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Utilization of Geographic Information System (GIS) For The Prevention of Land And Forest Fires As Mitigation Efforts For Peatland Disasters

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***Abstract* - Riau's forest and peatland fires are not only the focus of the Riau Provincial Government, but have become a national and international concern, as it has resulted in a fog disaster as soon as possible in several Asian countries. One of the efforts to prevent forest and peatland fires is to know the potential fire points, fire spreading mechanism, and the main causes of forest and peatland fires. The location of forest fire disaster mitigation is located in 4 villages and 1 village included in Bukit Batu Sub-district, Bengkalis Regency. The 4 villages are Sejangat, Pakning Asal, Sungai Selari, Batang Duku and one village, Sungai Pakning Village which is one of the red zone locations or areas prone to forest fires and peatlands. One of the objectives in disaster mitigation activities that can be done is by mapping to know the condition and coverage of existing water recervoir and skating channel. To determine the location used and implemented in Geographic Information Systems and community patrisipation. From the results of the research, it is found that mitigation of forest and peat fires by creating water recervoirs and canals in new locations will reduce the extent of disaster risk of forest and peat fires by increasing the area covered by water recervoirs and canals in hazard prone zones such as Sejangat Island the less vulnerable zone decreased by 4.06 percent, Pakning Asal Village decreased 6.96 percent, Sungai Pakning Village decreased by 3.15 percent, Sungai Selari village decreased by 213.85 percent and Batang Duku village decreased 2.2 percent, So, from the mapping based on Geographic Information System and Community Participation in the 4 Villages and 1 Village it is known that the construction of water recervoir and canal can reduce the risk of forest and peat land fire disaster**

Keywords: Forest Fire and Peatland, Geographic Information System, Community Participatio.

I. INTRODUCTION

Peatland fires and forests have made Indonesia a world-emitting country, 80 percent of the sources of emissions come from forest degradation, especially peatland and forest fires. While in the world, forest damage is the cause of 20 percent of greenhouse gas (GHG) emissions that trigger extreme climate change. Indonesia is estimated to have a peat area of 20.6 million hectares (ha) or about 10.8 percent of its land area. The width of peatland in Indonesia is the third largest in the world and mostly located in the lowlands coastal areas of Sumatra, Kalimantan and Papua islands.

Forest fires are a condition in which forests are hit by fire, causing damage to forests and / or forest products that cause economic losses and / or environmental value (Permenhut No.12 / Menhut-II / 2009). Forest fires can occur naturally or caused by human actions. Fires caused by human activities can occur intentionally accidentally. Forest fires are naturally triggered by weather and natural disasters such as lightning and volcanic lava melting. Forest fires triggered by human activities can be caused by two things, intentionally and unintentionally. Fires are deliberately mostly triggered by burning to clear land and burning due to the exploitation of natural resources. While accidental fires are more caused by negligence for not lethal fire, burning garbage, throwing cigarette butts, and other negligent acts. In Indonesia, 99% of forest fires are caused by human activities either intentionally or unintentionally. Only 1% of it happens naturally. Since the 1980s, the opening of oil palm plantation and Industrial Plantation Forest is thought to be the main cause. According to the Indonesian Forum for the Environment or Walhi, forest and land fires in Riau are one of the annual disasters caused by human behavior. Field facts show that there are intentional factors burning forests and land. The purpose of the burning is to conduct land clearing in preparation for plantation development. In early March 2014, forest and peatland fires in the Riau province of Sumatra, Indonesia, surged to a point that has not been found since the Southeast Asia haze crisis in June 2013. World Resources Institute (WRI) through the Global Forest Map project mapped the location of the

hotspots Riau during February 20 - March 12, 2014 with the help of the US Federal Aviation and Space Administration's (NASA) Active Fire Data. From February 20 to March 11, 2014, Global Forest Watch found 3,101 hotspots on the island of Sumatra. The amount exceeds the period of June 13 to June 30, 2013 and a total of 2,643 hotspots. Of these, in the period 4 to 11 March 2014, 87% of the fire points in Sumatra were found in Riau. In Riau itself, there are areas with high and low fire density densities. Fires are present in industrial timber forest concession areas such as pulp and paper, palm oil, timber concessions, and outside concessions. Forest and land fires in Riau are not only the focus of the Riau Provincial Government alone, but have become a national concern. One of the efforts to prevent forest and land fires is to know the potential fire points, fire spreading mechanism, and the main causes of forest and land fires. As mentioned earlier, the main cause of fire in Riau is due to land clearing activity by farmers using fire. If the clearing of the land occurs in the peat area, it will potentially be a major fire due to the difficult nature of peat if already burned fire.

Naturally, peatland ecosystems are always wet or humid. Peatland ecosystems have many functions, namely:

1) *As a container of water storage.*
2) *As a buffer or environmental or ecological balancer.*
3) *As a farmland.*
4) *As a habitat for several kinds of flora and fauna.*
5) *As raw material for the manufacture of charcoal briquettes and planting media for plants.*
6) *As a carbon sink; peat has the capacity to store carbon and large quantities and limit the release of carbon emissions into the atmosphere.*

However, due to the conversion of peatlands into plantation land, the wetland peatland ecosystem is then used as a dry land by means of dialalisation. Channeling is the process of draining water from peatlands to pre-prepared canals with the aim of preparing land for the water level of the land to be in accordance with the optimal criteria for growing crops and plantations. The canalization has transformed wet peatlands, became flammable and lost function as a water provider. One of the areas in Riau Province which has the largest peat area is Bengkalis district as described by Table 1 In addition, based on NOAA 18 satellite data during 2014, the number of hotspots in Bengkalis Regency is also the highest in Riau province.

TABLE I. DATA ON PEAT AREA IN RIAU PROVINCE IN 2009 SOURCE BPBD RIAU, 2014

No	Regency	Peatland Area	
		Peat Areas (Ha)	*Peat Areas (Ha)*
1	Bengkalis	1.240.122	474.383
2	Indragiri Hilir	1.267.237	222.706
3	Indragiri Hulu	225.635	107.938
4	Rokan Hilir	734.050	263.032
5	Rokan Hulu	117.645	19.607
6	Siak	735.835	231.990
7	Pelalawan	904.461	234.088
8	Dumai	298.521	123.317
9	Kampar	153.811	15.924
10	Pekanbaru	42.266	0

B. *Condition of Research Sites*

The disaster mitigation site of land and forest fires is located in 4 villages and 1 sub-district belonging to Bukit Batu Sub-district, Bengkalis Regency. The four villages are Sejangat Village, Pakning Asal Village, Sungai Selari Village, and Batang Duku Village, and one Kelurahan is Sungai Pakning Village.

II. RESEARCH METHOD

A. *Research Methods*

The method used in data collection is survey method supported by secondary data. Survey method is used to know the condition of the field as the renewal of secondary data and to get the field data not obtained in secondary data. The survey method is carried out by taking points (Plotting) of the research location in this case is the location of land burning, border, embung, and canal of each village which then processed using ArcGIS software to analyze the survey data with secondary data in the form of aerial photograph complete the survey results in the field.

B. *Data analysis*

Primary data in the form of survey results in the field of secondary data in the form of aerial photographs and then applied into the GIS for analysis of data which will then be displayed in the form of maps. Mitigation The forest fires disaster requires some data, among others:

1) Land use data is important because land use data is used as a basis for determining disaster mitigation plans. Land use data obtained from aerial photographs.
2) The data of vulnerable / burned areas was obtained from interviews with the village MPA concerned as a group of people who had knowledge and experience about the location of prone / ever burned which then the data will be processed by using GIS into the map form to facilitate in determining disaster mitigation plans.
3) Data on the distribution of water recervoirs and canals is needed to determine the location and affordability of the covered areas in preparation for disaster mitigation. Data distribution of water recervoir and channel in the form of dots and lines will then be processed with GIS utuk then emerging affordability covering the area around the embung and the canal with buffer analysis. For the buffer area use the basis of ownership of the tool in the form of each MPA hose so that the buffer size is different from each village. And
4) Data plan of recuvoir water reclamation location is obtained from analysis of land use data, prone / burnt, and distribution of water recervoir and canal with input from village head / village head and MPA of each village in question so that water recervoir and canal will be made is appropriate and useful especially in forest fire disaster mitigation. After the location of

water recervoir plan and the channel will be processed again with GIS, so it can get data of water recervoir and new channel accessibility in addition to existing embungs and canals. With the creation of new water recervoir and canal is expected to increase the area that can be covered by the existence of water recervoir and the canal.

III. RESULT AND DISCUSSION

A. Result

Based on the research that has been done, the results obtained include general condition of research location, distribution of embungs and canals, and prone to burning areas in Sejangat, Pakning Asal, Batang Duku, Sungai Selari and Sungai Pakning, Bukit Batu, Bengkalis, Riau Province. The results will provide an overview of the distribution of embungs and canals, vulnerable / burned areas as a reference in forest fire disaster mitigation plans.

1) Research Sites

The overall research location lies at the coordinate point 1 ° 19'23.468 "LU - 1 ° 24'25.317" LU and 102 ° 4'2,466 "BT - 102 ° 9'32.799" BT. Administratively, the location of this research is located in 4 (four) villages and 1 (one) urban village in Bukit Batu District, Bengkalis Regency, Riau Province. The research area has borders, the south is bordered by Dompas Village, Northern Part Borders Bengkalis Strait, Eastern Bordered Bengkalis Strait, and West Bordered by Bukit Batu Village.

2) Description Existing water recervoir, Canal and Zone Burned

a) Desa Sejangat

Based on a community-based field survey, the village has 28 embungs and 1 canal. The location of water recervoirs and canals spread east of the ring road, while in the western part of the ring road there is no water recervoir.

Based on GIS analysis Sejangat Village has the following geographical conditions:

TABLE II. THE EXISTENCE CONDITION OF DESA SEJANGAT (SOURCE: ANALYZE DATA THROUGH GIS

Regency	Fire Prone Zone	The Water Reservoir Range and Canal Existence		The Unreached Area of Water Reservoir	
Ha	*Ha*	*Ha*	*%*	*Ha*	*%*
599,8	169,71	70,91	41,78	98,81	58,22

Based on SIG analysis Sejangat Village has an area of 599,8 Ha with 169,71 Ha of fire prone area and affordability area of embankment and canal of 103,45 Ha. The affordability of embungs and canals is influenced by the ownership of the tool in the form of a water hose which in this case Sejangat Village has a water hose along the 120 m. Based on the calculation there are flood-prone areas that are affordable by embungs and canals covering an area of 70.91 ha. So there are still prone areas burning area of 98.81 ha which has not been reached by water recervoir and canal.

a) Pakning Asal Village

According to the result of field survey based community participation, Pakning Asal village had 1 water reservoir and 1 canal. The location of water reservoir was in the border of the Sungai Pakning Urban Village; whereas the location of canal was extending from the west ring road to the east ring road entering the densely populated area.

Based on the analysis of GIS, Pakning Asal Village had geographical condition as follows :

TABLE III. THE EXISTENCE CONDITION OF PAKNING ASAL VILLAGE SOURCE: THE DATA ANALYSIS THROUGH *GIS*

The Wide of Village	Fire Prone Zone	The Water Reservoir Range and Canal Existence		The Unreached Area of Water Reservoir	
Ha	*Ha*	*Ha*	*%*	*Ha*	*%*
600	155	15.51	10	139.88	90

According to the analysis of GIS, Pakning Asal Village had wide area of 600Ha with the wide of the fire prone zone was 155 Ha, and the wide range area of water reservoir and canal was 106.67 Ha. The range area of water reservoir and canal was influenced by the ownership of a tool in the form of water hose; in this case Pakning Asal Village had water hose 100m in length. Based on the result of calculation, there were fire prone areas which reached by water reservoir and canal about 15.51 Ha. Thus, there were still fire prone areas about 139.88 Ha which unreached of water reservoir and canal.

b) Sungai Pakning Urban Village

The result of field survey based community participation showed that Sungai Pakning Urban Village had 1 water reservoir and 2 canals which united. The location of the water reservoir was in the shrubs area, in the west of ring road; whereas the location of the canal 1 was extending from west to east, and the location of canal 2 was extending from south to north then converging with the previous canal.

The data analysis of GIS, Sungai Pakning Urban Village had geographical condition as follows:

TABLE IV. *THE EXISTING CONDITION OF SUNGAI PAKNING URBAN VILLAGE SOURCE : DATA ANALYSIS THROUGH GIS*

The Wide of Village	Fire Prone Zone	The Water Reservoir Range and Canal Existence		The Unreached Area of Water Reservoir	
Ha	*Ha*	*Ha*	*%*	*Ha*	*%*
905.6	398.49	11.08	2.78	387.1	97.22

The result of data analysis through GIS, Sungai Pakning Urban Village had wide area 905.6 Ha with the wide of fire prone area was 398.49 ha and the wide range area of water reservoir and canal was 104.36 ha. The range of water reservoir and canal was influenced by the ownership of tool in the form of water hose which in this case Sungai Pakning Urban Village had water hose 110m in length. The calculation showed that there were fire prone areas that reached by water reservoir and canal about 11.08 ha. Thus, there were fire prone areas which unreached by water reservoir and canal about 387.41 ha.

c) Sungai Selari Village

The field survey based community participation also showed that Sungai Selari Village had water reservoir and 1 canal which were emptying in to the sea. The location of the water reservoir was in shrubs area in the west of ring road, and then the location of canal 1 was extending from the west to the east. The location of canal 2 was extending from south and north converging with the previous canal.

The data analysis of GIS showed that Sungai Selari Village had geographical condition as follows:

TABLE V. *THE EXISTENCE CONDITION OF SUNGAI SELARI VILLAGE SOURCE: THE DATA ANALYSIS THROUGH GIS*

The Wide of Village	**Fire Prone Zone**	**The Water Reservoir Range and Canal Existence**		**The Unreached Area of Water Reservoir**	
Ha	*Ha*	*Ha*	*%*	*Ha*	*%*
529	23.10	151.98	657.92	0	0

Based on the data analysis of GIS, Sungai Selari Village had wide area 529 Ha with the wide of the fire prone zone was 23.10 ha and the wide reach of water reservoir and canal was 151.98 ha. The range of water reservoir and canal was influenced by the ownership of a tool in the form of water hose. In this case, Sungai Selari Village had water hose 300m in length. Thus, it can be concluded that the fire prone zone in Sungai Selari had been covered by the range of water reservoir and canal.

d) Batang Duku Village

According to the field survey based community participation, Batang Duku Village had 8 water reservoirs and canals which emptying into the sea and the canals were located in the south which was conterminal with PT. Surya Dumai. Most of the water reservoir locations were in around of canal which emptying in to the sea.

Based on the data analysis of GIS, Batang Duku Village had geographical condition as follows:

TABLE VI. *THE EXISTENCE CONDITION OF BATANG DUKU VILLAGE SOURCE : THE DATA ANALYSIS TROUGH GIS*

The Wide of Village	**Fire Prone Zone**	**The Water Reservoir Range and Canal Existence**		**The Unreached Area of Water Reservoir**	
Ha	*Ha*	*Ha*	*%*	*Ha*	*%*
2265.6	951.4	85.92	9.03	865.48	90.97

The result of the data analysis through GIS showed that Batang Duku Village had wide area 2265.6 Ha with the wide of fire prone zone 951.4 ha, and the wide range area of water reservoir and canal was 331.56 Ha. The range of water reservoir and canal was influenced by the ownership water hose which in this case Batang Duku Village had water hose 150m in length. The result of calculation showed that there were fire prone zones which reached by water reservoir and canal about 85.92 ha. Thus, the fire prone zones which were unreached by water reservoir and canal were about 865.48 ha.

B. Discussions

The program of building water reservoir and canal in planning effort of *land and forest fires* disaster mitigation based Geographical Information System and community participation was as result of this study. The planning of building water reservoir and canal for each village was expected to assist in disaster mitigation of each village; therefore, in order to be benefit and appropriate, thus that was needed some data analysis and / with taking the consideration of the recommendation from the local community. The community participation was much needed, because they knew the condition of their environment. In deciding location of building the water reservoir and canal needed consideration of the existing condition in each village such as the existing of distribution location of water reservoir and canal, the existing range of each water reservoir and canal, and / by using fire prone or ever burned land as the priority location. Based on the result of analysis some data above then was applied in the form of map. These are the following maps of location plan of each village:

1) Sejangat Village

The location plan of building water reservoir and canal in Sejangat Village was in around the existing of water reservoir that was according to the Headman of Village and community's recommendation which represented by MPA. The wide of the fire prone zone in Sejangat Village was 169.71 Ha and the wide range of water reservoir and canal in fire prone zone was 98.81 Ha. With the plan of adding water reservoir and canal, thus the wide of fire prone zone which can be reached by water reservoir and canal would be reduced into 91.92 Ha. The explanation can be seen on the following map:

2) Pakning Asal Village

The plan of building water reservoir and canal in Pakning Asal Village was in fire prone zone which not reached yet by the existing of water reservoir and canal, the selection of the location was as recommendation for the Headman of Village and the community which represented by MPA. Pakning Asal Village had the wide of fire prone zone about 155 Ha and the wide range area of water reservoir and canal in the fire prone zone was 15.51 Ha. With the plan of adding water reservoir and canal, thus the wide of fire prone zone which can be reached by water reservoir and canal would be increased into10.79 Ha which means the wide of fire prone zone would be reduced into 129.09 Ha. The explanation can be seen on this map as follows:

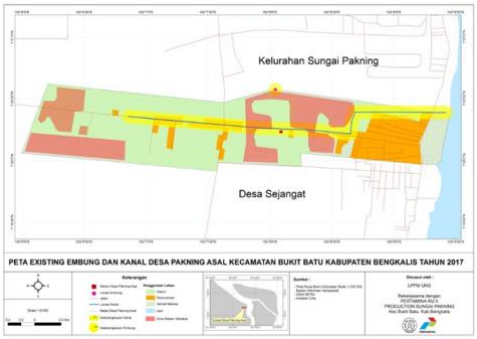

Fig 1. Map of the Water Reservoir and Canal Existence in Pakning Asal Village, Bukit Batu Sub- District, Bengkalis Regency in Year 2017

3) Sungai Pakning Urban Village

The location plan of building water reservoir and canal in Sungai Pakning Urban Village was in the fire prone zone which not reached yet of the existing of water reservoir and canal, the selection of the location was as a recommendation for the Headman of Village and the community which represented by MPA. Sungai Pakning Urban Village had the wide of fire prone zone about 398.49 Ha and the wide range of water reservoir and canal in the prone zone was 11.08 Ha. With the plan of adding water reservoir and canal, the wide of fire prone zone which could be reached by water reservoir and canal would be increased into 12.57 Ha which means that the wide of fire prone area would be reduced into 374. 84 Ha. The explanation can be seen in a map as follows:

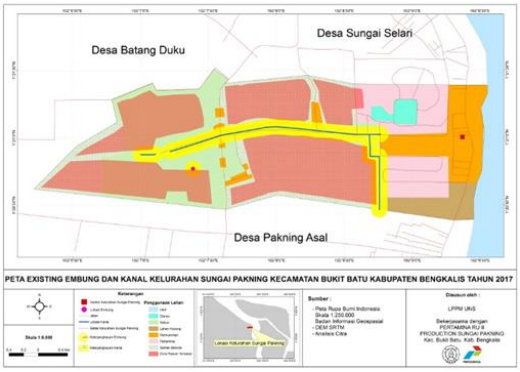

Fig 2. *A Map of the Water Reservoir and Canal Existence in Sungai Pakning Urban Village, Bukit Batu Sub District, Bengkalis Regency 2017*

4) Sungai Selari Village

The location plan of building water reservoir and canal in Sungai Selari Village was in the outside of fire prone area, because the fire prone area in Sungai Selari Village had been in the area reached by canal. However, it was still needed the selection of the location as a plan of land and forest fires disaster mitigation. The selection of the location was based on the land use which in the form of shrubs, because the use of the land has the potential to fire than other uses. This location was as recommendation for the Headman of Village and the community which represented by MPA. The wide of fire prone area in Sungai Selari Village was 23.10 Ha and the wide range of water reservoir and canal in the fire prone area was 151. 98 Ha. With the plan of adding the water reservoir and canal, the zone which can be reached by water reservoir and canal would be increased into 49.4 Ha, thus, the wide area which was covered by water reservoir and canal became 200.38 Ha. The explanation can be seen from a map as follows:

Fig 3. Map of the Water Reservoir and Canal Existence in Sungai Selari Village, Bukit Batu Sub District, Bengkalis Regency 2017

Fig.4 Existing water reservoirs and canals Map of Sejangat Village, Bukit Batu District Regency of Bengkalis Year 2017

5) Batang Duku Village

The plan of selecting location for water reservoir and canal in Batang Duku Village was in around the existing water reservoir, that was based on the Headman of Village recommendation with the community which in this activity was represented by MPA. Batang Duku Village had fire prone area with the wide was 951.4 Ha and had the wide range area of water reservoir and canal about 85.92 Ha. With the plan of adding the water reservoir and canal, the wide of fire prone zone which can be reached by water reservoir and canal would be increased into 20.9 Ha which means that the wide of fire prone area would reduced into 844.58 Ha. The explanation can be seen from a map below:

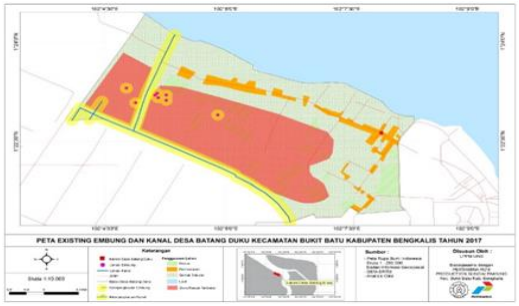

Fig 5. Map of the Water Reservoir and Canal Existence in Batang Duku Village, Bukit Batu Sub District, Bengkalis Regency 2017

IV. CONCLUSION

Disaster Mitigation could be done by some ways, one of them was by adding water reservoir and canal to the fire prone area. The addition of water reservoir and canal in each village could be expected to solve fire potential. Based on the analysis result and discussion thus it can be concluded as follows : The wide of fire prone area in Sejangat Village which not reached yet by water reservoir and canal was 98. 81 Ha. The plan of building new water reservoir and canal could reduce the wide of fire prone area into 91.92 Ha, the wide of fire prone area in Pakning Asal Village which not reached yet by water reservoir and canal was 139.88 Ha. The plan of building new water reservoir and canal could reduce the wide of fire prone area into 129.09 Ha, the wide of fire prone area in Sungai Pakning Urban Village which not reached yet by water reservoir and canal was 387.41 Ha. Then, the plan of building new water reservoir and canal could reduce the wide of fire prone area into 374.84 Ha, the wide of fire prone area in Sungai Selari Village had been totally reached by water reservoir and canal; however, it was still necessary to build water reservoir and canal in the area which had fire potential. The plan of building water reservoir and canal could increase the wide area which was covered by water reservoir and canal into 200. 38 Ha, the wide of fire prone are in Batang Duku Village which not reached yet by water reservoir and canal was 865.48 Ha and the plan of building new water reservoir and canal could reduce the wide of fire prone area into 844.58 Ha.

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