Sustainable agricultural land use determination modelling in Banyuwangi

F Firmansyah$^{1,2}$, N A Pratomoatmojo$^{1,2}$, U F Kurniawati$^{1,2}$, C Susetyo$^{1,2}$, A Pamungkas$^{1,2}$ and H Idajati$^{1,2}$

$^{1}$ Department Urban and Regional Planning
$^{2}$ Institut Teknologi Sepuluh Nopember, Surabaya 60111, Indonesia

Email: fendy.firmansyah@urplan.its.ac.id, ff.fendy.firmansyah@gmail.com

Abstract. Population growth in Banyuwangi Regency resulted in increasing food and land needs. This is very influential in the protection of agricultural land through Sustainable Food Agricultural-Land (LP2B) program. Spatial modeling for potential of sustainable agriculture land in Banyuwangi Regency based on land-use change is achieved through 4 stages: (1) identifying trend of land-use change, (2) identifying factors that affected agricultural land conversion, (3) modelling potential land for sustainable food agriculture, and (4) establishing sustainable food agriculture. The result of the analysis shows that the land-use change in Banyuwangi regency has developed into settlements area, industrial warehousing and trade service which is quite fast for the periods 2010-2016. Accessibility factors covering the road network, location factors of agricultural field covering the proximity to water source / water supply and the dynamics factors of urban growth covering the developing settlement area, has a very big influence in the occurrence of agricultural land conversion in Banyuwangi Regency.

Keywords: LP2B, Modelling, Land use Change

1. Introduction
Sustainable Food Agricultural-Land (LP2B) is a field of agricultural land established to be consistently protected and developed to produce essential food for national food self-sufficiency, resilience and sovereignty [1]. Land priorities that include of LP2B are land with high productivity, cropping index reaches three times in one growing season, integrated and has technical irrigation system and good actual land suitability level. Furthermore, it is mentioned in the regulation from the Minister of Agriculture No.07/PERMENTAN/OT.140/2/2012 that broad expanse of Sustainable Agriculture and/or Sustainable Food Farms in an area that meets the needs and consumption of basic staple food is at least 5 Ha.

The problems faced are increasing population while the land area is relatively fixed, productivity of cultivated agricultural land (levelling-off), and the competition of land use for development. Under these circumstances, if the stakeholder paradigm in spatial planning only focuses on the economic value and lease of land, there is no balance between the development of the agricultural sector and development in other sectors [2].

In an effort to realize Sustainable Food Agricultural-Land (LP2B) in the region, the Government of Banyuwangi Regency has issued Local Regulation of Banyuwangi Regency No. 08 of 2012 concerning
Spatial Planning (RTRW) of Banyuwangi Regency 2012-2032. In the third paragraph of article 55 paragraph 1a mentioned that sustainable food cultivation land with an area of approximately 61,841 hectares of food crops in Banyuwangi Regency amounted to 65,992 hectares. Subsequently confirmed in article 55 paragraph 3 that the area of sustainable food agriculture in each sub-district set in the Local Regulation with a map accuracy of 1 : 25,000 scale.

Based on this phenomenon, it is important to conduct a study on the existence of agricultural land based on the model of land-use change, which through this study is expected to be used as input in the determination of Sustainable Food Agricultural-Land in Banyuwangi Regency.

2. Identifying Trend of Land-Use Change

Analysis of land-use change in Banyuwangi Regency during the period of 2011-2016, conducted using raster data overlay method with the help of ArcGIS software.

![Figure 1. Land Use of Banyuwangi Regency in 2011 and 2016](image)

From the overlay analysis, the proportion of land use in Banyuwangi Regency between 2011 and 2016 has similarities in terms of dominant land use. The dominant land use in Banyuwangi Regency is protection forest, production forest, agricultural, plantation, then settlement. In 2011, the proportion of protection forest in Banyuwangi Regency was 27% of total land use, while production forest was 22%, agricultural 20%, plantation 17%, and settlement 9%. In 2016 the proportion of land use in Banyuwangi Regency did not experience significant development, as can be seen from the change in the proportion of land use in the year by 27% for protection forest, 21% for production forest, 21% for agricultural, 15% for plantation and 9% for settlement.

Based on land use comparisons In 2011 and 2016 there are several land uses that have expanded in area, this occurs in the use of vacant land, shrub, agricultural, settlement, trade and service, field, and warehousing industry. If we look further at the changes of each class of land in table 2, it can be explained that the growth of wetland in Banyuwangi Regency is caused by the conversion of plantation land and production forest into agricultural, besides changing the agricultural cropping pattern in Banyuwangi causing frequent land use change which was originally a field to agricultural fields.
The development of the city seen from the growth of built-up form of settlement land in Banyuwangi Regency for 5 years experienced considerable growth, where the average growth per year of 1.194 pixels settlements (107.46 hectares) with the tendency of growth of settlement land to convert non-constructed land in the form of vacant land, agricultural, and plantation. The growth of warehousing industry in Banyuwangi Regency is also experiencing rapid growth, which from the data can be explained that the average growth per year is 126 pixels (11.34 hectares), with the pattern of industrial land developments that tend to convert non-constructed land in the form vacant land, agricultural, plantation and fields.

3. Identifying Factors that Affected Agricultural Land Conversion

The analysis of factors that affected agricultural land conversion is done through Analytical Hierarchy Process (AHP). Based on the formulation of factors used in the determination of land conversion there are 3 factors that influence the Accessibility Factor, Dynamics Factor of City Growth, and Location of Agricultural Field Factor. Stakeholders in the local government of Banyuwangi Regency are the Regional Development Planning Board (Bappeda), the Public Works Agency (PU), the Agricultural Agency, and the Academics expert in Regional Planning. From the results of AHP analysis, it can be concluded that the weight of the influence of each factor can be explained in the following table:

| Factors                        | Weight Scores |
|--------------------------------|---------------|
| Transportation Facilities      | 0.063         |
| Existing Settlements           | 0.282         |
| Existing Industry              | 0.05          |
| Existing Trade and Services    | 0.087         |
| Public facilities              | 0.105         |
| Irrigation Network             | 0.027         |
| Supply / Water Resources       | 0.058         |

From the table it can be explained that the existing road network and settlement factors are the most dominant factor in influencing the conversion of wetland in the Study Area. This indicates that the more distant location of agricultural field with road network and residential area, the higher possibility for the happening of land conversion.

4. Modelling Potential Land for Sustainable Food Agriculture

This stage use to predict land-use change in Banyuwangi Regency, where the result of this analysis can be used as a basis to determine potential LP2B in Banyuwangi Regency. The first step in this land-use change model is prepare the rules or the path of the simulation. Basically, there are 2 (two) important things in preparing modeling rules, namely the allocation of land growth from each growing land class, and preparing the path of the land development in the simulation process.

| Land Use               | Growth per year (Pixel) | Growth in 20 year (Pixel) | Conversion Land Trend | Uncorverted Land Trend (Constrain) |
|------------------------|-------------------------|---------------------------|-----------------------|-----------------------------------|
| (7) Settlements        | 1.193,6                 | 23.872                    | 1, 3, 4, 6, 7, 11, 12, 14 | 0, 2, 5, 9, 10, 13, 15, 16, 17   |
| (9) Trade and Services | 28,4                    | 568                       | 1, 4, 7, 8, 11, 14    | 0, 2, 3, 5, 6, 9, 10, 11, 12, 13, 15, 16, 17 |
| (13) Warehousing       | 125,6                   | 2.512                     | 1, 4, 8, 11           | 0, 2, 3, 5, 6, 7, 9, 10, 12, 13, 14, 15, 16, 17 |
Table 3. The Effect of Land Conversion Factors on Land Development Patterns

| Factors                        | Weight Scores | Settlements | Trade and Services | Warehousing Industrial |
|-------------------------------|---------------|-------------|--------------------|------------------------|
| Road Network                  | 0.328         | Dec         | Dec                | Dec                    |
| Transportation / Public Facilities | 0.168         | Dec         | Dec                | Dec                    |
| Existing Settlements          | 0.282         | Dec         | Dec                | Inc                    |
| Existing Industry             | 0.05          | Inc         | Dec                | Dec                    |
| Existing Trade and Services   | 0.087         | Dec         | Dec                | Dec                    |
| Irrigation Network            | 0.027         | Inc         | Inc                | Inc                    |
| Supply / Water Resources      | 0.058         | Inc         | Inc                | Inc                    |

*Description:

Increasing (Inc) - The farther along with the factors that influence the higher growth opportunities in the land convert other land
Decreasing (Dec) - The closer to the factors that influence the higher the growth opportunities of the land in converting other land

From the modeling rules can be explained that land modeling did not model the growth of agricultural and fields, this is based on the urgency of this study which aims to find LP2B potential land in Banyuwangi Regency, so that agricultural and fields are assumed not to grow. Based on several spatial factors and modeling rules that have been formulated, the result of modeling of land change in Banyuwangi Regency is as follows.
Based on the simulation results and table 4 of land use comparison 2016 and 2036 it can be explained that the development of settled land (settlements, trade and services, and warehousing industry) in Banyuwangi tends to lead to urban areas. When viewed from the results of land use comparability, it can be explained also that within 20 years the development of built-up land in Banyuwangi regency for settlement land tends to convert the land that serves as a field of 10,268 pixels (924.12 Ha), the land that serves as a plantation of 8,724 pixels (785.16 Ha), the land that serves as a agricultural of 2,817 pixels (253.53 Ha), the land that serves as a production forest of 2,270 pixels (204.3 Ha), land that serves as pond as much as 95 pixels (8.55 Ha), and land that serves as a bush of 19 pixels (1.71 Ha).

For land use as trade and services, the results of simulation and comparison of land use rabel explains that in its development this land tends to convert agricultural by 33 pixel (2.97 Ha), settlement of 273 pixels (24.57 Ha), plantation of 84 pixels (7.56 Ha), 182 pixel (16.38 Ha) field, and 4 pixels production forest (0.36 ha). As for the warehousing industry in Banyuwangi Regency, it can be explained that this land is likely to convert agricultural by 1545 pixels (139.05 Ha), settlement of 857 pixels (77.13 Ha), and 70 pixels (6.3 Ha) field.

| Land Use 2036* | (0) Swamp | (1) Vacant Land | (2) River | (3) Shurb | (4) Agricultural | (5) Green Space | (6) Farms | (7) Settlement |
|----------------|-----------|-----------------|-----------|-----------|-----------------|----------------|---------|----------------|
| (0) Swamp      | 17006     |                 |           |           |                 |                |         |                |
| (1) Vacant Land|           | 4774            |           |           |                 |                |         |                |
| (2) River      |           | 13420           |           | 19        |                 |                |         |                |
| (3) Shurb      |           |                 |           | 844142    |                 |                |         | 2817           |
| (4) Agricultural|           |                 |           |           | 2335            |                |         |                |
| (5) Green Space|           |                 |           |           |                 | 58             |         | 350136         |
| (6) Farms      |           |                 |           |           |                 |                |         |                |
| (7) Settlement |           |                 |           |           |                 |                |         |                |
(8) Plantation 8724
(9) Trade and Service 10268
(10) Sea Sand 95
(11) Field 2270
(12) Pond
(13) Warehouse Industry
(14) Production Forest
(15) Protection Forest
(16) Transport Facilities
(17) Lake

Sum 17006 4774 13420 14032 844842 2335 58 374329

*1 pixel = 30 x 30 m = 900 m²

Table 4 (Continued)

| Land Use 2036 | (8) Plantation | (9) Trade and Service | (10) Sea Sand | (11) Field | (12) Pond | (13) Warehouse Industry | (14) Production Forest | (15) Protection Forest | (16) Transport Facilities | (17) Lake |
|---------------|----------------|-----------------------|---------------|------------|-----------|------------------------|------------------------|------------------------|------------------------|-----------|
| (0) Swamp      | 601573         | 84                    | 857           | 1599       |
| (1) Vacant Land| 3858           | 182                   | 172868        | 70         |
| (2) River      |                |                       |               |            |
| (3) Shrub      |                |                       |               |            |
| (4) Agricultural| 273            | 5586                  | 826665        | 1099742    |
| (5) Green Space|                |                       |               |            |
| (6) Farms      |                |                       |               |            |
| (7) Settlement |                |                       |               |            |
| (8) Plantation | 601573         | 84                    | 857           | 1599       |
| (9) Trade and Service | 3858 | 182 | 172868 | 70 |
| (10) Sea Sand  |                |                       |               |            |
| (11) Field     |                |                       |               |            |
| (12) Pond      |                |                       |               |            |
| (13) Warehouse Industry | 273 | 5586 | 826665 | 1099742 |
| (14) Production Forest | 601573 | 84 | 857 | 1599 |
| (15) Protection Forest | 3858 | 182 | 172868 | 70 |
| (16) Transport Facilities |                |                       |               |            |
| (17) Lake      | 1922           |                       |               |            |

Based on these results, it can be explained that the area of agricultural that has the potential to serve as sustainable food farming (LP2B) in Banyuwangi Regency is 844,842 pixels or 76,035,78 Ha. Based on the determination of LP2B land potential based on the simulation of the development of this land, the determination of LP2B land in Banyuwangi Regency needs to be reviewed again with technical provisions set by the Government in determining LP2B land in Indonesia.
5. Establishing Sustainable Food Agriculture

Based on the Regulation of the Minister of Agriculture No. 07/PERMENTAN/OT. 140/2/2012 about the Technical Guidelines on Criteria and Requirements for Sustainable Land, Reserves and Land of Food Reserves that the technical requirements for LP2B land acquisition are as follows:

- Width of agricultural fields > 5 Ha
- The determination of an agricultural field can be limited by physical boundaries such as road network, river network, and technical irrigation network.

![Figure 3. Result of Determination of LP2B in Banyuwangi Regency](image)

Based on the results of the analysis it is found that the area of agricultural fields that can be used as LP2B land in Banyuwangi regency of 73,955,41 Ha of total 76,035,78 Ha of agricultural fields in Banyuwangi.

6. Conclusion

Based on the prediction analysis of land use change based on land use trends and factors affecting agricultural fields area conversion, development of land use built in 2016 to 2036 experienced growth toward urban area. Settlement land converts fields, plantations, agricultural, production forests and some ponds and shrubs. While trade and services land convert settlements, fields, and some plantations, agricultural, and production forests. Warehousing industrial tends to convert agricultural, plantations, and some fields. The end result is the area of agricultural field which has potential as LP2B is 76,035,78 Ha from the simulation result 2036. Based on the technical criteria of LP2B determination, the result of LP2B potential land prediction in overlay with the technical stipulation of LP2B is obtained the width of field that can be used as LP2B amounting to 73,955,41 Ha of total LP2B prediction 76,035,78 Ha. The total area of LP2B can be made in 1,549 agricultural fields of Banyuwangi.

7. References

[1] Republic of Indonesia. 2009. *Law No. 41 of 2009 on Sustainable Land Farming Protection*. State Gazette of The Republic of Indonesia Year 2009, No. 149 State Secretariat. Jakarta.

[2] Agus, Fahmuddin, and Irawan. 2004. *Conversion and Environmental Aspects of Agricultural Fields in Agriculture Field and its Management Technology*. Center for Soil and Agro-climate Research and Development, Agricultural Research Agency.