with small-scale urban agriculture systems that prioritize household use over commercial output (Poulsen 2017).

Pest and Disease Occurrence within the Local Agroecological Context

Pests and diseases were reported based on field observations conducted by WFG members and documented through questionnaires and WhatsApp group discussions. Identification of pests and plant health issues was based on farmers' local knowledge and visual assessment, rather than laboratory or expert-based diagnostic procedures. Insect pests were the most frequently mentioned, including grasshoppers, caterpillars, aphids, mites, beetles, and thrips, which commonly attack vegetable crops in small-scale cultivation systems. In addition to insect pests, disturbances were also caused by wild animals such as rats, birds, and snails that feed on or damage plant tissues. Livestock, particularly chickens, goats, and cattle, were also reported to occasionally interfere with the planting structures, especially in areas located near household yards or semi-rural environments. Furthermore, domestic pets such as cats and dogs were mentioned as minor sources of disturbance around the GT units.

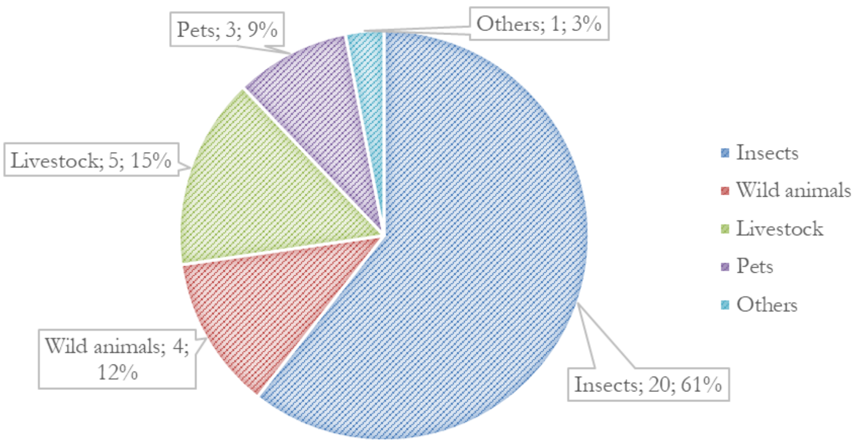

Figure 4. Percentage of pest categories

4. ábra. A megfigyelt károsítók aránya

Fungal infections were commonly observed, including general mold or fungal growth on plant tissues. Leaf-related diseases were also frequently mentioned, particularly symptoms such as leaf spots and rust that appear as discoloration or lesions on the leaf surface. In the early growth stage, some respondents reported the occurrence of damping-off disease in seedlings, which typically causes young plants to collapse during the nursery phase. Powdery mildew was also identified as a disease affecting plant leaves, characterized by the appearance of a white powder-like layer on the leaf surface. In addition, some respondents reported symptoms such as leaf scorching and plant wilting, which may be associated with physiological stress or pathogen infection. These observations indicate that both fungal diseases and stress-related symptoms were present in the GT cultivation systems and may influence plant health during the production cycle.

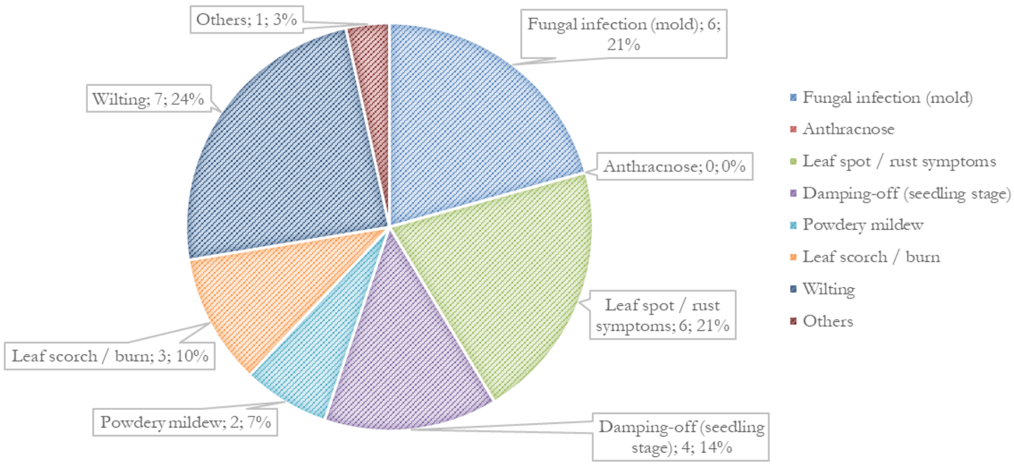

Figure 5. Disease and symptom types

5. ábra. A megfigyelt növényi betegségek és tünetek

Pests and diseases reported across the GT sites were generally consistent with those commonly encountered in surrounding home gardens and conventional vegetable cultivation systems. Insect pests represented the most frequently mentioned disturbances, while plant health issues such as wilting, fungal growth, and leaf spot symptoms were also observed. These conditions are widely recognized as common challenges in small-scale vegetable production, particularly under tropical growing conditions. It should be noted that the identification of pests and diseases in this study was based on field observations and participants' reports of visible symptoms rather than detailed pathological diagnosis. Therefore, the observations primarily reflect commonly recognized cultivation problems experienced by growers. Overall, the types of disturbances reported in the GT units followed patterns similar to those typically observed in conventional ground-based planting systems. This indicates that the use of the GT structure did not introduce new pest or disease pressures, but instead operated within the same ecological and agronomic context that characterizes traditional vegetable gardening practices.

This finding is consistent with studies showing that pest and disease dynamics in urban agriculture are largely shaped by local landscape context rather than by cultivation structure alone (Philpott et al. 2014). From an ecological perspective, the GT system functions as an integrated component of the urban agroecosystem, sharing biotic interactions with nearby gardens and green spaces.

Figure 6. Vegetables in GT are affected by pests and diseases

6. ábra. Példák a vertikális ültetőtornyokban megfigyelt növénykárosításra

Community Participation and Willingness to Continue the Program

The successful establishment and utilization of the Garden Tower (GT) units demonstrate the technical feasibility of the system for vegetable cultivation in land-limited urban and peri-urban environments. Harvested produce was primarily consumed by WFG members and in several cases shared within surrounding households, indicating that the GT system contributes to household-level food availability through small-scale routine production, a common feature of urban agriculture initiatives (Guitart et al. 2012; Okvat and Zautra 2011).

The frequency distribution of participant keywords further supports these findings (Figure 7). Dominant terms such as "good," "grow," "fertile," and "plant" suggest generally positive perceptions of plant growth performance and cultivation outcomes within the GT system, while the occurrence of "harvest" reflects its functional role in food production. These findings indicate that participants primarily perceived the GT as supporting productive household cultivation.

Several responses also reveal practical challenges during implementation, including pest disturbance, uneven structure, and planting media issues. These constraints suggest that GT performance remains influenced by operational and maintenance-related factors. Overall, the benefits identified in this study appear concentrated on supporting plant growth and household consumption, with limited evidence of broader economic impacts, a pattern commonly observed in early-stage community-based urban agriculture initiatives (Okvat and Zautra 2011).

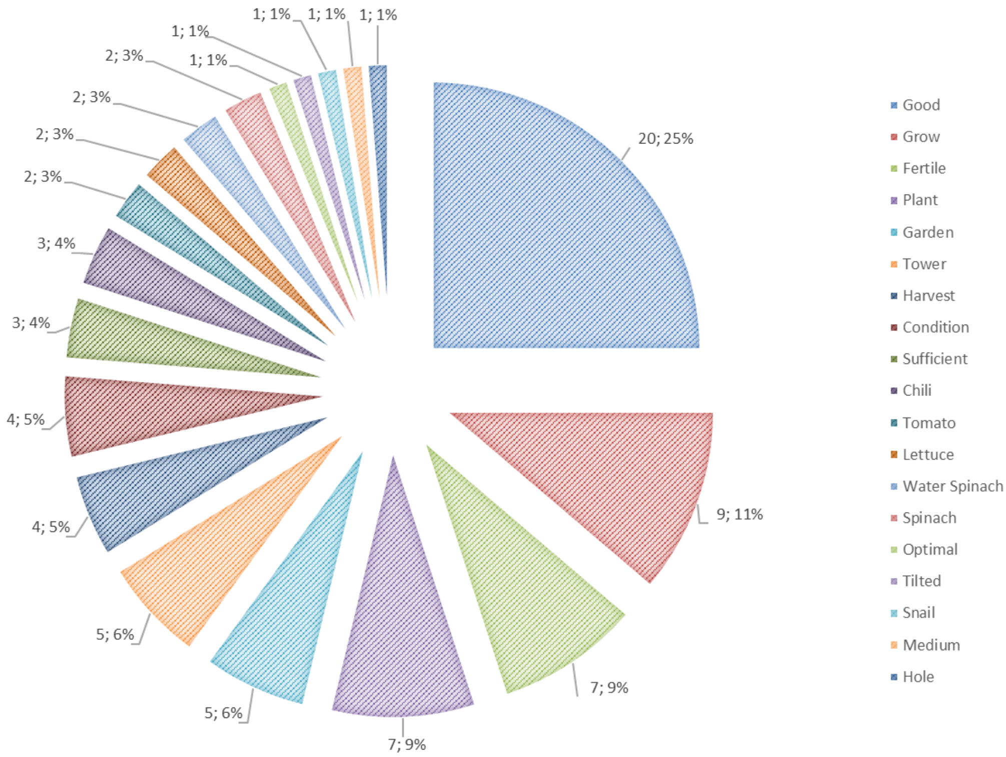

Figure 7. Frequency distribution of keywords in participants' responses on the Garden Tower (GT) system

7. ábra. A kulcsszavak gyakorisági eloszlása a résztvevők válaszaiban a vertikális ültetőtorony-rendszerek kapcsán végzett felmérésben

Implications for Landscape Ecology

From a landscape ecology perspective, the Garden Tower system represents a fine-grained, multifunctional green element embedded within the urban residential matrix. The Results and Discussion together demonstrate that the GT integrates food production, social interaction, and ecological processes at the household and neighborhood scales. Rather than functioning as an isolated production unit, the GT interacts with surrounding gardens and green spaces, sharing pest dynamics and management practices.

By utilizing vertical space, the GT enhances spatial efficiency and adds provisioning functions to existing residential landscapes without requiring a change in land use. This aligns with landscape ecology perspectives that emphasize multifunctionality, spatial configuration, and human management as key drivers of ecosystem functions in urban environments (Colding and Barthel 2013; Wu 2014). As urban areas continue to densify, vertically oriented, community-managed food production systems such as the GT may play an increasingly important role in maintaining resilient and multifunctional urban landscapes.

Conclusion

This study demonstrates that the Garden Tower (GT) system is a viable and practical approach to community-based vegetable cultivation in densely populated urban environments with limited land. Using tarpaulin-based vertical containers and a soil-based growing medium composed of locally available materials, the GT system supported satisfactory plant growth. It enabled regular harvesting across all participating Women Farmers Groups (WFGs). These findings confirm that the GT system can function effectively as a small-scale vertical landscape element contributing to household-level food availability.

Variation in crop performance highlights the importance of species selection in vertical planting systems. Leafy vegetables such as water spinach, bok choy, and green spinach, along with fruiting crops such as tomato and chili, showed high adaptability to the GT environment. In contrast, celery and red lettuce exhibited lower survival and productivity. Pest and disease occurrence within the GT system was comparable to that in conventional urban vegetable gardens, indicating that the system integrates well into existing urban agroecological conditions without introducing additional ecological pressures.

Beyond technical performance, the success of the GT system was strongly shaped by social factors. Active participation, collective management, and effective communication within WFGs were central to maintaining system performance and ensuring regular harvesting. While all WFGs expressed willingness to continue participating in the program, differences in time availability and human resources limited their capacity to serve as facilitators for future program expansion. This finding underscores that social capacity is a key determinant of scalability in community-based urban agriculture initiatives.

From a landscape ecology perspective, the GT system represents a multifunctional vertical green infrastructure embedded within residential urban landscapes. By combining spatial efficiency, local material use, and community-based management, the GT system contributes to the multifunctionality of urban landscapes through food provisioning and social engagement at the neighborhood scale. Future research should focus on quantifying crop yields and economic benefits, refining irrigation design, and assessing the long-term ecological and social impacts of GT systems at broader urban scales. Such efforts will strengthen the role of community-based vertical agriculture as a sustainable component of urban landscapes in rapidly urbanizing regions.

References

Al-kodmany, K. 2018: The Vertical Farm: A Review of Developments and. Buildings, 8(2): 1–36. https://doi.org/10.3390/buildings8020024

Artmann, M., Sartison, K. 2018: The Role of Urban Agriculture as a Nature-Based Solution: A Review for Developing a Systemic Assessment Framework. Sustainability, 10(6): 1–32. https://doi.org/10.3390/su10061937

Aune, D., Giovannucci, E., Boffetta, P., Riboli, E., Vatten, L. J., Tonstad, S. 2017: Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all- cause mortality — a systematic review and dose- response meta-analysis of prospective studies. International Journal of Epidemiology, 46(3): 1029–1056. https://doi.org/10.1093/ije/dyw319

Beacham, A. M., Vickers, L. H., Monaghan, J. M. 2019: Vertical farming: a summary of approaches to growing skywards. The Journal of Horticultural Science and Biotechnology, 94(3): 277–283. https://doi.org/10.1080/14620316.2019.1574214

Camps-Calvet, M., Langemeyer, J., Calvet-Mir, L., Gómez-Baggethun, E. 2016: Environmental Science & Policy Ecosystem services provided by urban gardens in Barcelona, Spain: Insights for policy and planning. Environmental Science & Policy Journal, 62: 14–23. https://doi.org/10.1016/j.envsci.2016.01.007

Cohen, N., Reynolds, K. 2014: Urban agriculture policy making in New York's "New Political Spaces" strategizing for a participatory and representative system. Journal of Planning Education and Research, 34(2): 221–234. https://doi.org/10.1177/0739456X14526453

Colding, J., Barthel, S. 2013: The potential of 'Urban Green Commons' in the resilience building of cities. Ecological Economics, 86: 156–166. https://doi.org/10.1016/j.ecolecon.2012.10.016

d'Amour, C. B., Reitsma, F., Baiocchi, G., Barthel, S., Güneralp, B., Erb, K.-H., Haberl, H., Creutzig, F., Seto, K. C. 2017: Future urban land expansion and implications for global croplands. Proceedings of the National Academy of Sciences, 114(34): 8939–8944. https://doi.org/10.1073/pnas.1606036114

Doss, C., Meinzen-Dick, R., Quisumbing, A., Theis, S. 2018: Women in agriculture: Four myths, 69–74. https://doi.org/10.1016/j.gfs.2017.10.001

Evans, D. L., Falagán, N., Hardman, C. A., Kourmpetli, S., Liu, L., Mead, B. R., Davies, J. A. C. 2022: Ecosystem service delivery by urban agriculture and green infrastructure – a systematic review. Ecosystem Services, 54: 101405. https://doi.org/10.1016/j.ecoser.2022.101405

Goldstein, B. P., Hauschild, M. Z., Fernandez, J. 2016: Urban versus conventional agriculture, taxonomy of resource profiles: a review. Agronomy for Sustainable Development, 36(9). https://doi.org/10.1007/s13593-015-0348-4

Guitart, D., Pickering, C., Byrne, J. 2012: Past results and future directions in urban community gardens research. Urban Forestry & Urban Greening, 11(4): 364–373. https://doi.org/10.1016/j.ufug.2012.06.00

Haase, D., Frantzeskaki, N., Elmqvist, T. 2014: Ecosystem Services in Urban Landscapes: Practical Applications and Governance Implications. Ambio, 43(4): 407–412. https://doi.org/10.1007/s13280-014-0503-1

Kalantari, F., Mohd Tahir, O., Mahmoudi Lahijani, A., Kalantari, S. 2017: A Review of Vertical Farming Technology: A Guide for Implementation of Building Integrated Agriculture in Cities. Advanced Engineering Forum, 24: 76–91. https://doi.org/10.4028/www.scientific.net/AEF.24.76

Mcdonald, R. I., Mansur, A. V, Ascensão, F., Colbert, M., Crossman, K., Elmqvist, T., Gonzalez, A., Güneralp, B., Haase, D., Hamann, M., Hillel, O., Huang, K., Kahnt, B., Maddox, D., Pacheco, A., Pereira, H. M., Seto, K. C., Simkin, R., Walsh, B., Ziter, C. 2020: Research gaps in knowledge of the impact of urban growth on biodiversity. Nature Sustainability, 3(1): 16–24. https://doi.org/10.1038/s41893-019-0436-6

Okvat, H. A., Zautra, A. J. 2011: Community gardening: A parsimonious path to individual, community, and environmental resilience. American Journal of Community Psychology, 47(3): 374–387. https://doi.org/10.1007/s10464-010-9404-z

Orsini, F., Kahane, R., Nono-Womdim, R., Gianquinto, G. 2013: Urban agriculture in the developing world: a review. Agronomy for Sustainable Development, 33(4): 695–720. https://doi.org/10.1007/s13593-013-0143-z

Philpott, S. M., Cotton, J., Bichier, P., Friedrich, R. L., Moorhead, L. C., Uno, S., Valdez, M. 2014: Local and landscape drivers of arthropod abundance, richness, and trophic composition in urban habitats. Urban Ecosystems, 17(2): 513–532. https://doi.org/10.1007/s11252-013-0333-0

Poulsen, M. N. 2017: The multifunctionality of urban farming: perceived benefits for neighbourhood improvement. Agriculture and Human Values, 22(11): 1411–1427. https://doi.org/10.1080/13549839.2017.1357686

Russo, A., Escobedo, F. J., Cirella, G. T., Zerbe, S. 2017: Edible green infrastructure: An approach and review of provisioning ecosystem services and disservices in urban environments. Agriculture, Ecosystems and Environment, 242: 53–66. https://doi.org/10.1016/j.agee.2017.03.026

Seto, K. C., Güneralp, B., Hutyra, L. R. 2012: Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools. Proceedings of the National Academy of Sciences, 16083–16088. https://doi.org/10.1073/pnas.1211658109

Specht, K., Siebert, R., Hartmann, I., Freisinger, U. B., Sawicka, M., Werner, A., Thomaier, S., Henckel, D., Walk, H., Dierich, A. 2014: Urban agriculture of the future: an overview of sustainability aspects of food production in and on buildings. Agriculture and Human Values, 31(1): 33–51. https://doi.org/10.1007/s10460-013-9448-4

Springmann, M., Spajic, L., Clark, M. A., Poore, J., Herforth, A., Webb, P., Rayner, M., Scarborough, P. 2020: The healthiness and sustainability of national and global food based dietary guidelines: modelling study. Bmj, 370. https://doi.org/10.1136/bmj.m2322

Tornaghi, C., Dehaene, M. 2020: Agroecology and Sustainable Food Systems The prefigurative power of urban political agroecology: rethinking the urbanisms of agroecological transitions for food system transformation. Agroecology and Sustainable Food Systems, 44(5): 594–610. https://doi.org/10.1080/21683565.2019.1680593

van Vliet, J., Eitelberg, D. A., Verburg, P. H. 2017: A global analysis of land take in cropland areas and production displacement from urbanization. Global Environmental Change, 43: 107–115. https://doi.org/10.1016/j.gloenvcha.2017.02.001

Weidner, T., Yang, A., Hamm, M. W. 2019: Consolidating the current knowledge on urban agriculture in productive urban food systems: learnings, gaps and outlook. Journal of Cleaner Production, 209: 1637–1655. https://doi.org/10.1016/j.jclepro.2018.11.004

Wu, J. 2014: Urban ecology and sustainability: The state-of-the-science and future directions. Landscape and Urban Planning, 125: 209–221. https://doi.org/10.1016/j.landurbplan.2014.01.018

Vertikális ültetőtornyok mint függőleges tájelemek a közösségi alapú városi élelmiszer-termelésben Indonéziában

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Kulcsszavak: vertikális ültetőtorony, városi növénytermesztés, függőleges gazdálkodás, közösségi alapú tájgazdálkodás, élelmiszer- és táplálkozásbiztonság

A gyors ütemű urbanizáció számos városi térségben – különösen a fejlődő országokban – csökkentette a mezőgazdasági művelésre alkalmas területek nagyságát, valamint korlátozta a friss zöldségekhez való hozzáférést. A városi mezőgazdaság, beleértve a vertikális termesztőrendszereket is, olyan alkalmazkodási stratégiaként jelent meg, amely hozzájárul az élelmiszer-ellátás javításához, valamint a sűrűn lakott területek társadalmi–ökológiai rezilienciájának erősítéséhez. Jelen tanulmány a Garden Tower (GT) rendszer teljesítményét értékeli mint a közösségi alapú zöldségtermesztést támogató vertikális tájépítészeti elemet az indonéziai Bogor városi és városkörnyéki térségeiben. A kutatás leíró–értékelő megközelítést alkalmazott, amelynek keretében 105 darab GT-egységet osztottak ki 21 Női Gazdálkodói Csoport (Women Farmers Groups, WFG) számára. A GT-rendszer ponyvaalapú, hengeres termesztőedényekből állt, amelyeket talajalapú termesztőközeggel töltöttek fel. A termesztőközeg talaj, rizshéj és szerves trágya keverékéből állt. Az adatgyűjtés terepi megfigyelések, fényképes dokumentáció, online kérdőívek és WhatsApp-csoportokon keresztüli kommunikáció révén történt. Az értékelés a növények növekedési teljesítményére, a kártevők és betegségek előfordulására, a termesztőedények hatékonyságára, valamint a közösségi részvétel mértékére terjedt ki. Az eredmények alapján valamennyi GT-egységet sikeresen telepítették, és mindegyik alkalmas volt betakarítható zöldségek előállítására. A paradicsom (*Solanum lycopersicum*) mutatta a legmagasabb növekedési sikerességi arányt (92,59%), míg a levélzöldségek – például a vízispenót (*Ipomoea aquatica*) és a bordás kel (*Brassica rapa*) – gyors növekedést és gyakori betakarítást tettek lehetővé. Ezzel szemben a vörös saláta (*Lactuca sativa*) és a zeller (*Apium graveolens*) alacsonyabb túlélési arányt mutatott. A GT-rendszerben megfigyelt kártevő- és betegség-előfordulás hasonló volt a hagyományos zöldségkertekben tapasztaltakhoz, ami arra utal, hogy a rendszer jól illeszkedik a helyi agroökológiai adottságokhoz. A társadalmi tényezők – különösen a WFG-tagok aktív részvétele és a közösségi alapú szervezés – a rendszer működésének és hosszú távú fenntarthatóságának meghatározó elemeinek bizonyultak. A vizsgálat megállapította, hogy a GT-rendszer a vertikális zöld infrastruktúra olyan gyakorlati és rugalmasan alkalmazható formáját képviseli, amely hatékonyan támogatja a közösségi alapú városi élelmiszer-termelést. A helyben rendelkezésre álló anyagok felhasználásának, a térhatékony kialakításnak és az erős közösségi szervezettségnek köszönhetően a GT-rendszer hozzájárul a városi élelmiszer- és táplálkozásbiztonság erősítéséhez, valamint jelentős alkalmazási potenciállal rendelkezik a gyorsan urbanizálódó térségekben.