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Arrangement of Green Open Space on River Borders with Constructed Wetlands Concept

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Abstract. The decline in river quality is due to the role of 60%-70% of domestic waste, 30% of industrial waste, and 10% of agricultural and livestock waste that pollutes rivers. In addition, because there are settlements on the banks of the river, if it is not handled, the quality of the rivers in Jakarta will certainly be bad. One way of treating wastewater is Constructed Wetlands, the goal is to improve water quality and reduce the harmful effects of waste, as well as water conservation efforts. Constructed Wetlands are usually applied to settlements that have yards, while settlements in Jakarta currently only have narrow yards there are no yards left. From this aspect, the post-normalization riverbank arrangement will be carried out using the Constructed Wetlands approach. The research located at the Kampung Baru, Cakung,River, East of Jakarta. To find out the results of this application, the method used is descriptive in knowing the conditions of settlements, and then data collection will be carried out from literature reviews and interviews. Furthermore, an analysis is carried out with basic mathematical calculations to answer the space requirements in the application of Constructed Wetlands so that it will produce a spatial pattern model for settlements.

Keywords: *Riverbanks, Normalization, Green open space, Constructed Wetlands*

INTRODUCTION

The increase in urbanization that occurs in Jakarta has resulted in the need for a place to live or a place for activities to also increase, resulting in an imbalance between the population and the increasingly limited availability of land. According to Harahap (2013), the poor management of the RTRW in Jakarta has made almost all of the land converted into buildings, ranging from settlements or housing for living, trade and production activities, to the existence of centers of activity from various sectors. So now it is very difficult to reach green open space for public spaces. The forms of settlement patterns in Jakarta tend to be close to each other and do not have enough yards to manage pollution and waste. In fact, the growth of these settlements has mushroomed to the point of standing on the banks of the river which destroys the function of the river, and the current condition of the rivers in Jakarta is very dirty, smelly, and black in color. According to Ismuyanto (2010), the quality of rivers in Jakarta is getting worse and polluted every year as a result of direct waste flowing into the river. The decline in river quality is due to the role of 60%-70% domestic waste, 30% industrial waste, and 10% agricultural and livestock waste that pollutes the river. The Jakarta government continues to strive to restore the function of the river, one of the programs carried out is the normalization of slum settlements that stand on the river border. However, the handling of waste problems that enter the river has not received serious attention. There is no concrete waste management program in Jakarta's 13 rivers, so far only relying on orange troops. If it is not handled, it is certain that the quality of rivers in Jakarta will get worse. According to Yudo (2014), it is important to improve the sanitation system, one of which is by treating wastewater before it is discharged into the river to reduce the pollutant load of surface water which is used as a water source. One way of treating wastewater is Constructed Wetlands (CWs). The aim is to improve water quality and reduce the harmful effects of waste, as well as contribute to water conservation efforts. According to Siswati & Wibisono (2013), Constructed Wetlands is an efficient green technology to reduce pollutant levels in liquid waste. Constructed Wetlands are not only used to treat domestic liquid waste, but also for industrial and mining waste. Constructed Wetlands (CWs) are usually applied to settlements that have sufficient yards. Meanwhile, the current condition of settlements in Jakarta generally only has a narrow yard, not even a yard left. From this aspect, the arrangement of green open space on the banks of the river will be forced to normalize using the Constructed Wetlands approach. The case study is located in the Kampung Baru settlement, Cakung, East Jakarta, which is located on the Cakung River.

METHODOLOGY

By looking at the two interrelated problem factors as the object of research, namely waste management and the need for green open space which will work together, the researcher will try to find solutions to answer these problems through an approach with the concept of Constructed Wetlands. In helping to apply the Constructed Wetlands approach, two methods will be used, namely: 1) Descriptive, the first method used in this research is descriptive method. Observation of the location of settlements is the first step to determine the existing conditions of settlement patterns. The goal is to be able to adjust the application of the Constructed Wetlands system to the right place because the nature of this research is to plan the use of vacant land from post-normalization; 2) Quantitative, to find out the area of space in running the Constructed Wetlands system, it is necessary to calculate the results or the amount of wastewater discharge issued by settlements. The amount of water discharge is calculated using basic mathematical calculations where wastewater is taken from 10 house samples. The results of this calculation will have a relationship with the descriptive method in drawing settlement conditions. In addition, there is also a calculation of the amount of carbon dioxide emitted from settlements so that it can find out the right green open space planning for vacant land from post-normalization. This approach also requires supporting data as a reference, while the data taken comes from journals, books, media, and the like. Analysis has done by comparing the results of the data that has been obtained and then reviewed with the theory used. The steps are as follows:

a. Collect all available data;
b. Comparing data from two different sources;
c. Relate data to theory;
d. Draw a conclusion.

RESULT AND DISCUSSION

In the results and discussion, several things will be discussed as follows: 1) normalization of river in the research location; 2) constructed wetlands system in settlements; 3) analysis of space requirements for vSSF constructed wetlands system; 4) analysis of green open space application; 5) analysis of settlement patterns; 6) analysis of effect of constructed wetlands system to settlement.

Normalization of River in the Research Location

The existence of regulations concerning the prohibition of the construction of buildings or settlements on the river border line is the basis which states that the river border line is a building-free locations, this regulation is written in UU No. 38 of 2011. There are many ways that the government has taken in relocating settlements that are on the river border's line, one of the actions taken is the relocation of settlements to Simple Flats for Rent. After normalization, the existing vacant land will be used as a road. However, in the discussion of this research, post-normalization land will function as green open space with a Constructed Wetlands approach. The application of Constructed Wetlands requires the number of buildings to determine the volume of waste released from the settlement which will be processed in a system before being discharged into the river. To find out the results of the volume released by the settlement, it is assumed that the research area has been relocated to Simple Flats for Rent. The following is a description of the post-normalization settlement model to Simple Flats for Rent.

FIGURE 1. Migration of Riverside Settlement to Simple Flats for Rent

The red line is the settlement located on the river border, the yellow line is Simple Flats for Rent, while the blue line is the 1.5 km research area, and the blue line is the area boundary. The settlement will be moved to Simple Flats for Rent which is close to the settlement. So the form of the settlement model will only be in one part.

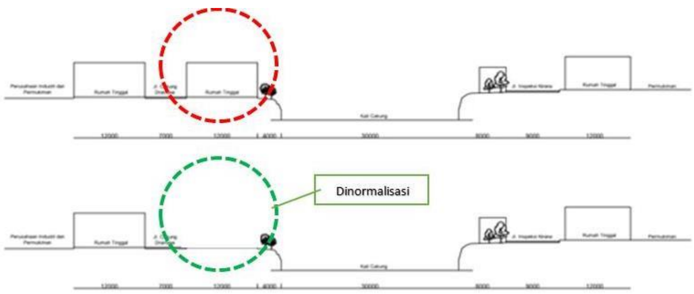

FIGURE 2. The Changes of Settlement Model

The Constructed Wetlands System in Settlements

The Constructed Wetlands system has two ways of implementation, namely CWs FWS and CWs SSF. The CWs FWS system treats its waste using the roots of the planting media that are submerged in water, while the CWs SSF uses various kinds of materials to treat waste. The material used can be gravel, plastic bottles, fibers, and the like. Differences also occur in the physical form of the results of the application, where the application of CWs FWs has results such as water ponds so that it requires a large area of land, while CWs SSF can be applied to parks in general. In an effort to treat waste from settlements and also improve the quality of green open space, the system that will be used is CWs SFF. This system is also very appropriate in the form of primary treatment of sewage, because it does not have a direct relationship with the pool of water and the atmosphere so that the community is not affected by disease from this system, and the system is suitable for communal or centralized scale. The plan for implementing the system is located at the river border, and placed below the ground surface to make the upper part of the land surface so that there is a lot of space that can have functions for the community to carry out activities. The system is called CWs vertical SSF (vSSF) or vertical water flow pattern system. The following is an overview of the system.

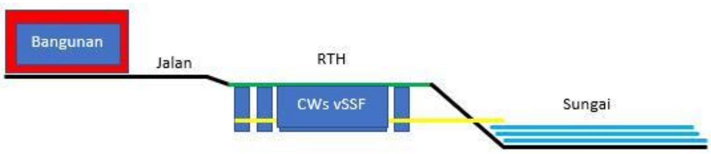

FIGURE 3. Planning for Laying CWs vertical SSF on Settlement Models

Waste treatment from the house will be deposited first in one reservoir, then flown using a pump to the filtering area with the help of plant media and various types of materials. The results from the filtered waste will be accommodated in a container before flowing into the river, but the waste in the last container before being channeled into the river can be re-filtered by adjusting the water flow which is rotated to the same path until the waste water becomes maximally filtered before being channeled into the river. . Disposal of waste into the river can be regulated on the valve section, so that the disposal time and the water content of the waste to be flowed into the river can be determined according to existing standards.

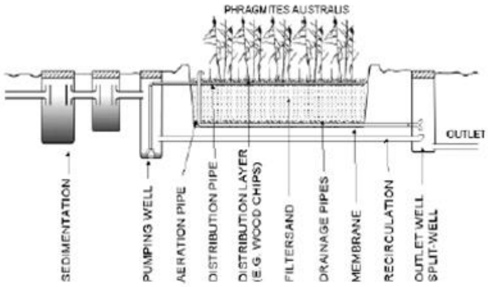

FIGURE 4. CWs vertical SSF Application System [5]

Analysis of Space Requirements For vertical SSF Constructed Wetlands System

The space requirement in implementing the vertical SSF system is calculated from the wastewater/house income to determine the volume of the reservoir. Data were taken from 10 samples of houses located in locations along the settlement, while the first data analyzed was in the form of calculating waste water for 1 day. Of the 10 samples, the average number of occupants in one house is 3-7 people and the amount of clean water consumed by each person ranges from 150-180 liters. From the clean water used by each person will produce waste water ranging from 60-70%. Here is a table of 10 sample houses:

TABLE 1. 10 Sample Houses

No	Family Name	Amount of Occupants	Average Clean Water Usage (liters)	Amount of Clean Water Usage (liters)	Average Wastewater Income 70% (liters)
1	Mr. Agung	6	150	900	630
2	Mr. Nedi	7	180	1260	882
3	Mr. Salam	4	180	720	504
4		4	150	600	420
5		4	150	600	420
6		6	180	1080	756
7		5	180	900	630
8	Mr. Bastian	3	180	540	378
9	Mrs. Apri	4	180	720	504
10	Mr. Armawan	7	180	1260	882
Total Wastewater Income					6006

The need for temporary storage space in implementing the CWs vertical SSF system is calculated from the wastewater/house income. Count 1000 liters of water = 1 m³, then the amount of space required from the production of wastewater 6006 / 1000 = 6.006 m³. When solved with a depth of 1 meter, then the area can be W x W x H (1 x 6 x 1) or (2 x 3 x 1). While the space requirement for one house ideally ranges from 2 x 1 m² with a depth of 0.8 m for the stage of the wastewater cleaning process system. The second data analyzed is the area of vacant land in the river body after normalization. To find out the space requirements when taken from 10 samples of houses that are sufficient or not on the land. The land used is right in front of the house after the road. Here is an overview of the research points of 10 houses.

FIGURE 5. Research Point Of 10 Houses

The width of each house from the 10 samples taken is 6 m, so the length of the empty space in front of the 10 sample houses is 60 m, and the width of the known vacant land is around 12 m. Then the available land area is 60 x 12 = 720 m². If in the process the CWs vSSF system 1 house requires a size of 2 m² x 4 filtering system = 8 m². So from 10 samples it takes 80 m² areas. When added to the need for a waste water storage area, which is 6 m² from 10 samples with the application (L x L x H = 1 x 6 x 1), then the total area required for the application of CWs vSSF = 86 m². From these results, the total remaining free space difference for the application of CWs vSSF to 10 sample houses is 720 m² - 86m² = 634 m². If the calculation is reversed, it becomes the result of how many houses can be used. So the result is (720 m² / 86 m²) x 10 = approximately 80 houses.

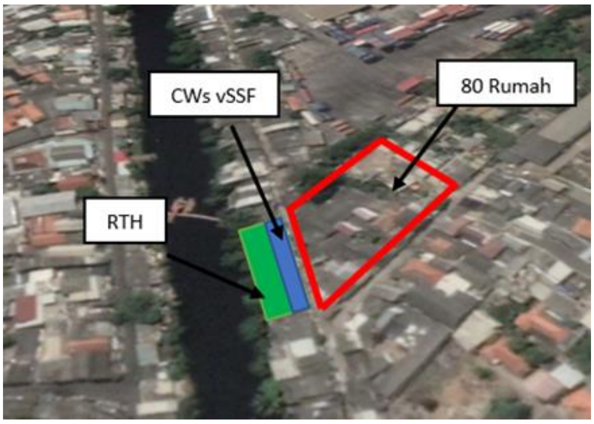

FIGURE 6. 80 Houses with CWs vSSF System

The settlement has a road length of ±1.5 km based on calculations from Google Maps and along the road has a different elevation. If it is assumed that the width of each house is 6 m, then the number of houses throughout the study is as follows. Settlement Length: 1 km = 1000 m, 1.5 km = 1500 m. Average House Length: 6 m

So the length of the settlement / length of the house = 1500 m / 6 m = 375 houses. While the total area requirements to accommodate all these settlements are as follows. Number of Houses/10 sample houses: 375 m / 10 = 37.5 m. If the area of 10 sample houses is 86m², derived from the calculation (L x L) = (86m x 1m), then the calculation is 37.5 m x 86 m = 3,225 m². The comparison of the remaining land as a whole along the outskirts of the Cakung River which is the object of research is as follows. Length of research object x width of research object: 1500 x 12 m = 18.000 m². Then the comparison is the Land Area/Needs for Application of the SSF CWs System: 18,000 m² / 3,225 m² = 5.5 m² = 1:5. The following is a description of the estimated land requirements on the map and a cut of the CWs SSF implementation system.

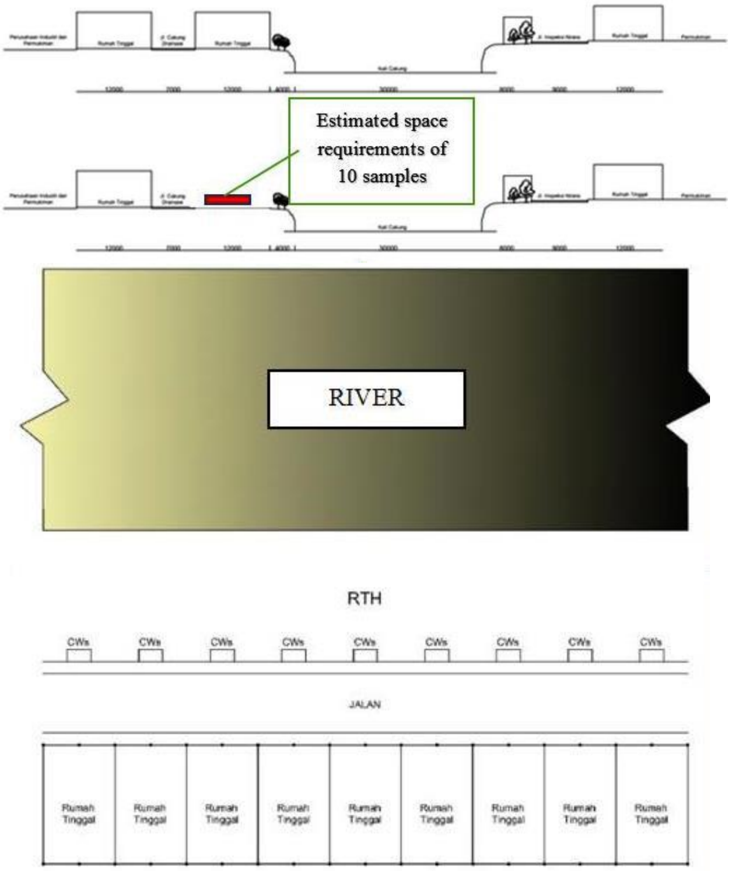

FIGURE 7. Map and Land Requirements of CWs vSSF Application

Seeing from the description of the proportion of space requirements in the application of CWs vSSF, it seems as if it can be planned on the road section of the settlement, but if you look at the condition of the settlement and the filtering process, it cannot be placed in that section because there are plants that will grow in the middle of the road so the plants need more roar in order to survive. Do not interfere with circulation in settlements that are still traversed by four-wheeled vehicles.

Analysis of Green Open Space Application

The application of the CWs vSSF system in these settlements does not take up much land from along the settlement object, the remaining land in the settlement will be used as green open space. The following is an analysis of the calculation of air quality in settlements when many trees are planted. The types of trees that are suitable for conditions on riverbanks and are easily found on the island of Java and are located on the banks of rivers are the *Trembesi* Tree, Bamboo Tree, *Johar* Tree, and Beringin Tree. The green open space planning is tried to be applied by classification using trees of small, medium, and large tree species. The largest tree size requires an estimated land area of 225 m². Then the results of the remaining land area of the application of the CWs vSSF system / Estimate area of one tree with the greatest need. (18000 m² - 975 m²) / 225 m² = 76 trees. Trees divided by 4 species = 681/4 = 19. The number of Bamboo Trees is taken from the results of the division of 4 types, namely 19. However, 1 Bamboo Tree Trunk only requires no more than 1 m of space. Then the number of trees that can be planted from bamboo tree land is 19 x 25 m² = 4,275 Bamboo Trees.

1. Analysis of CO_2 (Carbondioxide) Absorption (Roshintha & Mangkoedihardjo, 2016)
   - Trembesi Tree = 325.2 Kg CO_2/Hour
   - Bamboo Tree = 0.039 Kg CO_2/Hour
   - Johar Tree = 0.604 Kg CO_2/Hour
   - Beringin Tree = 114.6 Kg CO_2/Hour

   If this amount is applied, the resulting function is shown in the table below.

TABLE 2. Data on Carbon Dioxide Absorption in Cakung River's open space

No	Type of Tree	Amount	Total Carbondioxide Absorption per Hour
1	Trembesi Tree	19	6178 kg CO2/hour
2	Bamboo Tree	4275	166.72 kg CO2/hour
3	Cassia Tree	19	11.47 kg CO2/hour
4	Beringin Tree	19	2117.4 kg CO2/hour
	Total	4331	8533.60 kg CO2/hour

2. Vegetation Calculation Data Analysis (Ismaun, 2007).
In the process of respiration, humans produce about 2.3 pounds or the equivalent of 1.8 - 2.4 grams of carbon dioxide, so:The amount of carbon dioxide produced by 1 person in 1 minute: 2.4 x 60 minutes = 144 grams CO2/hour = 0.144 kg CO2/hour. The population is calculated based on survey data from 10 samples, the highest is 7 people and the number of houses is around 375 units, so: 7 x 375 = 2,625 people. The amount of carbon dioxide produced per hour according to the capacity of the Cakung River Settlement 0.144 kg CO2/hour x 2,625 people = 378 Kg CO2/hour. From the data obtained, motorized vehicles that consume 7.8 liters of fuel per 100 km and cover a distance of 16 thousand km produce 1.41 tons of CO2/year each year. And, a car type vehicle that consumes 7.8 liters of fuel per 100 km and travels a distance of 16 thousand km, then annually produces 3.06 tons of CO2/year. So: Motor: 1.41 tons CO2/year = 1410 kg CO2/year : 365 days = 3.8630 kg CO2/day. 3.8630 kg CO2/day: 24 hours = 0.1609 kg CO2/hour. Car: 3.06 tons CO2/year = 3060 kg CO2/year : 365 days = 8.3835 kg CO2/day. 8.3835 kg CO2/day : 24 hours = 0.3493 kg CO2/hour.

TABLE 3. Data on Carbon Dioxide Production around the Cakung River Settlement

No.	CO2 Producer	Amount	Production CO2 (kg/our)	∑ Production CO2 (kg/our)
1.	Motor	375	0,1609	60,33
2.	Car	8	0,3493	2,79
3.	Human	2.625	0,144	378
	Total production CO2			441,12

From the calculation of the absorption of carbon dioxide from four types of trees in the open space of settlements are 8,533.6 Kg CO2/hour. If the difference between the amount of carbon dioxide production in the settlements is 8,533.26 – 441.12 = 0.092.48 Kg O2/hour. From the results of the difference, it is concluded that green space will greatly affect the quality of settlements.

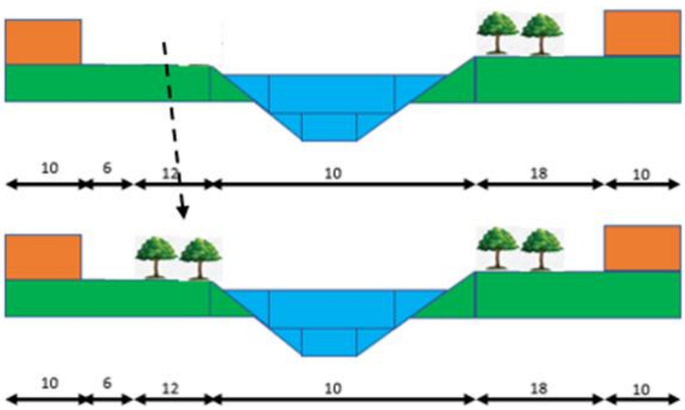

FIGURE 8. Application of Green Open Space on River Borders

Analysis of Settlement Patterns

The zoning in the research area is not only filled with residential areas, but there is also a container factory located behind the settlements. The most densely populated part of residents' houses is at door A Jl. Tipar Cakung while door B Jl. Cakung Cilincing is a container factory.

FIGURE 9. Territory Zoning

From the existing conditions of the settlements above and also the results of the calculation analysis, the CWs vSSF planning design will be made into two patterns. Pattern 1 will be centered and located in the area of the door A, this is done to raise the settlements at the back.

FIGURE 10. Pattern 1 of CWs vSSF Planning

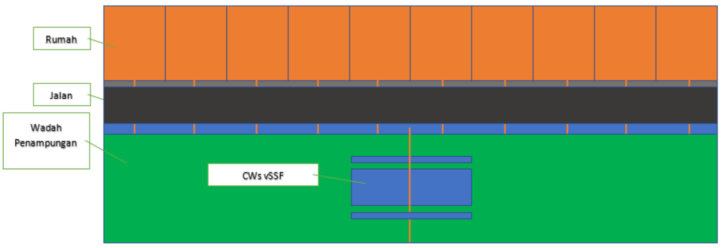

FIGURE 11. Pattern 1 of CWs vSSF Planning

The black line in the image is the sewer grouping. However, this grouping also still has to be adjusted to the settlement pattern in order to drain water properly. While pattern 2 is made in a row with a distribution of 1:10 or 1 CWs vSSF for 10 houses. This is done to facilitate the distribution of settlements and also in arranging the pattern of green open space because there is a lot of empty space.

Analysis of Effect of Constructed Wetlands System to Settlement

From the discussion above, the application of CWs vSSF will have an important role in river quality because wastewater from settlements has been treated first and there will be space or land to make green open space which improves air quality in settlements. In addition there are other influences that may occur, namely:

1. There is a change in the location of the chicken farm. Chicken farming will allow damage to existing plants, this is important because most people living along the river keep chickens for personal consumption or sale.

FIGURE 12. Chicken farm in residential

2. Green Open Space in settlements will become a place of recreation that is visited by the public. This will allow the formation of street vendors who also have the potential to damage the system if not regulated.
3. Good river quality will make various types of living things or animals come. So the community needs to make regular observations of the system so that no animals make nests such as rats, monitor lizards, and snakes that can damage.

CONCLUSION

The application of the Constructed Wetlands system is on the Cakung river border in the settlement of Kampung Baru, East Jakarta, which is planned in the event of normalization. This system can be implemented without violating government regulation No. 38 of 2011 concerning rivers, but the system strongly supports government programs such as normalization or naturalization. This system is very applicable because the space requirements required from this application can be accommodated, even the remaining space from this system can reach the settlements around the study to the rear if the entire land is planned for this system.

The results of Constructed Wetlands produce two positive impacts for settlements, the first is that the quality of the river returns to normal because the management system is made by rotating or repeating circulation so that the level of cleanliness of wastewater can be regulated. And secondly, the remaining space from this application can also be applied as green open space which is very influential in absorbing carbon dioxide, so that green open space can produce good air quality for settlements.

However, the results will be maximized if there is a proper arrangement from the house sewage pipe to the Constructed Wetlands system. Due to the irregular conditions of the settlements, it is better if the settlement pattern is arranged in advance so that the circulation of the waste water flow does not cause new problems. The parts that need to be considered in making the Constructed Wetlands contour system in settlements. In addition, to support the return of river quality in Jakarta, it is necessary to carry out a thorough normalization of the river, and also to prevent flooding that will damage the Constructed Wetlands.

This application will also slightly change the culture in settlements such as the loss of people's livelihoods by raising chickens. Chicken farming will allow damage to existing plants, this is important because most people living along the river keep chickens for personal consumption or sale. But on the other hand, green open space in settlements will become a recreational place that is visited by the public. This will allow the formation of street vendors who also have the potential to damage the system if not regulated.

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