# Contribution of urban farms to urban ecology of a developing city

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**Abstract.** Urban ecology has become a more popular concern as the awareness for mutual sharing between humans and other ecosystem members is increasing. This study aimed at assessing the value of urban farms in the city of Makassar, a fast-developing Indonesian city which according to its city council classification covered significant area of the city. The research employed Rapid Biodiversity Assessment (RBA) to assess quality of urban farms. The method assessed two important aspects of spaces in terms of ecology *i.e.* vegetation structures and vascular plants. Results showed the biodiversity of urban farms in Makassar compared to other typologies was high. Urban farms in Makassar in general have potential for ecological spots because despite they are more cultural than natural, their high plant biodiversity score, dominance of trees and less built areas make them always available for improvement to become more ecological spots.

## 1. Introduction

Urban areas are now main habitat for people in this planet. The fact that urban areas only covers around 3% of earth's space, does not limit the more than 50% world population to reside in them [1, 2], it equals to around 3 billion people of the 21st Century's first decade [3]. Urbanization has become the inevitable results of urban development, forming cities, peri urban and urbanized rural areas. To define a city, it is a district within urban areas with powers and corporate status of self-government. It is relatively large in size and become the home for a range of population size and background. On the other hand, urban region is a city plus its surrounding areas with all connections and interactions in between [3]. Other distinction character of a city is the population size, an area can be considered as urban when there are at least 150 people living within a square kilometre area [4].

Human occupancy has resulted in dynamic changes which include economy, society, culture and technology which all aimed at increasing life quality of the urban residents. However, development always has inevitable implications to the environment and other biotic components, hence affected ecosystem ecology [5] which tend to threaten the natural sites [6] through habitat fragmentation [7][8]. As a result, urban areas tend to become improving in economy but declining in ecological quality. Urban development relates with land use conversion, and among many types of lands that tend to be 'sacrificed' is agricultural land or in other term urban farms.

Several concepts for ecological improvement in urban areas have been introduced [9] all targeting at the improvement of spaces in urban area that favor the interests for creation of habitat for all possible

species besides human [10]. The intention is not to stop urban development, but how to preserve the ecological function of urban area whilst developing [9].

Being a developing country, Indonesia has many growing cities and urbanizing area. One of big cities and the biggest in Eastern Indonesia is Makassar. This city needs preservation of its natural areas, to maintain their existence and function while the city is still developing [11]. The growing infrastructure and built areas in cities has unfavorably affected the existence of productive sites such as urban farms. It has been observed in may big cities in Indonesia such as Depok [12], Bandung [13], Yogyakarta [14], Tegal [15], Malang [16], Bali [17] and also observable in Makassar [18, 19]. It could be seen as a disadvantage as urban agriculture is one of strategic resources which are valuable in many terms such as economy, social and environmental terms [20].

Despite some thoughts regarding agricultural activities to be more cultural than natural, in environmental perspectives agriculture sites in general are more compatible with principle of environmental preservation, not to mention the intrinsic values of agriculture sites as preservation of biodiversity and for educational purposes [15]. Even agriculture sites are not really natural, their existence preservation within urban area at least will limit the expansion of built structures within.

Therefore, it is necessary to understand the state of urban farms within a city, and this paper select Makassar to study how is the existence of them and what values they have that might contribute to ecology of the city. One important parameter of ecology is the state of biodiversity, as many definitions of biodiversity emphasizes on existence living organisms as the main component with ecological complexity [21, 22].

In terms of application, biodiversity assessment in general comprises both animal and plant species [23], for urban context, biodiversity relates with the existence of natural sites (or its remnants), cultural and even artificial. Understanding the intensive human interaction in urban sites, it might not be significant to expect species of wild animal within, therefore urban biodiversity state could be assessed by regarding two factors: vegetation structures and vascular plants diversity. These two factors should be able to represent the general state of biodiversity since structure of vegetation determines habitat complexity and many studies have indicated the complexity and composition of habitat are acceptable indicator of biodiversity in general [24]. Additionally, vegetation structural composition of habitats in urban areas could be used as substitute in assessing their biodiversity [25] and coverage of vegetation is an important contributors to ecological health and hence is indicative of wildlife habitat and ecological value through their vegetation attributes [26]

This paper presents the study and assessment on biodiversity of urban farms in the city of Makassar, using a Rapid Biodiversity Assessment (RBA) developed by Tzoulas and James [24] in order to get general description of biodiversity state of urban farms and how they can be improved for their ecological contribution, because according to Iswoyo *et al.* [11] assessment of biodiversity could be taken as the first stage of assessment of urban ecology.

## 2. Research Methodology

### *2.1. Urban Farm Identification among Urban Spaces*

One of common land use in urban areas is agriculture sites, it has been a common classification and be adapted with various terms including urban farm. This study adapted the classification of spaces which was developed through aerial and ground observation and defined in form of typologies [9]. The urban farm is classified as one of patches in Makassar and defined as '*Areas which are used for farming by people living nearby, mostly with seasonal plants, including paddy fields*'[9 p.9]. Based on that classification, all spaces in the city are digitized and defined with GIS which urban farms later are surveyed for field observation and assessment. Sampling locations are determined based on farming types as seen through aerial photograph and based on secondary references. The number of sampling points for each urban farm location is determined based on variabilities of land coverage as seen through aerial photograph and covered at least 10% of the area. This study identified 186 spots of urban farms within the city, and the distribution based on district can be in table 1 and figure 1.

**Table 1.** Identified urban farm in Makassar based on spatial observation and randomized ground confirmation

| District and Type of Urban Farm | Area (hectare) |
|---|---|
| **Biringkanaya** | **770.31** |
| Farm field | 215.21 |
| Paddy field | 288.50 |
| Paddy field and farm | 248.68 |
| Plantation | 17.92 |
| **Makassar** | **3.44** |
| Farm field | 3.44 |
| **Manggala** | **837.97** |
| Farm field | 229.08 |
| Paddy field | 578.67 |
| Paddy field and farm | 30.23 |
| **Panakkukang** | **40.50** |
| Farm field | 1.81 |
| Fish pond, farm | 5.78 |
| Mixed Agriculture field | 32.91 |
| **Rappocini** | **14.80** |
| Farm field | 3.54 |
| Paddy field | 11.26 |
| **Tallo** | **18.43** |
| Farm field | 18.43 |
| **Tamalanrea** | **548.75** |
| Farm field | 238.11 |
| Paddy field | 143.29 |
| Paddy field and farm | 167.35 |
| **Tamalate** | **614.08** |
| Farm field | 97.53 |
| Paddy field | 516.55 |
| **TOTAL** | **2848.28** |

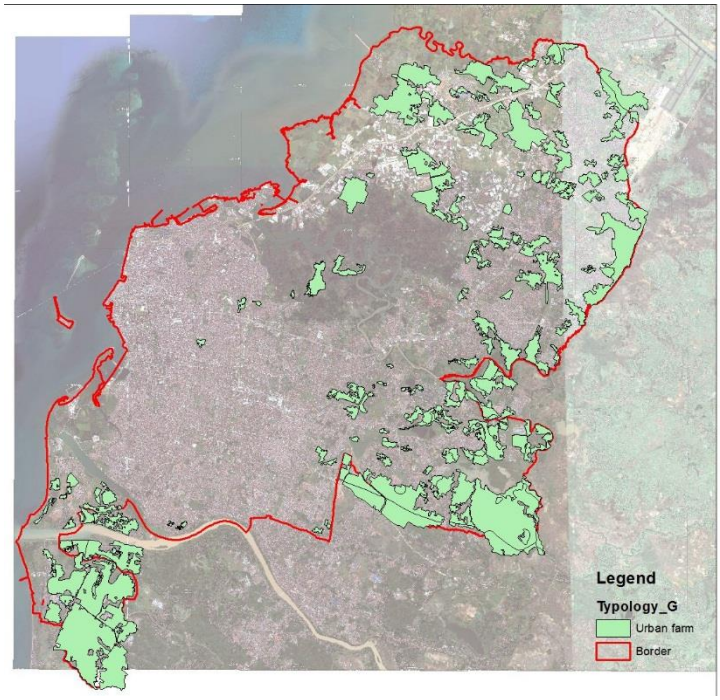


**Figure 1.** Distribution of urban farms in Makassar

Among all those identified urban farm spots, this study selected 11 spots that were taken as sampling points which represent few locations and 4 dominating districts. The selection was based on the type of identified farms, and pattern variation based on aerial observation.

*2.2. Biodiversity Scoring with Urban Rapid Biodiversity Assessment (RBA) method*
This method was developed by Tzoulas and James [24] based on a study in the UK. This method was adapted and adjusted to local developing and tropical context. It consists of several stages.

*2.2.1. Development of Field Sheet Record*. A sheet to guide the surveyor in performing vegetation structure assessment. All structures are prescribed based on the composition and height variability of trees, shrubs, forbs and grasses as well as built structures and water features in an area. The structures were assessed for their Domin value [27].

*2.2.2. Vascular plant checklist development.* The study could not obtain existing list of vascular plants in Makassar, therefore the study developed a list based on vascular plant species recorded at the survey locations.

2.2.3. *Assessing land coverage by vegetation structure and diversity of vascular plants*. This stage consists of three main activities: determining sample size, number of sampling points, and recording vegetation structure as well as vegetation diversity.

*2.2.4. Recording of vegetation structures and diversity of vascular plants*. This stage started by defining visual horizons of each sampling location, then from consistent exact position, structures of vegetation, built and water bodies were recorded for their dominance. After Domin value of each structure is recorded, vascular plants were identified and recorded into a vascular plants list.

*2.2.5. Combining all indicators into a biodiversity score.* Using approach developed in Tzoulas and James [24] a final score calculation produced scores of each sampled location of urban farms in Makassar.

## 3. Results and Discussion

*3.1. Biodiversity Score*.
As a city that keeps growing and developing, Makassar only has little space for agricultural fields. Most urban farms in Makassar are located in the urban fringe and only few are within the city area. Results of biodiversity assessment conducted in 6 locations and 11 sampling points is presented in table 2, locations of sampled urban farms are shown in figure 2.

As seen in figure 2, most urban farms are in the fringe of Makassar. There are some scattered patches of farms more towards the centre of the city although they are not significant in size. These farm spots are possible remnants of previous large agricultural fields. Those fields were encroached and fragmented due to construction of infrastructure development. Understanding the development trend, there is no guarantee that they will still be exist in the further future. Most of urban farms sampled in this study are privately owned, or under collective ownership. These statuses clearly posed a 'threat' for the farms for possible conversion in the future. It is a common thing due to civilization which tend to cause agricultural landscapes to contain only small isolated patches [28]. On the other hand, some mentioned agriculture sites to be the cause of natural sites fragmentation [29, 30]. This of course will need to be seen from the perspective of how the urban farms are formed and the direction of conversion. Creating farms out of natural forest would of course be negative, but preserving farms from conversion to a shopping mall will certainly be positive in ecological perspectives.

**Table 2**. Biodiversity score of each urban farm sampling point.

| Location Name and District | Sampling point No. | Vegetation Structures Scores | | | | | | | | Number of Vascular Plants | Bio-diversity score |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | High trees | Low trees | Bushes | High grasses and forbs | Low grasses and forbs | Ground flora | Aquatic | Built | | |
| Baddoka (Biringkanaya) | 01 | 4 | 1 | 2 | 2 | 7 | 2 | 0 | 0 | 11 | 13 |
| Baddoka (Biringkanaya) | 02 | 7 | 2 | 2 | 3 | 5 | 2 | 0 | 1 | 15 | 15 |
| Baddoka (Biringkanaya) | 03 | 8 | 5 | 4 | 3 | 6 | 5 | 0 | 0 | 17 | 14 |
| South of BTP (Tamalanrea) | 04 | 1 | 1 | 2 | 0 | 7 | 1 | 2 | 1 | 18 | 15 |
| Bukit Baruga (Manggala) | 05 | 1 | 1 | 2 | 6 | 7 | 0 | 1 | 2 | 34 | 17 |
| Antang (Manggala) | 06 | 6 | 3 | 3 | 2 | 2 | 4 | 2 | 0 | 25 | 17 |
| Antang (Manggala) | 07 | 8 | 7 | 7 | 7 | 6 | 7 | 0 | 0 | 41 | 18 |
| Antang (Manggala) | 08 | 1 | 1 | 3 | 5 | 6 | 1 | 2 | 1 | 32 | 19 |
| Borong (Panakkukang) | 09 | 2 | 2 | 3 | 3 | 3 | 9 | 5 | 3 | 30 | 16 |
| Urip Sumoharjo (behind Finance Bld) (Panakkukang) | 10 | 3 | 2 | 4 | 2 | 3 | 3 | 1 | 6 | 42 | 14 |
| Urip Sumoharjo (behind Finance Bld) (Panakkukang) | 11 | 5 | 2 | 2 | 1 | 2 | 2 | 5 | 2 | 27 | 17 |
| *Total* | | 46 | 27 | 34 | 34 | 54 | 36 | 18 | 16 | 292 | **175** |
| *Average* | | 4.18 | 2.45 | 3.09 | 3.09 | 4.91 | 3.27 | 1.64 | 1.45 | 26.55 | **15.91** |

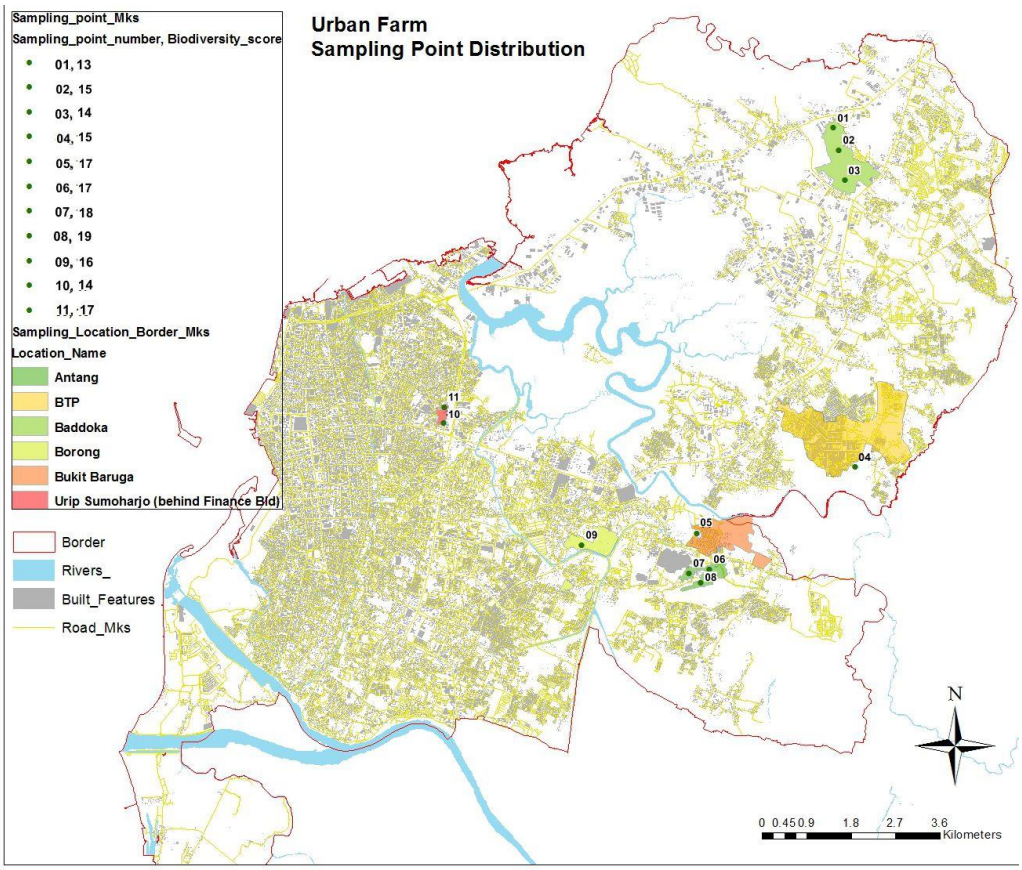


**Figure 2.** Sampled urban farms in the city of Makassar.

The following figures show the appearance of selected surveyed urban farms in Makassar and the structures of vegetation recorded in panoramic photographs.


**Figure 3**. Aerial view of two urban farms in Makassar

**Figure 4.** Panoramic views of a vegetable farms in Makassar

Regarding the biodiversity score, the average score of all sites are 15.91. Based on the original method of RBA, there is no range of 'high', 'medium' or 'low' class for score of individual site or typology. The scoring purpose is for comparing the results with other sites or typologies. In order to see how is the biodiversity of urban farm in Makassar, we compared it with scores of other typologies of spaces in this city from other study. Based on the results of scoring of other typologies [11], the score range between the lowest and the highest was 4 – 16. Therefore, using deviation standard for making 3 classes (high, medium and low) the score of urban farm in this study could be classified 'high'. As for vegetation structure, high trees is more dominant than other structures and average number of recorded vascular plants (26) can be considered good compared to the results found in [24].

Being one type of most fragile agriculture field, paddy fields are actually important ecosystem for some animal species. It is very common for most paddy fields in Indonesian also deliberately culture various species of fish such as 'Nila' (*Oreochromis niloticus*), 'Mas' (*Cyprinus carpio*), 'Bandeng' (*Chanos chanos*), and various edible crabs. Other common non consumable animals usually reside in paddy fields are some reptiles, frogs, some species of birds and small mammals [31]. As paddy fields normally connected to rivers through irrigation lines, they have potential to also harbor varieties of river fishes. Fish existence in paddy fields also help farmers in predating insect larvae of potential pests, and their wastes could increase soil fertility [32]. Additionally, the significance of paddy fields as habitat for various plants and animals also reported [32]. Some of them as also found in this study are *'kangkung'* (*Ipomoea aquatica* Conv.), '*Semanggi*' (*Marsilea crenata* Mars) and '*Genjer*' (*Limnocharis flava* Limn).

**Figure 5.** Panoramic views of two paddy fields in Makassar.

*3.2. Further Improvement for the Sake of Ecology*

For a city like Makassar where green spaces are limited, the existence of land that is still a working urban farm is a potential for ecology and hence need to be preserved.

Human activities whatsoever are dominant in agriculture, therefore, potentially pose disruption to the natural system. Apart from that, vegetation in urban farms are dominated by agricultural crops and cultivated plants, both are not favorable components of a natural ecological habitat. Consequently, as this study also observed, they have low potential in terms of habitat function. However, they still have value as green areas and functioning accordingly, if that they can be preserved from conversion. It is due to the fact that vegetation diversity is quite high as reflected from the recorded vascular plants, although they are rather cultural than natural.

At locations in Antang, tree coverage in the farms is quite good, at least of course it is justifiable to expect usual environmental services provided by trees such as mentioned in [33, 34, 22]. Another promising feature of urban farm for urban habitat is the absence of built structures.

Agricultural fields, especially paddy fields, are open poor in plant diversity other than the cultured varieties. The openness of paddy field makes them less feasible to serve as a site of refuge for wildlife. However, there is an opportunity as paddy fields have non-planted areas as well as the borders that might be optimized by planting vegetation with specific ecological function and uses. According to USDA guidelines [35], "*conservation buffers are strips of vegetation planted in the landscape of fields to effect ecological processes favorably and provide a variety of goods and services to people and the ecosystem*".

**Figure 6.** Conservation buffer in agricultural fields [35].

For agriculture fields around streams or rivers, setting up these buffers would act as barriers that protect the water bodies from spray drift which may harm non-target species as well as poisoning stream water. Moreover, conservation buffers could serve as homes for beneficial insects. In the event of overflow, these buffers can slow the run off and absorb excess water, hence farm fields are less threatened by flooding [35].

## 4. Conclusion

Despite the area is declining due to development of the city, urban farms in Makassar still exist and provide benefits in economy, culture and ecology. Although in general urban farms have been strongly influenced by human intervention which result in causing them to become more cultural and less natural, their high plant biodiversity score, status as green areas and less built structure around them giving them great potential for future development to become better sites for ecology, ecosystem and urban habitats.

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