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Urban Farming as Nature-Based Solutions Comparative Governance Models from Tangerang Regency, Indonesia

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turnitin Page 5 of 25 - Integrity Submission Submission ID trn:oid:::3618:156866261

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Urban Farming as Nature-Based Solutions: Comparative Governance Models from Tangerang Regency, Indonesia

Rahmi Elsa Diana[1*], Eduwin Eko Franjaya[2], Septi Maulidyah[3], Gilig Setyo Rahardjo[1], Virgi Nanca Lorizkian[1], Nixia Stephanie[1], Farell Bertram Candra[1], Narisha Chelsea Aliyah Subhan[1]

[1]Department of Architecture, Faculty of Art and Design, Universitas Multimedia Nusantara, Tangerang, Banten, Indonesia
[2]Architecture Program, Graduate School of Advanced Science and Engineering, Hiroshima University, Higashi-Hiroshima City, Hiroshima, Japan
[3]Landscape Architecture Program, Department of Infrastructure and Territorial Technology, Institut Teknologi Sumatera, South Lampung, Lampung, Indonesia

*Corresponding author: rahmi.diana@lecturer.umn.ac.id

ABSTRACT

Urban farming is increasingly being examined as a Nature-Based Solution (NbS) that is globally recognized in addressing food security, environmental degradation, and social well-being. However, empirical evidence shows that NbS performance highly depends on the governance model. The governance structures in urban farming are reflected in management priorities and influence ecological awareness and the level of social inclusivity. **Aims:** This study analyses three distinct governance models and their roles in shaping NbS performance. The comparison of governance models identifies NbS contributions, constraints and overall performance. **Methodology and results:** The research uses a qualitative comparative analysis. Three urban farming initiatives in Tangerang Regency were selected as case studies to represent different governance models; private, governmental, and community-based systems. The cases include Kebun Kumara, Kebun BRMP/Balitsa, and KWT Curug Kulon. Each case was analysed using governance-related indicators, including operational routines, plant diversity, cultivation systems, distribution mechanisms, and public benefits. Data were collected through field observations, semi-structured interviews, and archival reviews. The findings show that urban farming cannot automatically function as an NbS. Governance models influence the overall socio-ecological performance. The private model is strongly associated with environmental education and biodiversity awareness. The governmental model prioritizes research and agricultural productivity. Meanwhile, the community-based model reflects stronger social inclusion and local food security contributions. **Conclusion, significance and impact study:** This research positions urban farming not only as a food-production activity, but also as a socio-ecological governance system within the NbS framework.

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turnitin Page 5 of 25 - Integrity Submission Submission ID trn:oid:::3618:156866261

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1. INTRODUCTION

The rapid growth of cities in Indonesia has increasingly contributed to environmental decline, higher climate risks, and the loss of green open spaces. These challenges are especially evident in peri-urban areas around major metropolitan regions, where urban expansion often occurs in an unplanned and uncontrolled manner (Agnes & Naqash, 2025; Diana, 2025; FAO, 2023; IFC, 2024). Tangerang Regency, as one of the satellite cities of the Jakarta metropolitan area, has experienced rapid land-use conversion due to residential, industrial, and infrastructure development, which has declined urban ecological quality and reduced access to productive green space (Diana *et al.,* 2026). These conditions are becoming increasingly prevalent across metropolitan areas in Southeast Asia.

When implemented as urban green infrastructure, urban agriculture can contribute ecologically to biodiversity enhancement, microclimate regulation, and urban heat island mitigation (Earth5R, n.d.; Kanosvamhira & Shade, 2025). Urban farming has also been seen as a landscape-based strategy that integrates social, ecological, and economic functions.

Over the decade, research on urban agriculture has evolved in both scope and conceptual depth. Between 2014 and 2016, urban farming studies primarily focused on foundational aspects, such as food security, biodiversity, or basic ecosystem services like soil conservation and climate mitigation. The implementation of green infrastructure in urban areas was still limited to rooftop gardens and their integration with municipal services (Brown *et al*., 2016; Orsini *et al*., 2014). The literature in 2018 and 2019 discusses urban agriculture more explicitly as an NbS. It broadens perspectives related to societal challenges, public health, and economic development (Artmann & Sartison, 2018; Säumel *et al.,* 2019).

During 2021-2022, research explored the circular-economy framework of urban agriculture, particularly in stormwater management and resource recovery. The systematic reviews highlighted the need for more empirical data and policy alignment to enhance multifunctionality (Canet-Martí *et al*., 2021; Deksissa *et al*., 2021; Evans *et al.,* 2022). Since 2023, empirical case studies across diverse global cities have increasingly examined the socio-ecological impacts and governance challenges of urban agriculture as an NbS. These frameworks aimed to support scalable and resilient urban food systems (Eiter *et al*., 2025; Pradhan *et al*., 2024; Remme *et al*., 2024). Recent studies further emphasize systemic co-benefits, trade-offs, and the importance of

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governance innovation and transdisciplinary approaches for integrating urban agriculture into urban resilience strategies (Camacho-Caballero *et al*., 2024; Ternell *et al*., 2024).

According to the International Union for Conservation of Nature (IUCN), NbS are actions that protect, sustainably manage, and restore ecosystems while simultaneously addressing societal challenges and enhancing community well-being (Diana, 2025; IUCN, 2020). This definition further emphasizes the integration of ecological processes, landscape management, and governance mechanisms to achieve long-term resilience and sustainability (FAO, 2021). In urban planning discourse, NbS are increasingly recognized as strategic tools for reconnecting cities with natural systems while delivering co-benefits for climate adaptation, food systems, and social inclusion (Gkoltsiou, 2023).

Previous studies have demonstrated that urban farming enhances community well-being and urban food security by providing a local source of fresh and nutritious produce (Chaminuka *et al.*, 2021; FAO, 2021). For instance, in Malawi, Southern Africa, households cultivate fruits and vegetables in their own home gardens. They sell crop results and consume them. In another part of the world, Mexico City, the people meet their food needs through the "*waterborne chinampa farming system*", which is also known as floating gardens. This local farming system is well utilized by community farmers as part of their social identity (GFDRR-World Bank, 2021).

An assessment conducted in São Paulo revealed that urban agriculture not only secures food supply and supports local economies, but also contributes to income generation for producers, urban waste management, and the maintenance of ecological processes. In addition, urban farming has been shown to improve soil health and fertility and to provide spaces for education, recreation, and community interaction. Urban farming also serves as a learning environment for sustainable practices and food systems (Bennedetti *et al*., 2024; Pueyo-Ros *et al*., 2024). In the residential area, urban farming may strengthen the eco-settlement concept of the city (Franjaya *et al*., 2024). Gardening is also associated with human well-being and social cohesion through interactions among residents around the gardening spaces (Kingsley *et al.*, 2021).

Urban farming should be understood not merely as green infrastructure. Existing NbS studies often emphasize ecological and technical performance and still narrowly focus on food production. Urban farming is typically discussed in accordance with ecosystem services, social inclusion, or long-term landscape management (Luggen-Hölscher & Anica, 2023). Governance dimensions such as actor involvement, decision making, and resource allocation are rarely

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examined as determinants of NbS performance. There is a critical gap in understanding how different governance models shape the capacity of urban farming to deliver the NbS concept, particularly in developing-country contexts (IFC, 2024).

This research aims to answer the potential roles of different urban farming governance models as NbS by assessing how variations in governance: the private sector, governmental, and community-based models influence the overall effectiveness of NbS. Different governance settings also influence accessibility and ecological functions that indicate their functions as an NbS. The institutional structures, participation, and management priorities shape the effectiveness of Nature-based Solutions (NbS).

2. RESEARCH METHODOLOGY

This study utilizes purposive sampling to systematically select three urban farming initiatives due to their inherently distinct governance and landscape management methods. The selected cases are:

1) Kebun Kumara, a privately owned urban farming focusing on environmental education and basic farming workshops.
2) The Indonesian Center for Vegetable Research and Quality Testing (BRMP Sayuran), a government-managed agricultural center emphasizing local food productivity and vocational training.
3) Kelompok Wanita Tani (KWT) Melati Curug Kulon, a community-based urban farming initiative focusing on household food security and social cohesion.

Furthermore, the selected urban farming initiatives have major differences in terms of operational objectives, stakeholder composition, funding structures, and spatial organization. The differences should render data variation, which is suitable for cross-case comparison regarding governance arrangements' effects on NbS performance.

2.1 Data Collection Methods

This study uses a qualitative descriptive approach, with field observation and semi-structured interviews conducted on August 15th, 2025 and August 29th, 2025. Each urban farming site's infrastructure, activities, and spatial arrangement were documented through direct observation

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into architectural drawings. Planting zone mapping, vegetation diversity, and supporting infrastructure were all included in observation activities. Semi-structured interviews were conducted. The following participants are being selected based on their roles in the governance structure of urban farming initiatives. Two participants were gathered from each case, consisting of farm managers, heads of community, and institutional representatives. Both community leaders and local stakeholders should embed a participatory framework in the program and its activities, while farm managers give operational insights in cultivation management and landscape maintenance. All respondents are expected to voluntarily participate and provide informed consent before interviews.

A purposive sampling approach was used to establish participants' roles in each case governance mechanism. Starting with:

1) Farm managers were selected to represent roles in operational planning, cultivation management, and resource allocation, and
2) Community leaders and institutional representatives were selected to provide collective insights on participatory methods within the community and, or institutional domain, including organizational hierarchy, decision-making processes, and program implementation.

The prior interview should last between 40 and 100 minutes, exploring major themes including governance structures, management routines, stakeholder participation, cultivation practices, distribution systems, environmental objectives, and perceived socio-ecological risks and assets.

To strengthen the findings, this study employed triangulation by comparing primary data from field observations, semi-structured interviews, and archival reviews. Observational findings on spatial organization, systems of cultivation, and infrastructural conditions were compared with interview results and institutional publications, including reports and other published materials. In addition, interpretative biases were reduced by identifying consistencies from thorough reading and comparisons among participants' statements.

turnitin Page 10 of 25 - Integrity Submission Submission ID trn:oid:::3618:156866261

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2.2 Analytical Framework

Natre-based Solutions frameworks as defined by IUCN and the European Commission are used to conduct analytical processes (Diana, 2025; FAO, 2021; IUCN, 2020). The following indicators related to governance:

1) Operational routine and activity procedures
2) Catalogue of plant diversity and species in relevance
3) Cultivation systems and their link to natural processes
4) Resource and management distribution mechanisms and accessibility
5) Public benefits toward the environment, social, and education.

Table 1 Governance-related indicators descriptions

Indicator	Operational Definition	Observed Variables	Data Source
Operational Routine	Temporal structure and scheduling in management activities	Maintenance scheduling, cycles of planting, staff involved, monitoring activities	Observation, interviews
Plant Diversity and Relevance	Catalogue of cultivated plant species and their roles (ecological and/or food-related)	Variation of crop, native species, types of plants, and polyculture methods	Observation, vegetation mapping
Cultivation System	Ecological integration degree in farming processes	Crop rotation, systems of irrigation, composting methods, monoculture/polyculture systems	Observation, interviews
Distribution Mechanism and Accessibility	Access to harvested products and participatory allowances	Community distribution chain, educational access, market access, and institutional access	Interviews, document review
Public Benefits	Length of socio-ecological contributions generated by urban farming activities	Environmental education, food security, social cohesion, public engagement	Interviews, observation

In the coding of primary data, such as interview transcripts, field notes, and observational data, this study adopted a qualitative comparative analysis. In Table 1, shows the selected methods aim to identify recurring themes related to governance systematization and accessibility, including participation mechanisms, operational continuity, ecological resources management, and socio-environmental benefits. The findings were organized into the analytical category of the NbS framework proposed by the IUCN and the European Commission. Furthermore, this study conducted cross-case comparisons of similar practices among the

turnitin Page 10 of 25 - Integrity Submission Submission ID trn:oid:::3618:156866261

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selected urban farming initiatives to identify governance-related assets and constraints that influence NbS implementation methods and management performance.

This framework provides a systematic comparison of how different governance models condition opportunities either/or constrain NbS performance in urban farming initiatives.

3. RESULTS AND DISCUSSION

These three sites illustrate how urban farming practices can serve as NbS. Their spatial organization, management focus, stakeholder participation, operational routines, and levels of community engagement differ significantly across cases.

3.1 Kebun Kumara: Private Sector Governance

Kebun Kumara is a privately owned eco-learning hub located within the Scientia Square Park (SQP) complex. Founded in 2016, the initiative seeks to reconnect citizens with nature through hands-on environmental education, and sustainable lifestyle workshops. The farm in SQP occupied approximately 1,200-1,500 m² of cultivated land as of December 2024. The landscape functions primarily as an urban farming showcase rather than a production-oriented farm.

Spatial organization includes an educational park, edible garden, management house, ornamental planting areas, green open lawns, rainwater-harvesting facilities, shaded seating areas, vegetable gardens, a workshop area, a pocket forest, a nursery, a chicken coop, and storage facilities, as shown in Figure 1 and Figure 2.

Regular activities at the farm include environmental education sessions, landscape demonstrations, and small-scale harvest events. In terms of their programs, Kebun Kumara hosts company workshops, corporate volunteering and CSR activities, structured after-school programs, and volunteer-based fieldwork support. Kebun Kumara also has design-and-build services and conducts environmental campaigns. These programs are implemented by a collective composting program from 2017 to 2023. Besides that, Kebun Kumara actively creates regular educational content on social media platforms (Kebun Kumara, 2024).

Management routines are organized into daily, weekly, and monthly activities. Watering, plant health checking, weeding, public area cleaning, and livestock feeding are carried out daily. Weekly routines include soil preparation, polyculture planting arrangements, replanting, composting, pruning, and selective harvesting. The monthly routines are evaluation, program

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scheduling, inventory planning, soil assessment, and infrastructure maintenance.

Kebun Kumara also organizes the working team's daily lunch using selected harvests. This practice reflects a strong commitment to food sustainability principles. Continuous production is maintained while also supporting ecological sustainability through crop rotation planning, a plant zoning system, and harvesting cycles. Plant selection considers seasonal conditions, educational purposes and vertical layering strategies.

Plant species vary across thematic zones. The cultivated plants are selected according to their roles as edible crops, educational plants, and experimental species. Representative plant species across different zones within Kebun Kumara are presented in Table 2.

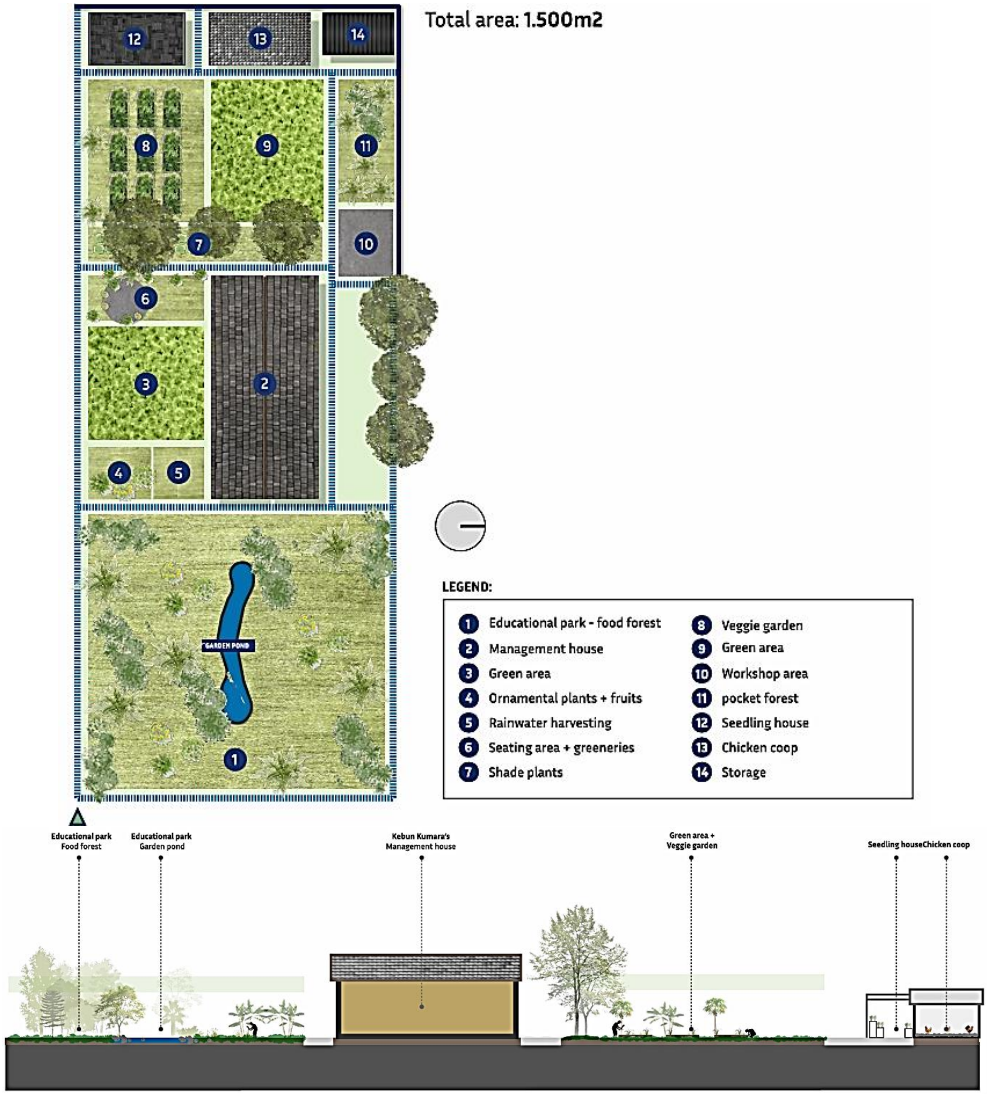


Figure 1 Kebun Kumara spatial organization

turnitin Page 13 of 25 - Integrity Submission Submission ID trn:oid:::3618:156866261

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Figure 2 Facilities of Kebun Kumara (1st row: rainwater harvesting facilities and water feature; 2nd row from left to right: seating area, nursery, workshop area; 3rd row from left to right: vegetable garden, chicken coops, management house)

Table 2 Representative species based on functional zone in Kebun Kumara

Zonation	Plant Type	Representative Species (Latin name-common name)
Shade plant	Trees (perennial)	*Schizolobium parahyba* (Brazilian fern tree); *Ficus religiosa* (Bodhi tree); *Melaleuca leucadendra* (Weeping paperbark)
Educational park (edible garden & perennial)	Trees	*Cocos nucifera* (Coconut); *Musa* sp. (Banana); *Carica papaya* (Papaya); *Plumeria sp.* (Kamboja); *Canarium indicum* L. (Walnut tree)
	Herbs & Flowers	*Helianthus annuus* (Sunflower); *Turnera subulate* (Yellow alder); *Orthosiphon aristatus* (Cat's Whiskers); *Cosmos caudatus* (Kenikir); *Cymbopogon* sp. (Lemongrass); *Ocimum citriodorum* (Lemon basil); *Ocimum tenuiflorum* (Holy basil); *Etlingera elatior* (Torch ginger); *Curcuma longa* (Turmeric); *Moringa oleifera* (Moringa); *Coleus amboinicus* (Mexican mint); *Bergera koenigii* (Curry leaves)
	Tuber crops	*Manihot esculenta* (Cassava); *Alpinia galanga* (Galangal)
Green area	Herbs garden	*Mentha* sp. (Mint); *Stevia rebaudiana* (Sweetleaf)
Veggie garden	Vegetables & tuber crops	*Ipomoea aquatica* (Water spinach); *Spinacia oleracea* (Spinach); *Ipomoea batatas* (Sweet potato); *Arachis hypogaea* (Groundnut); *Solanum melongena* (Eggplant); *Capsicum annuum* (Cayenne pepper); *Sorghum bicolor* (Sorghum); *Brassica rapa chinensis* (Bok choy)
Ornamental plants & fruits	Flower	*Tagetes erecta* (Marigold); *Clitoria ternatea* (Butterfly pea)

Data collected in August 2025

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turnitin Page 13 of 25 - Integrity Submission Submission ID trn:oid:::3618:156866261

turnitin Page 14 of 25 - Integrity Submission Submission ID trn:oid:::3618:156866261

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Within the shade plant zone and the educational park, perennial tree varieties are cultivated to help regulate the microclimate. Perennial vegetation contributes to ecosystem stability while supporting multifunctional land use (Aduloju *et al.,* 2024; Cilliers *et al*., 2020). Meanwhile, annual crops are primarily concentrated in the veggie garden with rotational crops to ensure a continuous food supply. Rotational cropping is a key strategy for enhancing food security in urban farming systems (Chaminuka *et al*., 2021; Payen *et al*., 2022).

The vegetable garden requires more frequent crop rotation, particularly for annual species such as water spinach, spinach, lettuce, bok choy, and mustard greens. Frequent crop rotation supports both productivity and soil health, while allowing flexibility to meet daily consumption needs (Mamun *et al.,* 2023; Tomatis *et al*., 2023). Mixes of multiple species within the same planting zone will accelerate rotation cycles and enhance on-site biodiversity.

Biodiversity management is strengthened through harvest planning based on estimated maturation periods. The working teams have to continuously estimate the cycles of harvesting, replanting, and seedling. Harvest frequency varies depending on crop type and daily consumption needs. Plants that are consumed in small quantities, such as pandan, mint, and turmeric are harvested daily. Brazilian spinach is harvested weekly, and moringa is harvested monthly. Seasonal fruit crops, including tomatoes, chili peppers, melons, watermelons, and papaya are harvested according to their growing cycles.

Plant diversity is designed to mimic forests through the polyculture systems that can also reduce vulnerability to pests and diseases. Vertical layering combines trees, shrubs, groundcover, and climbing plants to maximize spatial efficiency, ensure harvest continuity, and support organic pest management. Different plant species also extract varying nutrients from the soil, reducing competition and improving overall soil health. The placement and layering system is arranged based on solar orientation to optimize plants' growth. These practices are aligned with ecological integration principles within the NbS framework (Diana, 2025; IUCN, 2020).

3.2 BRMP Sayuran/Balitsa Serpong Farm: Governmental Governance

The Indonesian Center for Vegetable Research and Quality Testing (BRMP Sayuran) is located in the Pagedangan subdistrict, Tangerang Regency. Formerly known as the Indonesian Vegetable Research Institute (Balitsa), this initiative represents a municipal model within a structured bureaucracy. BRMP Sayuran Farm operates to support food productivity, agricultural training,

turnitin Page 14 of 25 - Integrity Submission Submission ID trn:oid:::3618:156866261

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and educational activities by providing internship (PKL) programs for agricultural vocational high school (SMK Pertanian) and nearby universities (BRMP Sayuran, n.d.).

The area is approximately 30,000 m² and divided into 11 plots. Each plot is dominated by monoculture with rotational practices. In August 2025, two vacant plots were available for lease, and the remaining land was under cultivation. The vacant plots were used by local farming communities in 2021, but this only lasted for one year.

Across the land, several varieties such as corn, chili, and leafy vegetables are cultivated. On the raised planting beds especially in the peanut farm zone, the varieties are planted in smaller plots (Figure 3). Adjacent to the management office, there is a food crop garden used as a demonstration plot for vocational high school (SMK) students' training activities. The area is planted with cauliflower, eggplant, chili peppers, mango trees, and other seasonal crops.



Figure 3 BRMP Sayuran/Balitsa Farm spatial organization

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SCOPUS ID: 21101257967

Every day, the staff maintain the farm through irrigation, fertilization, and pest control activities. Planting and harvesting are conducted weekly. Every month, the agendas include evaluation, research coordination, and training preparation. Staff and technicians are assigned to produce seeds, manage crop trials, and prepare plots for training purposes.

The farm manages rotational crop systems to prevent nutrient deficiencies caused by monoculture systems. Crop rotation also helps reduce soil degradation. To ensure continuous productivity, the varieties are selected based on their fast-harvesting periods and pest-resistant. This consideration aligns with NbS principles that optimize natural processes and sustain ecosystems (Payen *et al*., 2022; Tomatis *et al*., 2023). However, the monoculture system with rotational crops remains a conventional agricultural practice. The crop distribution across the BRMP Sayuran Farm reflects its functional zoning for seed production, crop cultivation, and training activities. As shown in Table 3, different zones are allocated for specific crop groups, including vegetables, food crops, fruit trees, and field-margin species.

Table 3 Crop Distribution by zone in BRMP Sayuran Farm

Zone	Plant Type	Representative Species (Latin name-common name)
Seedling area	Spice	*Allium cepa* (Shallot); *Capsicum frustescens* (Green chili)
Food crop garden	Vegetable	*Brassica oleracea* var. *botrytis* (Cauliflower); *Brassica oleracea var. italica* (Broccoli); *Brassica juncea* (Mustard Greens); *Moringa oleifera* (Tomato); *Capsicum annuum* (Cayenne Pepper); *Vigna unguiculata* (Long bean); *Solanum melongena* (Eggplant)
	Tree	*Mangifera indica* (Mango)
Corn farm	Crop	*Zea mays* (Corn)
Chilli farm		*Capsicum frustescens* (Green chilli)
Peanut farm		*Arachis hypogaea* L. (Peanut); *Glycine max* (Edamame); *Ipomoea aquatica* (Water spinach); *Spinacia oleracea* (Spinach)
Avocado farm		*Persea americana* (Avocado)
Field margins		*Carica papaya* (Papaya); *Musa* sp. (Banana tree)

Data collected in August 2025

Water is supplied through groundwater pumps and the municipal water system (PDAM). The crops depend on daily chemical fertilizers and pesticides to increase the harvest productivity rather than maintain ecological balance. This approach is commonly observed in institutional urban farming systems (Mamun *et al*., 2023). Figure 4 illustrates key components of the BRMP Sayuran Farm, including the food crop garden, groundwater pump, and chilli cultivation area.

Urban Farming as Nature-Based Solutions: Comparative Governance Models from Tangerang Regency, Indonesia
Diana, Franjaya, Maulidyah, Rahardjo, Lorizkian, Stephanie, Candra, Subhan
p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 9, Number 2, page 534-554, October 2026
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SCOPUS ID: 21101257967



Figure 4 BRMP Sayuran/Balitsa farm (from left to right: food crop garden, water pump, chilli farm)

Public activities such as visits from the nearby school are tentatively scheduled. During harvest seasons, affordable harvest sales will be held at least once a week. These activities demonstrate the potential social benefits of urban agriculture. Similar social values within urban agriculture in previous studies are reflected in food access, learning opportunities, and community interaction (Zutter & Stoltz, 2023; Chaminuka *et al.*, 2021; Ichioka, 2016). Although BRMP Sayuran Farm also has potential social co-benefits, these aspects are not yet fully integrated into broader urban environmental agendas.

3.3 KWT Curug Kulon: Community-Based Governance

The community-driven model can be observed in the Kelompok Wanita Tani (KWT) Curug Kulon in which the nearby residents actively collaborate to manage the program. Through this effort, previously unused land could be repurposed into a versatile green area that supports food cultivation, educational activities, and participatory community management (Diana *et al.,* 2026). Similar patterns can also be found in many urban agriculture projects driven by local communities throughout the Global South (Chaminuka *et al.,* 2021; Kanosvamhira, 2019; Zutter & Stoltz, 2023).

The site spans approximately 2,500 m^2 and includes a nursery house, vertical geoponic structures, vegetable gardens, food crop plantations, raised planting bed zones and unplanted areas. In Figure 5 shows, the KWT integrates conventional soil-based cultivation with vertical farming systems to optimize limited urban space, reflecting adaptive strategies as documented in urban farming literature (Jayne, 2025; Payen *et al.*, 2022).

Urban Farming as Nature-Based Solutions: Comparative Governance Models from Tangerang Regency, Indonesia
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SCOPUS ID: 21101257967



Figure 5 KWT Curug Kulon Farm (from left to right: nursery house, vertical geoponic, raised planting bed)

Two plots, the nursery house and the vertical garden were developed through external grant funding and are integrated with an irrigation system powered by a groundwater pump. There are ground-based cultivation areas surrounding the plots that are managed by KWT members. Several vacant plots are also leased to the local community. These spatial arrangements can be gradually activated for food production while preserving them for future use (Aduloju *et al.*, 2024). The spatial organization of the site reflects the functional allocation of cultivation, nursery, communal, and supporting areas within the community-managed farm, as illustrated in Figure 6.

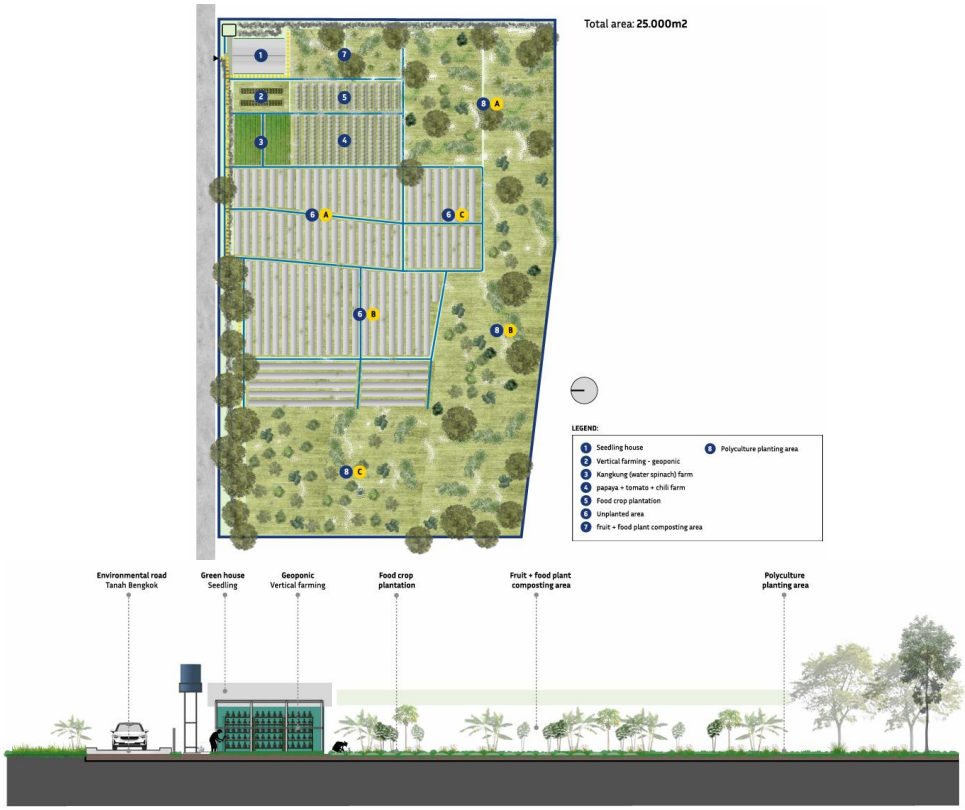


Figure 6 BRMP Sayuran/Balitsa Farm spatial organization

Urban Farming as Nature-Based Solutions: Comparative Governance Models from Tangerang Regency, Indonesia
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SCOPUS ID: 21101257967

All decisions are made through regular group meetings, where members together determine crop selection, and planting schedules. Daily management is shaped by household needs as well as seasonal conditions, with operations carried out through voluntary labour and mutual cooperation. These practices maintain community-based urban farming systems that strengthen social ties and reinforce the community's sense of belonging (Ichioka, 2016; Kanosvamhira, 2019; Sharif & Ujang, 2021).

KWT members and local stakeholders determine the crop varieties especially for the healthy meal programs organized by community-based health service posts (Posyandu) (Diana *et al*., 2026). Meanwhile, the farm also supports educational activities for nearby kindergartens. When yields exceed local demand, harvests are sold through informal distribution channels such as mobile vegetable vendors. This practice is commonly observed in community-based urban food systems (Tabrez & Behera, 2025; Zutter & Stoltz, 2023). However, most harvests are primarily used to meet local needs.

The farm relies on a crop rotation system. The plantations are mainly selected based on short harvest periods, such as water spinach, cucumber, and long bean. These crops are commonly cultivated in small-scale urban farming systems (Mamun *et al*., 2023; Tomatis *et al*., 2023). Some crops may be harvested daily, while others depend on their maturity period. Harvest periods are usually scheduled every two weeks during the KWT members' monitoring and evaluation meetings. In these meetings, KWT members manage the rotational picket system (Table 4.).

Table 4 Main cultivated crop in KWT Curug Kulon Farm

Zone	Plant Type	Representative Species (Latin name – common name)
Vertical Farming	Fruit & Vegetable	*Solanum melongena* (Eggplant); *Moringa oleifera* (Tomato); *Capsicum annuum* (Cayenne Pepper); *Ipomoea aquatica* (Water spinach); *Fragaria x ananassa* (Strawberry)
Water spinach farm	Crop	*Ipomoea aquatica* (Water spinach)
Papaya + tomato, chilli (raised planting bed zone)		*Cnidoscolus aconitifolius* (Japanese Papaya); *Moringa oleifera* (Tomato); *Capsicum annuum* (Cayenne Pepper)
Food Crop Plantation		*Cucumis sativus* (Cucumber); *Brassica chinensis* (Bhok coy); *Moringa oleifera* (Tomato); *Vigna unguiculata* (Long beans)
Field margins	Tree & Flower	*Musa* sp. (Banana tree), *Clitoria ternatea* L. (Butterfly pea)

Data collected in August 2025

The farm has operated since March 2025 and demonstrates multifunctional benefits in food production, children's education, and the provision of communal space. The farm also offers

turnitin Page 20 of 25 - Integrity Submission Submission ID trn:oid:::3618:156866261

p-ISSN 2579-9150; e-ISSN 2579-9207, Volume 9, Number 2, page 534-554, October 2026
Accredited SINTA 1 by Ministry of Higher Education, Science, and Technology of The Republic of Indonesia No. 295/C/C3/KPT/2026 on January 2nd, 2026 from October 1st, 2024 to April 31st, 2029
SCOPUS ID: 21101257967

social benefits by providing interaction spaces and engaging local community members. This practice is in line with studies highlighting the social benefits of urban agriculture (Cilliers *et al*., 2020; Diana *et al*., 2026; Mohd Sharif & Ujang, 2021).

3.4 Comparative Discussion of Governance Models

This study uses five related indicators to examine how governance arrangements influence NbS performance. The governance-related indicators are operational continuity, plant diversity and food relevance, cultivation systems, distribution mechanisms, and public benefits (sTable 5).

Table 5 Comparative urban farming governance models and NbS performance

Category	Kebun Kumara	BRMP Sayuran/Balitsa Farm	KWT Curug Kulon Farm
Governance Model	Private	Governmental	Community-based
Primary Function	Environmental education & demonstration model	Agricultural training & research	Local food security & social inclusivity
Operational Continuity	High (routine maintenance, structured programs)	High (institutionally supported)	Moderate (community-based scheduling)
Plant Diversity & Food Relevance	High (polyculture & edible species)	Moderate (crop production)	Moderate (local food crops)
Cultivation System	Permaculture, soil-based polyculture	Monoculture with rotational systems	Soil-based & vertical systems
Distribution & Access	Limited (internal use)	Limited public access (institutionally mediated)	High (direct distribution)
Main NbS Contributions	Environmental awareness, biodiversity education	Agricultural productivity and technical training	Local food access, community empowerment
Main Constraints	Limited inclusivity & visitor dependence	Limited participation & low ecological diversification	Limited technical and financial capacity
Overall NbS Performance	High ecological & educational performance	Partial NbS alignment	High socio-community performance

To conclude, the governance structures play a decisive role in determining NbS effectiveness. The private model excels in environmental education through permaculture principles and awareness-oriented landscape design. However, it highly relies on visitor participation and financial feasibility. The governmental model represents research-based practices but remains limited to food production activities. The initiative also remains less connected to broader environmental and social goals. These conditions oppose studies in the Global South that

turnitin Page 20 of 25 - Integrity Submission Submission ID trn:oid:::3618:156866261

Urban Farming as Nature-Based Solutions: Comparative Governance Models from Tangerang Regency, Indonesia
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SCOPUS ID: 21101257967

emphasize sustained participation to achieve resilient urban food systems (Kanosvamhira, 2019; Kanosvamhira & Shade, 2025). In contrast, the community-based model fosters inclusivity and social empowerment (Diana *et al.,* 2026). The three governance models demonstrate the multi-scalar nature of NbS in urban contexts. The various potential benefits highlight the importance of institutionalizing the participation mechanisms to widen urban sustainability agendas (Chaminuka *et al.,* 2021; Tabrez & Behera, 2025).

4. CONCLUSION

Urban farming cannot automatically be considered as an NbS. Previous studies mainly examine urban farming from a food production perspective. However, urban farming may also be analysed from a governance perspective, especially in shaping community participation, operational continuity, and socio-ecological balance. The findings show that different governance models result in different environmental and social outcomes. However, this study has some limitations. First, the research was conducted within a specific period and may not fully describe governance dynamics or seasonal crop variations. Second, the limited research area may not fully reflect broader socio-political and environmental conditions. Third, the limited number of selected cases may create selection bias and restrict broader conclusions. The transferability of the findings may also be influenced by other contextual factors such as institutional capacity, land availability, funding feasibility, policy support and community participation levels. Urban agriculture may be integrated into green space infrastructure through spatial planning regulations. However, translating these policies into operational NbS remains a critical challenge. The findings indicate that each governance structure applies NbS principles differently in practice. In an urban-peri-urban context, governance flexibility and stakeholder collaboration should be considered in spatial planning policies. Policymakers should encourage hybrid governance arrangements that combine institutional support, community participation, and ecological awareness. Perhaps, the collaboration will support the multifunctionality, accessibility, and long-term sustainability of urban NbS.

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Urban Farming as Nature-Based Solutions: Comparative Governance Models from Tangerang Regency, Indonesia
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SCOPUS ID: 21101257967

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