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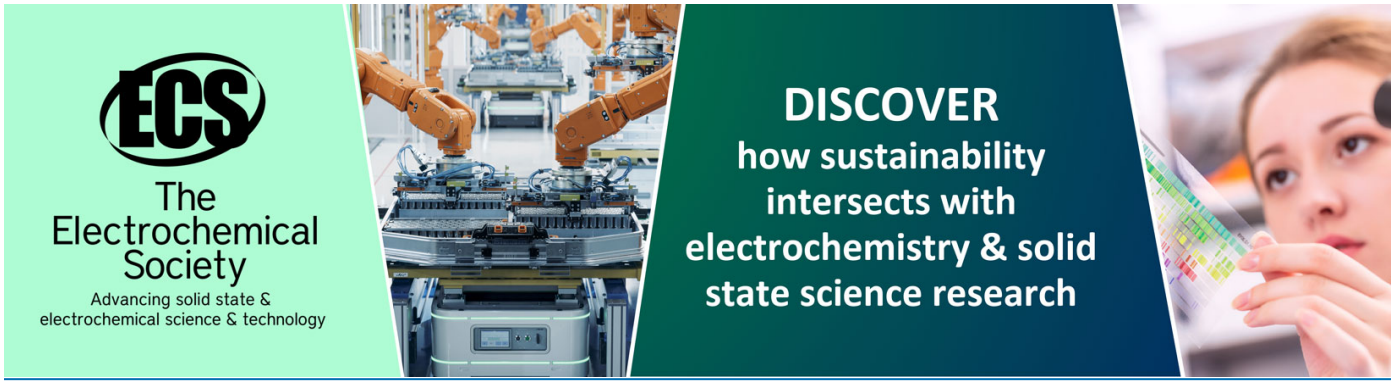

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Spatial Dynamics of Agricultural Lands in Regions with High Pressure Land Use Change (Case Study of Purwakarta Regency)

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Abstract. Land use changes are so prevalent in almost all regions in Indonesia, including in Purwakarta Regency. Purwakarta Regency is located between Jakarta City as the capital city of Indonesia and Bandung City as the provincial capital of West Java. The conversion of agricultural were due to the pressures from other land uses. Agricultural land use changes certainly have implications for microclimate changes. The objectives of this study were to analyse changes in paddy fields due to the pressure from other land use conversion and to formulate solutions for land conversion control policy. The study was conducted in Purwakarta Regency, including the Citarum watershed area. The studied area has a total of 62,398 ha out of the total 97,172 ha of the whole Purwakarta. The study used the Spatial Dynamics Analysis approach with Powersim Studio and IDRISI to predict the land changes in the year 2030. The simulation showed that paddy field areas decreased to 36.07 % from 20,394 ha in 2012 to 13,036.90 ha in 2030. On the contary, residential areas increased as much as 105.94 % from 5,418.44 ha in 2012 to 11,158.7 ha in 2030. The loss of paddy fields totalling to 8,668.21 ha from 2009 to 2030, has implications on the microclimate changes with the economic value of environmental services, in particular prevention of an increase temperature, of IDR 2,812,240,804,033.00. Policies are needed to clearly define the spatial land use with regional regulations to control paddy fields conversion, implement Sustainable Food Crop Areas owned by the government with farmer empowerment and develop derivative products by utilising the wastes.

1. Introduction

Rapid development has caused changes in land use patterns, where built space increasingly dominates and urges natural spaces to change its function. This phenomenon mainly occurs in urban areas, where changes in land use takes place very dynamically. The conversion of paddy fields into non-paddy fields continues to increase and it can threaten the stability of future food security. This will also have an impact on the characteristic of rural development, where most paddy fields areas are converted housing-settlements. This will eventually transform the characteristics of rural areas into urban areas, which is a transition to a new growth areas.

Rice field is a producer of staple food for the people of Indonesia, thus must be maintained and utilised for the welfare of the community. In addition to functioning as a grain producer, paddy fields have a wider function, including maintaining the stability of hydrological functions of watersheds (DAS), reducing erosion, enhancing food security, providing soil nutrients, improving climate, providing habitat for flora and fauna, absorbing labour, providing rural uniqueness and attractiveness as well as maintaining rural cultural values [18]. The area of rice fields in West Java Province is the third

most extensive out of the total area of rice fields in Indonesia, covering an area of 912,794 ha (11.28%) after East Java Province with an area of 1,091,752 ha (13.4%) and Central Java Province with an area of 912,794 ha (11.93%). However, the contribution of West Java Province's rice production is in the second place, amounting to 11,373,144 tonnes (15.08%) after East Java Province with a production of 13,154,967 tonnes (17.44%) [5].

The uncontrolled land use change can threaten the food supply capacity, even in the long term it could become a social and national disaster and can encourage food monopolies from importing countries. The total Purwakarta Regency area is about 97,172 ha, of which 62,398 ha of Purwakarta Regency are parts of the Citarum watershed area, which has high pressure on the agricultural lands, especially the rice fields.

Food shortages can affect poor nutrition, health, and at the same time reduce the quality of human resources. Therefore, the government continues to strive to maintain food security, especially rice. Along with this effort in its operations, the vital problem faced today is the conversion of rice fields [14]. At present and in the future, rice fields will continue to experience pressures from various factors such as population growth and pressures on the livelihoods of farmers that cause rice fields to be traded. Lower value of land for rice fields and spatial control that is not optimum has also increase the pressure.

If there is no immediate anticipation of the rate of conversion of rice fields, it is feared that at some point, the rural areas in Purwakarta Regency, which belong to the Citarum watershed, will lose their function as the national rice production centres, and will reduce the conservation value of the region as a whole [10]. Several regulations have been issued by the government to limit the conversion of rice fields. Integration of Act No. 41 of 2009 and its derivative regulations into the Provincial, District and the City Short and Medium Term Development Plans have not yet been fully implemented. In the same line, Government Regulation No.12 of 2012 concerning Incentives for Sustainable Food Farming, has not yet accommodating the basic needs of farmers not to sell their rice fields. On the other hand, there are also rice fields that have been sold but the new managers are not knowledgable enough to manage the rice fields, hence become unproductive, and land conversion still occurs. This study has the objectives to analyse land use changes of rice fields from other land use pressures and formulate policy solutions on land conversion control.

2. Methods

In this study, a spatial approach was used by digitising the map of Purwakarta Regency land use which included the Citarum watershed area. Data used in the form of spatial time series data, namely the 2000 and 2012 maps of land use sourced from the Ministry of Forestry as well as tabular data from 2012 to 2017. Other spatial data used was a 1: 25,000 scale map of Indonesian Earth sourced from the Geospatial Information Agency. Spatial analysis was carried out using ArcGIS software to identify the land use changes in the study area.

Spatial dynamics analysis was conducted to predict land use area in 2030 and predict the variables of food sufficiency and economic value to prevent temperature increase, using Powersim Studio and TerrSet software. The result of the spatial dynamics analysis is a map of land use changes in the coming years.

Prevention of increase in temperature was calculated using the calculation results of the average change in rice fields into settlements, the average use of cooling in housing and the comparison of the results of the economic valuation calculation.

3. Results and Discussion

3.1. Analysis of Land Use and its Trends

Agricultural land is formed through a long process [14] because it is a part of the cultural system. The sustainability of the functions of rice fields in the Citarum watershed is currently decreasing, in line with the increasing conversion to non-agricultural use. The control of rice fields' conversion already exists, both from the legal and technical aspects, but the rule clashes with the economic considerations of the owners/farmers, especially farmers whose land tenure and ownership were below the economic scale. Many factors were the causes of land conversions, both in terms of farmer characteristics as internal

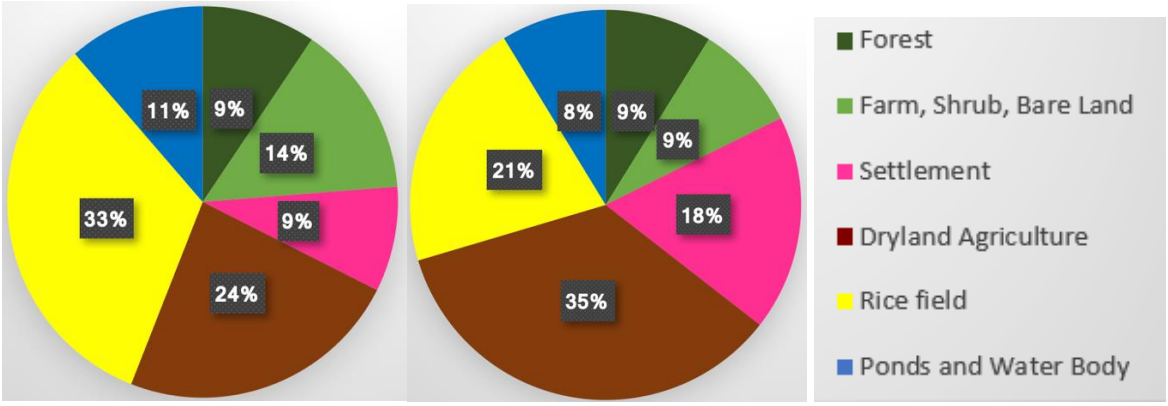
factors and environmental pressure as external factors. The control of rice fields needs to be implemented properly so that the conversion rate could be slowed and minimised.

Based on the results of studies in Purwakarta Regency, the area of rice fields included in the Citarum watershed area has decreased from year 2000 to 2012 (Table 1). Based on the results of spatial dynamics analysis, it was estimated that there would be a change in land use area where the area of rice fields converted between 2012 to 2030 was quite significant, covering an area of 7,357 ha (36.07%). Land use type that was expected to increase in the periods of 2012 to 2030 were settlements and dryland agriculture. For settlements there would be an increase of 5,740.26 ha (105.94%), while for dryland agriculture there would be an increase of 7,070.87 ha (48.15%).

Table 1. Land Use Change and trends.

Land Use	Area (ha)		
	2000	**2012**	**2030**
Forest	6,012.81	5,887.19	5,524.67
Farm, Shrub, Bare Land	9,457.87	8,935.46	5,493.31
Settlement	4,319.36	5,418.44	11,158.70
Dryland Agriculture	13,788.41	14,684.83	21,755.70
Rice field	21,728.21	20,394.00	13,036.90
Ponds and Water Body	7,091.99	7,078.72	5,429.36
Grand Total	**62,398.64**	**62,398.64**	**62,398.64**

From the comparison of the percentage of land uses in 2012 and 2030, the dominant land use in 2012 was 33% rice fields followed by dryland agriculture at 24%, while in 2030 the largest percentage of use would be for dryland agriculture (35%) and rice fields (21%). Settlements in 2012 was 9% while in 2030 it would be doubled to 18% (Figure 1). Visually spatial changes in land use from 2000, 2012 and 2030 are presented in Figure 2.



(a) (b)

Figure 1. Comparison of the percentage of land use in year 2012 (a) and year 2030 (b).

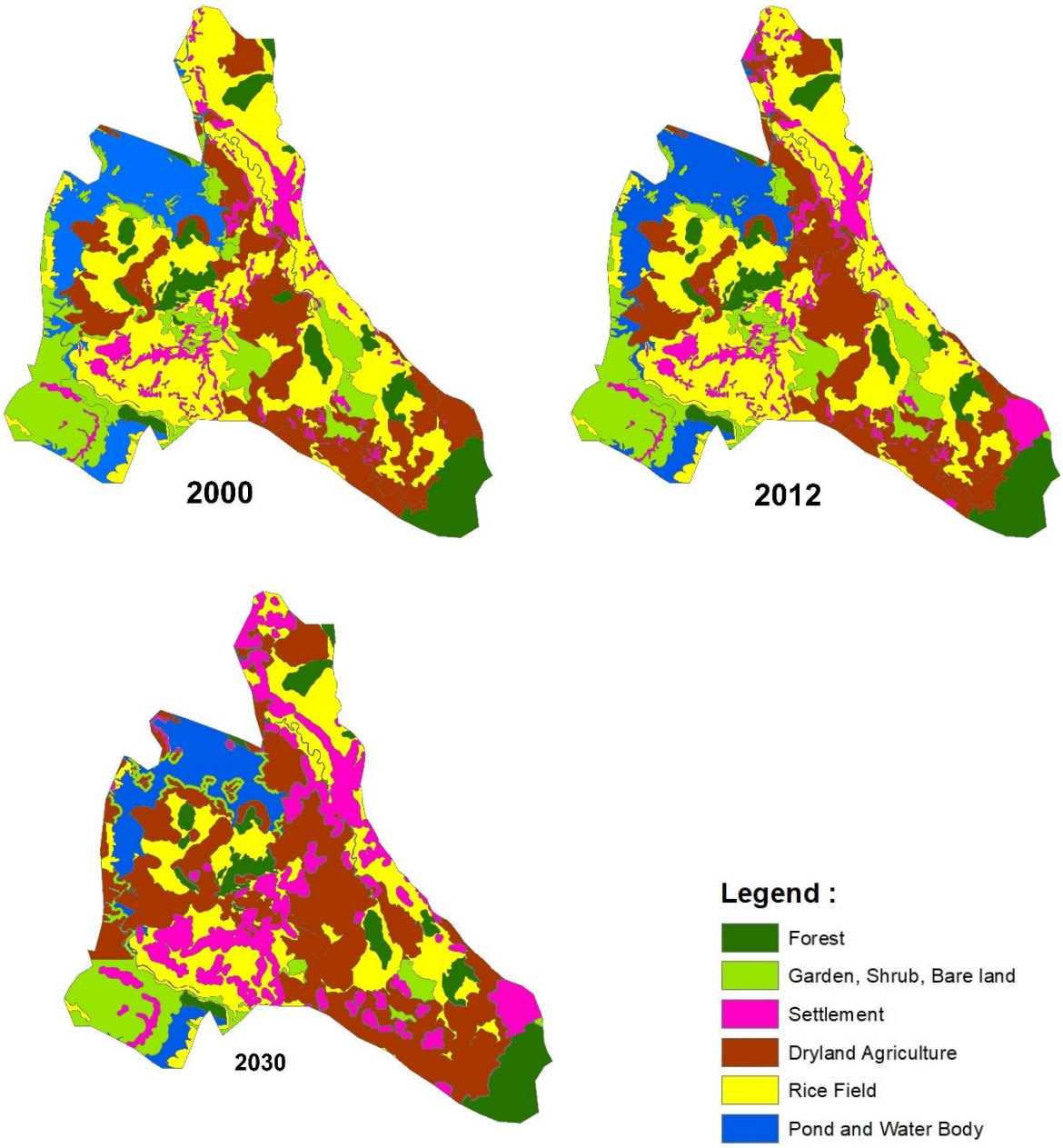


Figure 2. Changes in Land Use in 2000, 2012 and 2030.

3.2. System Dynamics in Food Security in Purwakarta Regency

Rice fields are currently under pressure. This pressure can come from various factors, including the characteristics of the farmers themselves [13]; [7], population growth pressures [2], land prices/land rent [13]; [19]; [9], regional economy, other land uses [8]; [15]; [6], land productivity [19] and accessibility [20]; [9]; [15]; [6]. The existing policies have not been optimal to compensate for the pressure on rice fields because the policy has not considered the interrelationships between dimensions, namely social, economic, environmental, infrastructure and technology as well as law and institutions.

Simulation models were carried out to observe the pressure on rice fields in the future. The simulations were carried out until 2030 because the long-term District Spatial Planning was up to 2030. Causal loops were used to look at the relationships between the variables that affect changes in land use of rice fields in Purwakarta Regency. Agricultural lands, especially rice fields, would experience annual

pressures to be converted due to increasing population, so that the needs of residential land would also increase. Another seen rise in growth was the increase in clothing, food and shelter needs, hence the regional economic activities will emerge which lead to increased road networks and land rent. This is in line with the research conducted in Lamongan Regency [9], which showed that the variables influencing the conversion of rice fields were the ratio of land prices and regional accessibility ratios. Regarding accessibility, research by [20] showed that using the analysis based on distance from highways and national roads, up to a distance of 3 km from the road, the largest increase in residential land was found to be at the closest distance of 1 km from the road. The results of the study by [16] in China stated that in the process of urbanisation, increasing the status of being urbanised, rice fields are the most risky land use which has a broad decline. Agricultural land, as a characteristic of rural areas, will continue to experience pressure due to the growth and economic development of a region. In the face of declining rice land area, rice production would also decrease and would affect the adequacy of food in the study area (Figure 3).

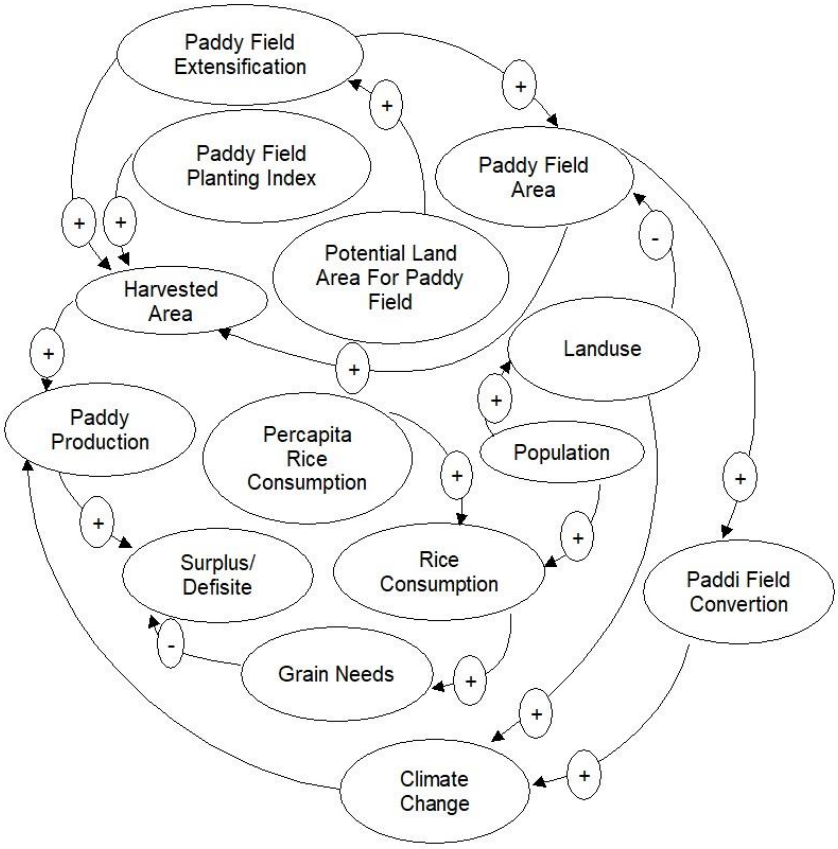


Figure 3. Diagram of *Causal Loop.*

Human population has increased in 2012 to about 565,562 people, and 589,126 people in 2015 and it was projected to reached a total of 722,521 individuals in 2030. Nevertheless, the food needs for Purwakarta Regency which included in the Citarum watershed area were still fulfilled. Food needs in the study area in 2012 were a surplus of 115,539 tonnes in 2012 and in 2030 there will be a surplus of 40,824 tonnes (Figure 4).

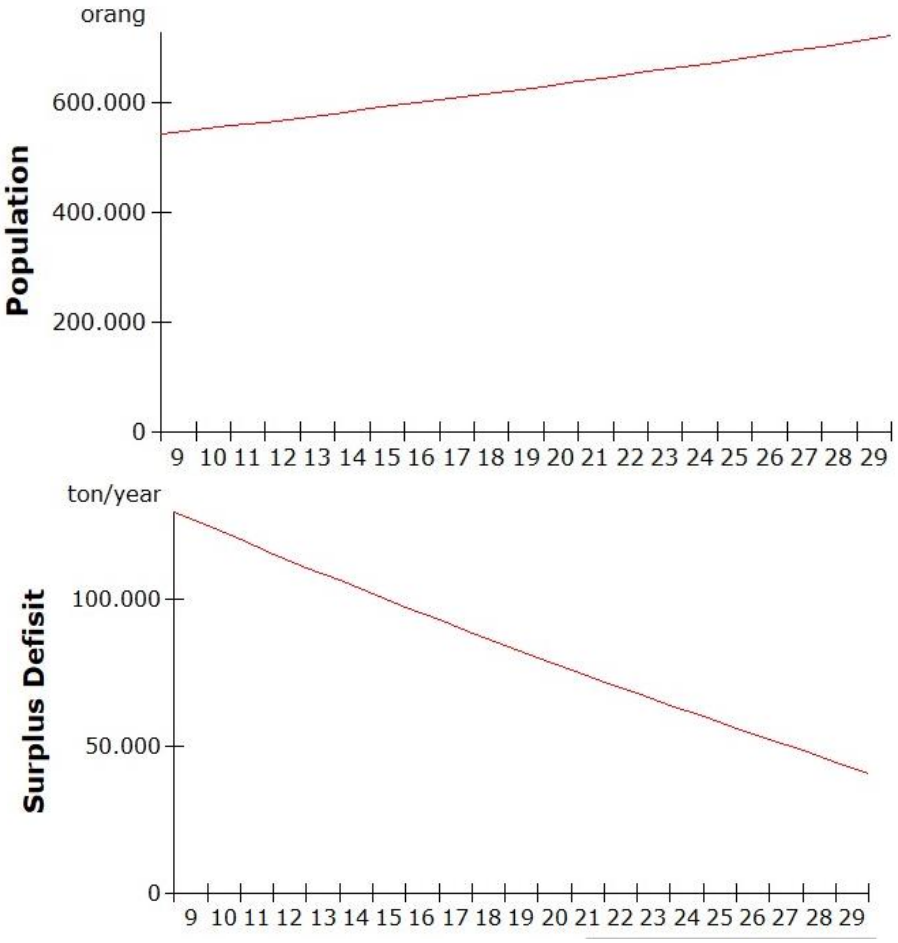


Figure 4. Population Projection and Food Adequacy.

3.3. Micro Climate Improvement as Environmental Services in Convertible Paddy Fields

Rice fields have a direct function, namely food production, but on the other hand rice fields also have intangible economic values including slowdown run off, water resource conservation, erosion control, landslide control, organic waste recycling, air purification (freshness), recreation and relaxation and prevention functions of increasing temperature [1]. Firmansyah's research [7] takes into account the conversion of rice fields per hectare where the assumption of changes in rice fields into settlements will lead to an increase in microclimate so that the need for a cooling process in the settlements built in rice fields with an average preventive value of temperature is Rp. 383,445,866 per ha, so that with the loss of rice fields covering an area of 8,668.21 ha from 2009 to 2030, it will have an economic value to prevent an increase in local temperature of Rp. 2,812,240,804,033 (Figure 5).

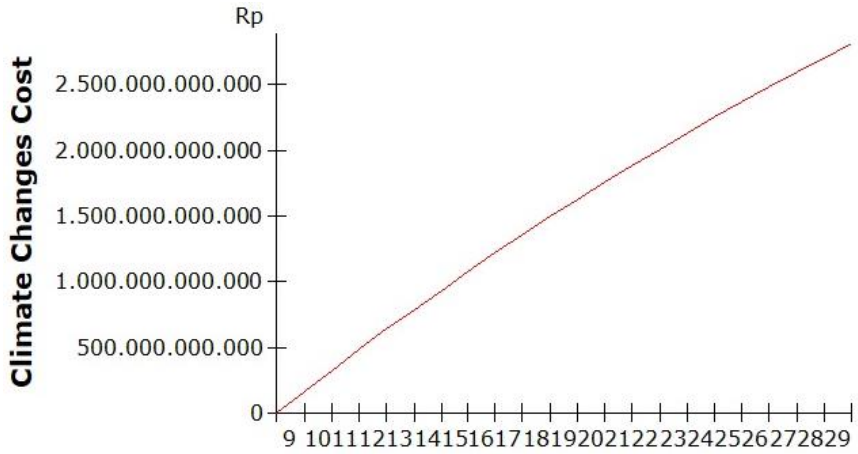


Figure 5. Prevention of Increased Temperature Costs in Converted Paddy Fields.

3.4. The Direction of Policy Strategy for Paddy Fields Conversion Control Model

3.4.1. Spatial Assertiveness as a Long-Term Paddy Field Management Concept. Government support in the long run is very important so that the operation of government LP2B is based on empowering farmers. Development of management concepts is needed that can be accepted by various stakeholders. Government support in the form of this policy is important to ensure the legal certainty of the use of the rice fields. Planning with a focus on farmers' needs is a priority so that protected rice fields are sustainable.

3.4.2. Paddy Field Protection through the Establishment of Government LP2B Institutions. The lack of ownership of the land used has encouraged the suggestion that the ownership of rice fields be directed to government ownership. In this proposed scheme, the community continues to manage it as a land of livelihood with all conditions being the responsibility of the manager because the results obtained are indeed for managing farmers. Thus the sense of belonging will be embedded through the form of cooperation designed by LP2B institutions.The implementation of the policy of protecting rice fields, among others, can be proposed with the implementation of the land banking system. This system is a government activity to provide land to be allocated in the future. Land bank has a function [17] such as a land keeper, land security for various activities in the future development needs (land warranty), land control (land purchaser) and land distribution for various development purposes (land distributor). So far there have been obstacles in the cooperation of national banking for lending to the agricultural sector [3]. In an agricultural system, there needs to be a special bank, or the alternative is through the application of a land banking system.

3.4.3. Utilisation of Waste as Added Value. Policy directives for mainstreaming regional economic development need to be synchronised with the aim of meeting farmers' needs, as well as more directed at optimising agricultural products and developing derivative products. Regional superior commodities can be developed so that the characteristics of rural areas remain based on agriculture. The application of the concept of blue economy needs to be developed in combination with creativity and innovation.

The amount of waste that can be used is quite a lot. Grain waste, for example, reaches 3.8 tonnes / ha while straw reaches 12-15 tonnes / ha at a price of Rp.175 / kg. Grain waste can be used as husk, bran and groats. Based on the calculations from the Agricultural Research Agency (2015) on a rice milling process, obtained byproducts, among others, are rice which is crushed rice (± 5%) at a price of Rp. 3,000 / kg, bran / bran, which is epidermis, is produced from the process of ignition (8-12%) at a price of Rp. 2,000 / kg and husk, which is part of the outer shell / wrapper (15-20%) at a price of Rp. 280 / kg. If these wastes can be utilised, it will increase farmers' income from the by-products of the rice. For this waste, optimisation at the farm level is in the form of straw, while the others are in the mill.

Improving the welfare of farmers through the use of waste is expected to contribute to reducing the conversion rate of rice fields. The application of processing agricultural waste into fermented straw has been carried out by the Jatikersa Farmer Group in Cicurug Village, Majalengka Regency. Agricultural wastes in the form of rice straw and corn were fermented using biostats as a result of Institute for Agricultural Technology Studies West Java [12].

4. Conclusion

Conversion of rice fields in Purwakarta Regency between 2012 - 2030 is quite significant, the decreased of rice fields by 36.07%, whereas land use that has increased is settlements of 105.94% and dryland agriculture of 48.15%.The supply of food needs still has a surplus even though it has decreased from 2017 with a surplus of 92,973 tonnes and in 2030 it will become a surplus of 40,824 tonnes.

Increasing the temperature of the microclimate as an environmental service for paddy fields, the loss of paddy fields from 2009 to 2030 covering an area of 8,668.21 ha would have an economic value in preventing an increase in local temperature of Rp. 2,812,240,804,033.

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