The dynamic changes in peri-urban agricultural area and typology of multi-function agriculture in Batu City, Indonesia

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Abstract. Urbanization and population growth are logical consequences for economic growth and regional development. In the face of the pressure of urbanization, both in the form of competition for land use and increasing food needs, an adaptation effort of the agricultural system is needed. This study analyzes the patterns of in-situ urbanization that occurred in Batu City, East Java, and the dynamics of the development of agricultural areas in Batu City. This study used land use change analysis, descriptive statistics on socio-economic data, and spatial clustering analysis to map and obtain a relationship between in-situ urbanization processes that occur with the development of agricultural areas in Batu City. The results of this study indicate that there was a strong relationship between the process of in-situ urbanization that occurred in Batu City towards changes in agricultural land use and resulted in the adaptation of a multifunctional farming system in Batu City. There are three types of multifunction agriculture in the Batu City, with focused on incorporating the tourism and agriculture, and create a strong social-environmental awareness of the sustainability development. The development of multifunctional agriculture in Batu City is one of the main strategies to face of current in-situ urbanization.

1. Introduction
The process of urbanization is not limited to the movement of population from villages to cities, but also describes the growth of population in urban areas as a result of the growth and development of urban society [1], [2]. With the increasing rate of urbanization, it is projected that in 2020, 55% of the human population will live in urban areas and will continue to increase to 60-70% in 2050 [3]. The growth of urbanization in Indonesia is concentrated in Java [4]. Between 2000 and 2010, all provinces on Java Island experienced higher urbanization rates (60.8%) compared to other provinces in Indonesia [4]. The leading causes of urbanization in Indonesia are (1) economic improvement and industrialization; (2) regional autonomy; and (3) economic crisis [4].

Previous literatures [2], [3], [5] conclude that agriculture in the future will face urbanization pressures in meeting rising food demand. Besides, agriculture in urban areas also faces challenges to create sustainable agriculture that can prevent poverty in agricultural actors around urban areas. Agriculture in urban and surrounding areas, known as the concept of urban agriculture, has an essential role in achieving food security and supporting the welfare of farmers in the region [5], [6].

One of the metropolitan areas in Indonesia that have experienced rapid in situ processes of urbanization and urban growth in the last ten years is the Malang Raya metropolitan area [7], [8]. The
Greater Malang metropolitan area is centred in the city of Malang as the centre of the urban area, and Batu City as the peri-urban area. Batu City, as a peri-urban area, experiences very rapid development in infrastructure development, especially tourism and agriculture supporting infrastructure. Previous research shows that the development of Batu City were focusing towards the development of tourism [9] and the development of agricultural commodities [10].

The in-situ urbanization process in Batu City has an impact on changes in environmental quality. Some of the negative impacts due to changes in environmental quality include reduced water catchment areas, increased soil erosion, and sedimentation due to reduced land cover, reduced productive agricultural land, and decreased habitat quality for agricultural activities. To overcome these negative impacts, it is necessary to develop a multi-functional urban agriculture system supported by spatial planning policies, policies in the macro economy and environmental protection policies. The regional development planning can be approached with the multifunctional urban agricultural system based on ecological, economic and social sustainability. This study analyzes the patterns of in-situ urbanization that occurred in Batu City, East Java, and the dynamics of the development of agricultural areas in Batu City as a response to the in-situ urbanization process. Furthermore, this study also identifies the typology of multifunction agriculture that developed in the Batu City.

2. Material and methods
This research consists of two types of analysis, namely the land use change analysis, and the identification of typology of multifunction agriculture that developed in the Batu City.

2.1. Research area
This research will be conducted in Batu City area and two sub-districts in Malang Regency, East Java Province (Figure 1). Batu City is one of the cities in East Java Province which has experienced rapid economic growth in the last decade [11]. Administratively, Batu City is divided into 3 (three) Districts, namely Batu District, Junrejo District and Bumiaji District, which are detailed in 20 villages and 4 sub-districts. Batu City is located on the lower slopes of Mount Panderman, Mount Arjuno and Mount Welirang. Based on the geological structure, Batu City is formed from volcanic formations which are dominated by Andisols and Inceptisols which are rich in soil organic matter so that it is fertile which is an area suitable for agriculture. Batu City is also the upstream area of the Brantas River Basin (DAS), and has 83 springs which are utilized by the Batu City Government and the people of Batu City [10]. Based on the Regional Spatial Plan (RTRW) of Batu City, 40% of the Batu city area is State Forest located on the slopes of Mount Arjuno, Mount Welirang and Mount Panderman.

2.2. Land use change analysis
To see the effect of urbanization on peri-urban agricultural activities in Batu City, a correlation analysis was carried out between changes in land use in Batu City in the period of 2008 and 2018 and the development of peri-urban agriculture that occurred in Batu City. The analysis of land use change was carried out using a supervised and maximum likelihood approach to satellite imagery of Batu city (2008 using Landsat 7 imagery, 2018 using Sentinel imagery) and using a semi-automatic classification plugin in Qgis software (ver. 3.0.3) developed by Congedo [12]. The recent satellite imagery (2018) was classified into 6 classes of land use: irrigated agricultural field, dryland agriculture, horticulture plantation, secondary mixed forest, scrub and bushes, and built-up area. There were 25 independent ground control points that had been set up to define the accuracy of the land use classification. The land use classification of previous year (2008) was complemented with older land use maps from the Regional Development Agency of Batu City. Further analysis of the land use changes was done with cross tabulation to calculate the gains and losses of each land uses from 2008 to 2018.

2.3. Descriptive socioeconomics analysis
The dynamics of regional economic development between the year 2008 and 2018 was measured by using the changes in Gross Domestic Product (GDP) sectoral data from the Indonesian Statistics Bureau
(BPS). The dynamics of four main sectors of economic development from the Batu City are namely the agricultural, construction, accommodations, and tourism sectors.

![Figure 1. Map of research area.](image)

2.4. Identification of multifunction agriculture

Analysis of the multifunctional urban agricultural system in the city of Batu will be carried out by adopting a framework approach of urban agriculture in Swiss [13] and Jakarta [14]. The peri urban agriculture framework [13] suggests that the framework for a multifunctional urban agricultural system can be approached based on three frameworks, namely: (1) development of high value agricultural commodities; (2) application of the principles of environmentally friendly agriculture (agri-environment practices); and (3) diversification of urban agricultural activities by developing recreational activities and environmental awareness. This study analysed the developing framework in urban agriculture in Batu city based on the approach of peri urban agriculture [13] and modified the indicators for the framework. Based on this framework and based on the a-priori literature review process, variables that represent the multifunctional agricultural system that are developing in Batu city have been determined (Table 1). Spatiotemporal analysis of changes in agricultural land during the last 10 years will be carried out and followed by descriptive statistical analysis of the socio-economic data of agriculture in Batu City to obtain a correlation between the in-situ process of urbanization and the development of the urban multi-function system.
Table 1. Multifunctional agriculture framework used in this study.

| Framework | Agricultural activities | Indicators |
|-----------|-------------------------|------------|
|           | Organic agriculture production | Total area of organic vegetables production (potatoes, carrot, cabbage, shallots, garlic, and tomatoes) |
|           | Flower and Nursery | Total area of flower and nursery (philodendron, rose, chrysanthemum) |
|           | Plantation (fruits) | Total area of fruits plantation (mandarin oranges, apples and guava) |
|           | Plantation (non-fruits) | Total area of plantation (sugar cane, coffee) |
|           | Animal Production | Total animal production (mutton, poultry, goat, rabbit) |
|           | Subsistent Agriculture | Total area of rice and maize production |
| Specification of high-value agricultural Commodities | Good agricultural practice | Organic certification at village level |
|           | Composting facilities for agricultural input | Composting facilities at village level |
| Activities that promotes environmental awareness and agri-environmental practices | Agriculture education-based homestay tourism | Participation with the agriculture education-based homestay tourism at village level |
|           | Environmental Awareness | Participation with the environmental awareness activities at village level |

2.5. Spatial clustering for determine the typology of multifunction agriculture

The typology of multifunction peri urban agriculture (PUA) was analysed by identified the types of peri urban agriculture developed in each village of Batu City. Spatial data such as the area of peri urban agriculture and the production of subsequent peri agriculture activities were used the determined the typology of peri urban agriculture that developed in Batu City. Other data such as the participation of village in environmental awareness activities and education-based homestay tourism activities were gathered from survey and interviewed with representative of farmers in each village.

A Principal Component Analysis (PCA) was used to extract the independent variables that contributes to the determine the typology of PUA. The variables that being used as independent variables in this study were: area of subsistent agriculture, area of organic vegetables production, area of flower and nursery, area of fruits production, total production of goat farming, total production of goat farming poultry farming, total production of goat farming rabbit farming, certification of organic agriculture, composting facilities, participation with the agriculture education-based homestay tourism, and participation with the environmental awareness activities. The results from the PCA was used as input for the spatial contiguous analysis [15] to classified and clustered the types of PUA in Batu City.

The spatial contiguous analysis [15] was developed to incorporate the contiguity of spatial location in the spatial clustering analysis. Based on this method, there are contiguity for each location (village and sub-district) with similar variables in the clustering analysis. The spatial Euclidean distance was calculated for each village and sub-district in the Batu city. The spatial Euclidean distance for the multivariate variables was calculated with:
The spatial Euclidean distance for each village and sub-district then was used as input for clustering analysis along with the results from PCA analysis. The clustering analysis technique used in this study was the K-mean cluster analysis with IBM SPSS statistic software ver 22.

3. Results and discussion

3.1. Land use changes in Batu period 2008 – 2018

The Greater Malang Metropolitan Area is one of the areas that has experienced a process of in situ urbanization and rapid urban growth in the last 10 years which is marked by the growth of urban sprawl, especially in Batu City and the western region of Malang City [16], [17]. Particularly in Batu City, a very rapid development has occurred in infrastructure development, especially tourism and agriculture supporting infrastructure.

The result from spatio-temporal analysis of land use changes in Batu City from 2008 to 2018 (Figure 2) showed that most of the land use is fruit plantation, followed by irrigated paddy field and dryland agriculture. The growth of built-up area for this period was concentrated in the center area of Batu City, where the construction of accommodations, restaurant and facilities that benefits from the tourism activities. Mainly, the shrub and bushes and dryland were converted into built-up area, while there was a little conversion from irrigated paddy field into built-up area.

The gain and losses of each land use was calculated between 2008 to 2018, and the results is presented in Table 2. In total, there was growth of built-up area of 554.4 ha (2.78%) and this growth was associated with conversion from agriculture land into built-up area. Interestingly, the secondary forest also increased from 7889.3 ha in 2008 to 9101.3 ha in 2018 (6.07% growth). In the same period, there were losses of agriculture area (341.1 ha), which were converted either to built-up area or the secondary forest.

Figure 2. Land use changes in Batu City from 2008 to 2018.
Table 2. Gain and losses of land use in Batu City from 2008 to 2018

| Landuse          | Area (ha) | Gain/losses (ha) | Agriculture Land Gain/Losses (ha) |
|------------------|-----------|------------------|----------------------------------|
|                   | 2008      | 2018             |                                  |
| Builtup Area     | 1620.4    | 2174.8           | 554.4                            | 2.78                            |
| Secondary Forest | 7889.6    | 9101.3           | 1211.7                           | 6.07                            |
| Plantation       | 2308.9    | 2286.2           | -22.7                            | -0.11                           |
| Dryland          | 2865.6    | 2624.1           | -241.5                           | -1.21                           |
| Irrigated paddy field | 2568.4 | 2491.6           | -76.8                            | -0.38                           |
| Shrub and Bushes | 2720.2    | 1295.2           | -1425.0                          | -7.13                           |
| Total Area       | 19973.1   | 19973.1          |                                   |                                 |

3.2. Dynamics of socioeconomics changes in Batu period 2008 – 2018

The contribution of the agricultural sector to the Gross Regional Domestic Product (GRDP) in the recent years has declined from 5.8% in 2008 to 2.1% in 2018 (Figure 3). The share of tourism and recreation sector to the GRDP of Batu City has increased from 5.8% in 2008 to 7.6% in 2018. This increased also associated with the growth of construction sector as well as the accommodation and restaurant. These results showed that in the recent years, the economic growth of Batu City has shifted from agricultural production to tourism and other economic activities that supported the tourism.

3.3. Typology multifunction peri urban agriculture in Batu City

The results from the PCA showed there are four main group of indicators that determine the typology of PUA in Batu City (Table 3). The first group is PUA that specified in fruit production, flower and nursery, rabbit farming, involvement both in environmental awareness activities and agricultural education-based tourism (highlighted in yellow). The second group is PUA that excel in organic vegetables production, with certified organic management, as well as the composting facilities to produce sustainable agricultural input for the organic farming. The third group is PUA that mainly for goat and poultry farming, while the last group is the PUA that still subsistent. These four group of PUA then was spatially analyzed to determine the spatial cluster/class that formed in Batu City.
Table 3. Independent variables for PUA in Batu City.

| Component       | 1      | 2      | 3      | 4      |
|-----------------|--------|--------|--------|--------|
| Subsistent      | -.043  | .234   | .029   | .884   |
| Organic vegetables | -.110  | .758   | .003   | .216   |
| Fruit           | .767   | .298   | .036   | -.182  |
| Flower and nursery | .772   | -.130  | -.019  | .009   |
| Goat            | -.073  | -.027  | .912   | -.087  |
| Poultry         | .037   | -.163  | .725   | .552   |
| Rabbit          | .863   | .141   | -.026  | -.302  |
| Organic certification | .132   | .780   | -.020  | -.033  |
| Composting facilities | .283   | .620   | -.429  | .031   |
| Environmental awareness | .790   | -.141  | -.284  | .397   |
| Agriculture education-based tourism | .825   | .150   | -.040  | .137   |

The typology of PUA in Batu City were spatially clustered in level of village/sub-districts as indicated by the K-mean Cluster analysis (Figure 4). The spatial cluster indicates the closeness between multi-function agricultural activities along with their spatial weight for the spatial contiguous cluster. The results of spatial cluster showed that there are three types of PUA cluster in Batu City. The first cluster is the subsistent-oriented PUA (9 villages in the central – south of Batu City). The second cluster is the multifunctional PUA (5 villages in the north of Batu City). The third cluster is the market oriented PUA (10 villages in the central – west of Batu City). The description of each PUA with their indicators is presented in Figure 5.
In carrying out medium-term development, the Batu City Government refers to the Batu City Regional Development Plan (RTRW) for the 2010-2030 period which is contained in the Batu City Regional Regulation (Perda) Number 7 of 2011. Based on the Perda, the vision of Batu City spatial planning is as a tourist city and agropolitan city in East Java Province. Previous research shows that the development direction of Batu City is centered on the development of natural tourism and community-based tourism [9] and agricultural development, especially horticultural commodities in the form of vegetables and fruit plants, especially apple, mandarin oranges and guava [10].

The in-situ urbanization process in Batu City has led to an increase in food demand which has an impact on agricultural intensification and extensification efforts to increase agricultural production. On the other hand, an increase in population also causes the need for housing to increase. As a result of population increases, agricultural activities and the need for housing lead to competition for land use. In addition, the Batu City Government's work program to increase tourism activities has also led to competition for land use in Batu City. This challenge is clearly faced by farmers in Batu City, where agricultural land has a higher land rent value for other land uses than for agriculture. The high land rent value causes some farmers in Batu City to sell agricultural land to be converted into other land uses.

Previous research conducted to analyse the sustainability of agriculture in Batu [10] reported that there was competition for land use between tourism and agricultural development that occurs in Batu City. One case that shows competition for land use is in the Bumiaji district of Batu City, where the sub-district has an area of 12,798.2 ha and consists of a buffer forest area of 8,751.6 ha of the Upstream Brantas watershed. Based on the 2010-2030 RTRW of Batu City, Bumiaji sub-district is the centre of an agricultural area, however in 2011 there was an increase in the conversion of agricultural land into tourism supporting facilities (lodging - souvenir centre - restaurants and cafes) for tourists [10]. On the other hand, agricultural land in Bumiaji District is typically fertile land for agriculture (high rainfall, fertile volcanic soil, suitable micro-climatic conditions for horticultural commodities). The dilemma faced by the Batu City Government today is competition for land use for tourism and agricultural development.

The competition in land use mentioned above is indicated by the occurrence of land conversion in Batu City. Research on land use changes in Batu [18] showed that in the period 2000 - 2010 there has been a change in the function of agricultural land into residential land and tourism support facilities of 863.9 ha. The same researcher also revealed that land use change did not only occur on agricultural land, but also on forest land in Batu City. In the period 2000 - 2010, there was a conversion of forest land into agricultural land for 449.4 ha, and a conversion of forest land into settlements and tourism supporting facilities for 309 ha [18]. From 2010 onwards, the results from this study showed that most of the shrub
and bushes were converted into secondary forest, as a result from the conservation project conducted by Perum Jasatirta and the Batu regional government.

By using the concept of a multi-functional agricultural system, the urban agricultural system will not be limited to meeting the food needs of urban communities, but also providing added value to sustainable development (economic - social - environmental). The urban agricultural system is able to provide two main roles related to sustainable development, namely: (1) increasing the standard of living of urban communities by providing foodstuffs that are environmentally friendly; and (2) increasing the productivity of agricultural activities outside the main function of providing food to improve the quality of life of farmers and alleviate poverty [19], [20].

The in-situ urbanization process in Batu City has an impact on changes in environmental quality. Some of the negative impacts resulting from changes in environmental quality include reduced water catchment areas, increased erosion, and sedimentation due to reduced land cover, reduced productive agricultural land, and decreased habitat quality for agricultural activities. To overcome these negative impacts, it is necessary to develop a multi-functional urban agriculture system supported by spatial planning policies, policies in the macroeconomic sector and policies on environmental protection. Planning for the area can be approached based on a multifunctional urban agricultural system based on ecological, economic, and social sustainability.

4. Conclusion
Land use changes in Batu from 2008 – 2018 showed that agricultural lands have shifted from paddy field to urban areas and high value horticulture commodities. Although the agricultural sectors showed a relatively steady contribution to the GRDP of Batu, the growth in the last five years is declining. In the last five years, Batu has concentrated on developing man-made recreation and tourism attractions, and supporting infrastructure (hotels, restaurants, etc.).

Land use planning is an important key in realizing an urban agricultural system that is able to support multi-function agriculture and achieve agricultural sustainability. Community involvement in planning is important to ensure that the urban farming system can support the concept of multi-functional agriculture which will increase the sustainability of agriculture. The peri-urban agricultural system with a high multi-functional capacity not only emphasizes the function of food production, but also on the aspects of social cohesion, improving the standard of living of farmers, and conserving the environment.

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