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Hydrotophography Approach on Aquaculture Development at The Reclaimed Tidal Lowlands

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ABSTRACT

There are 1.8 million ha of reclaimed lowlands for transmigration financed by the government of Indonesia scattered in Sumatra, Kalimantan and Papua. An estimate of more than 1 million main house holds and additional ones living on each of 0.25 home plots. Each of the family has at least 2.0 ha of land planted with rice, corn, beans or tree crops. Experiences in Telang I, Muara Telang sub-districts, and Telang II, Tanjung Lago subdistricts, schemes in Banyuasin districts of South Sumatra have shown that rice-rice-corn, rice-corn-water melon cropping pattern can be achieved depend on the hydrotophographical (A, B, C, D type) condition of the areas. At the lower area of type A where the tidal water can easily penetrate to the land (land less than 1.50 m above the mean sea level) food crops such as: rice-rice-corn per year can easily be grown. Land with type B of 1.50-2.00 m above mean sea level where only high tide in the rainy season can flood the soil surface has rice – ratton rice - corn or rice- water melon- corn cropping pattern in one year. Increased farmers income and standard of living have made the improved houses or even the new ones are made. Earthen soil to rice the house floor was taken around the home plots resulting the formation of small to medium size water ponds depth of 1-1.5 m. These water ponds are later used for aquaculture with different degree of success. Water table fluctuation of the soil together with the rainfall and tidal data are very usefull for managing the pond water quality for fish culture in this regards. The hydrotophography concept is useful for planning, organizing, actuating and controlling the quality of fish culture on such areas.

Keywords: *Hydrotopography, aqua culture, tidal lowlands, transmigration, fish pond*

INTRODUCTION

The spontaneous settlers in the lowland areas settled to find a new living in these areas. The spontaneous settlement dates from about hundred years ago, but the impression exist that also in recent years quite some spontaneous settlement has taken place. Since 1969 the Indonesian Government was actively reclaiming lowlands. The original objectives for these projects were: to increase the national food production; to support the transmigration programs; to support facilitation of job opportunities; to support equal distribution of regional development; to increase export commodities in the agricultural sector (Suprianto et al, 2009; Ministry of Public Works, 2007).

The reclamation was generally based on a gradual long-term process. The features of the stages are: I. un-controlled & open channel, II. semi-closed & controlled, III. closed & fully controlled water management systems. This stage wise approach still deserves full support from other sectors, although the contents of the different stages will have to be modified in light of the present day conditions.

During 1985 - 1995 there were almost no new reclamations initiated by the Government, main focus was on improvement (phase II) of reclaimed areas. In 1996 the Government started with new reclamations in South and Central Kalimantan, mainly in river flood plains. In these schemes, due to the different river water levels during the wet and the dry season, in addition to irrigation and drainage, also flood protection is required. Due to this already in the initial stage inlet and outlet structures had to be

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installed at the locations where the primary, or secondary irrigation and drainage canals cross the dike. So in fact these projects more or less directly start in phase II (Suprianto et al., 2009; Susanto, 2003).

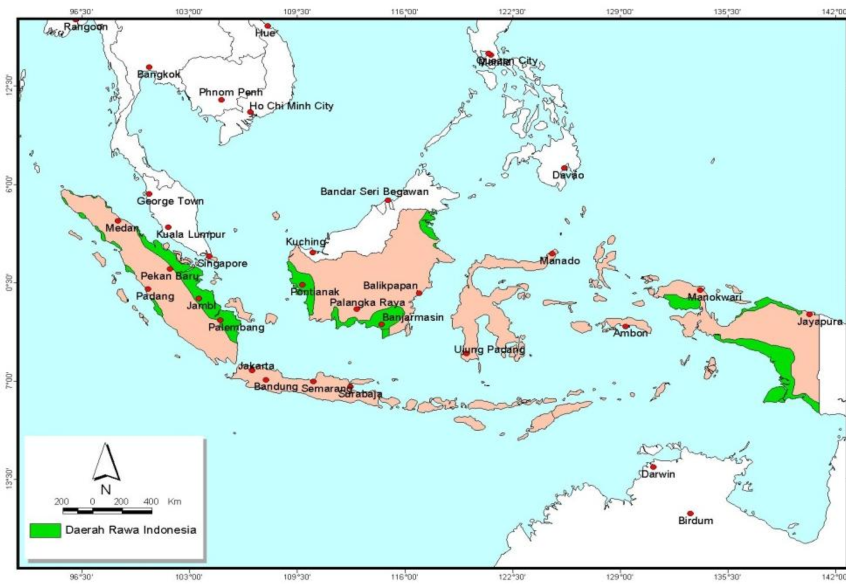

Figure 1. Lowlands distribution mostly at the three major islands of Sumatera, Kalimantan and Papua

Table 1. Reclaimed Lowlands sponsored by Indonesian Government for Transmigration purpose

Place	Available Lowland Areas			Reclaimed Lowlands support by the Government of Indonesia		
	Tidal Lowlands (Ha)	Non-tidal Lowlands (Lebak) (Ha)	Total (Ha)	Tidal Lowlands (Ha)	Non-tidal Lowlands (Lebak) (Ha)	Total (Ha)
Sumatera	6.604.000	2.766.000	9.370.000	691.704	110.176	801.880
Kalimantan	8.126.900	3.580.500	11.707.400	694.935	194.765	889.700
Sulawesi	1.148.950	644.500	1.793.450	71.835	12.875	84.710
Papua	4.216.950	6.305.770	10.522.720	-	23.710	23.710
	20.096.800	13.296.770	33.393.570	1.458.474	341.526	1.800.000

It is not clear how the spontaneous settlement has developed during the past twenty years. The impression exists that the spontaneous settlement has been very substantial and that the area which is reclaimed by spontaneous settlers is significantly larger than the 2.4 million ha that has been used so far. Due to the political changes in the country during 1998 the new reclamations by the Government came to an end. However, because of the need to increase food production it will most probably be a must for the Indonesian Government to undertake new lowland reclamations in the future, together with phase II and later phase III developments, mechanisation in agriculture, and larger scale farming in the already

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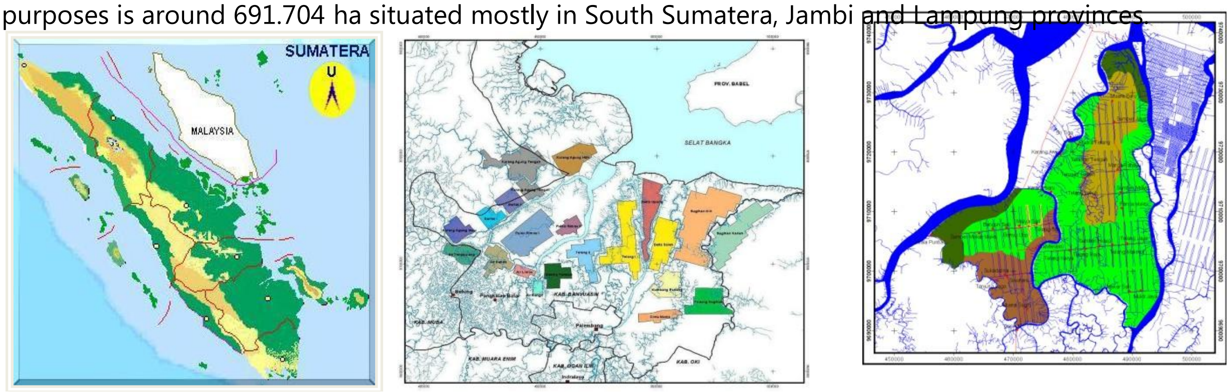
reclaimed areas. The actual roles of the Government in the framework of these developments may be subject to further considerations (Suprianto et al., 2009).

Existing Reclaimed Lowlands For Food Crops And Transmigration Program In Sumatera. Reclaimed lowlands in Sumatera island can be found in Lampung, South Sumatera, Jambi and Riau provinces. Reclaimation mainly conducted for transmigration (food crops), estate crop, and pulp wood industries. Total reclaimed lowlands sponsored by the Indonesian Government for transmigration purposes is around 691.704 ha situated mostly in South Sumatera, Jambi and Lampung provinces.



Sumatra Island — Reclaimed lowlands in Banyuasin distric — Tanjung barelang

Figure 2. Reclaimed lowlands for transmigration in South Sumatera mainly in Banyuasin district

As can be seen in Figure 2, reclaimed lowlands for transmigration program with mostly food crops (rice, corn, bean) accomodate more then 360.000 ha in South Sumatra scattered in Banyuasin, Muba and OKI districts. A good example of food crops activities can be found in Tanjung Lago and Muara Telang subditricts (Telang II and Telang I drainage schemes).

Hydrological Condition of The Reclaimed Area in Banyuasin Districts. Hydro-topographical conditions are defined as the field elevation in comparison to river, or canal water levels in the nearest open water system. In the tidal lowlands of Indonesia four hydro-topographic classes are generally distinguished (Figure 3):

- *category A (tidal irrigated areas).* The fields can be flooded by the tides at least 4 or 5 times during a 14-day neap-spring tidal cycle season. These areas are situated mostly in depressions, or close to river mouths;
- *category B (periodically tidal irrigated areas).* The fields can be flooded by the tides at least 4 or 5 times during a 14-day neap-spring tidal cycle in the wet season only;
- *category C (areas just above tidal high water).* The fields cannot be regularly flooded during high tide. The groundwater table may still be influenced by the tides. Cropping is mainly dependent on rainfall, although some additional water supply by infiltration might be possible with an intensive field ditch system. Many category C areas in the wet season are generally planted with a rice crop. For the dry season a dry food crop is the most likely alternative. With a sufficiently large tidal range the cultivation of tree crops is an option for these areas;
- *category D (upland areas).* The fields are entirely above tidal influence. Dry food crops and tree crops are best suited to these areas when they do not receive extra water from adjoining higher areas.

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In the first phase for category A, B and C areas only one rice crop during the wet season is cultivated. In the category D areas this may be a dry food crop, or a tree crop as well. Occasionally a crop is grown during the dry season. In the areas where water control structures have been installed, there may also be the cultivation of a second crop in the dry season, which will generally be rice in the category A and B areas, a dry food crop (corn) in the category C areas and a tree crop in the category D areas. Therefore the objectives of the water management systems are basically (Suryadi, 1996; Suprianto et al, 2009; Susanto, 2003, 2007):

- to provide during the wet season suitable conditions for rice in the category A, B and C areas and for a dry food crop, or tree crop in the category D areas;

to provide during the dry season suitable conditions for rice in category A and B areas, for dry food crops in the category C areas and for tree crops in the category D areas

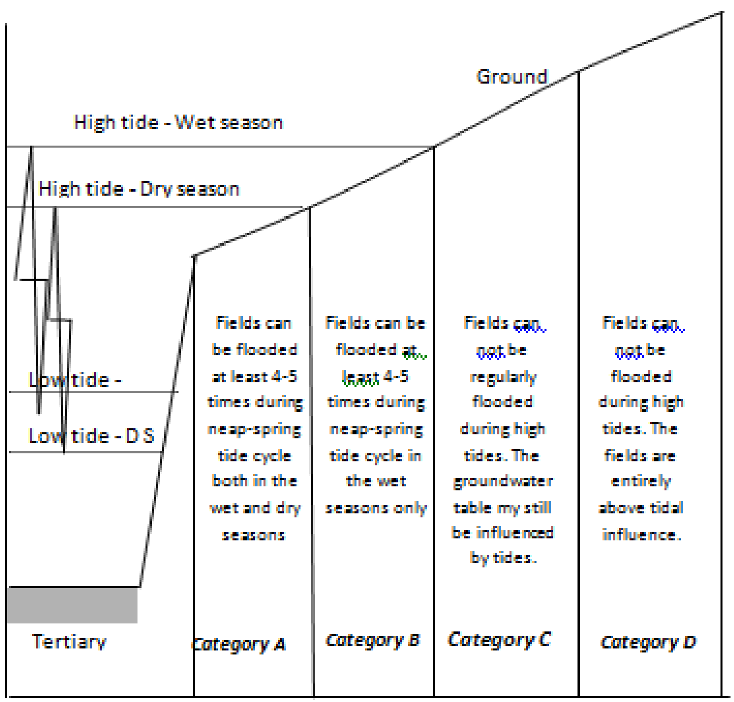

Figure 3. Four hydro-topographic classes are generally distinguished (Euroconsult, 1996; Suryadi, 1996

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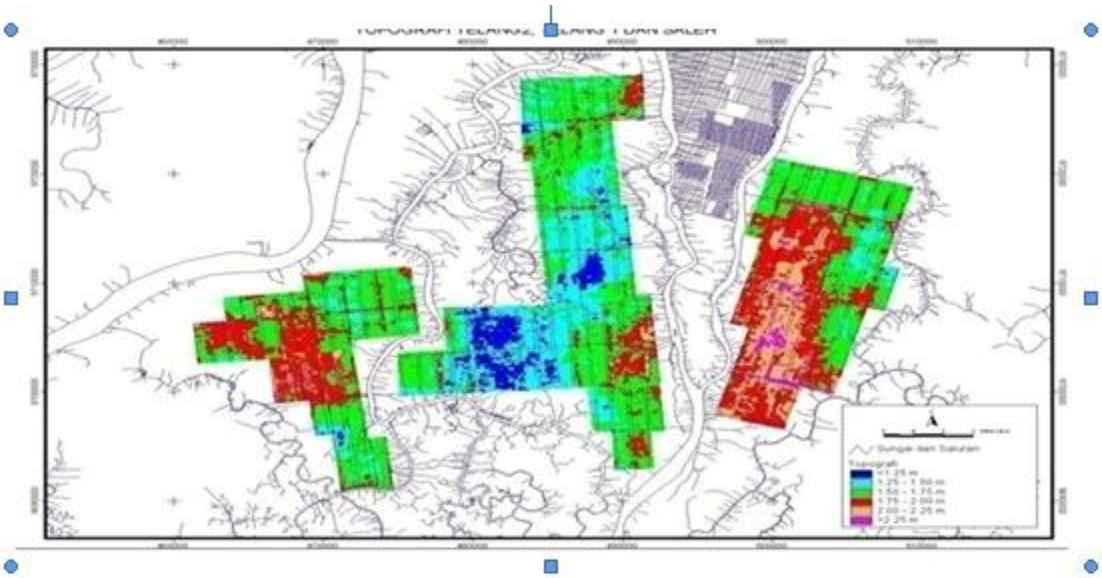

Figure 4. Topography of Telang I, Telang II and Saleh area (Euroconsult, 1996); Land height are < 1.25 m (A), 1.25 – 1.50 m (A), 1.50 – 1.75 m (B), 1.75 – 2.00 m (B), 2.00 – 2.25 m (C), > 2.25 m (C) above average mean sea level

In Figure 4, topographical condition of Telang I, Telang II and Saleh drainage schemes can clearly shown the differences in heights of the areas. In general the height of the soil surface from the average of mean sea level can be categorized as: Land height are < 1.25 m (type A), 1.25 – 1.50 m (type A), 1.50 – 1.75 m (type B), 1.75 – 2.00 m (type B), 2.00 – 2.25 m (type C), > 2.25 m (type C). So, in general the hydrotopographical condition of the area are in type A, B and C. Type A area such as in primary 8 of Telang I has been succesfully planted with 3 crops of rice – rice – corn per year. The first rice crop planted in November and harvested in February with yield of 6-7 ton dry husk rice per hectar. In the second season of March – June, rice is again planted with yield of 4-5 ton dry husk per ha; followed by corn during the third season in June-September.

Water Table Fluctuation Within The Secondary And Tertiary Block. An example of a secondary block (250 ha) with water control structures is given in Figure 5. One secondary block area is 256 ha with original number of house hold of 128 families. Each of the family has 2 ha land for cropping and 0.25 ha of 50 m by 50 m for their home yard. The size of secondary block is 3200 length and 800 wide. The length of secondary block of 3200 m can be devided into 8 tertiary block width of 400 m or 16 tertiary block of 200 m. Figure 5 shows the tertiary canals in every 400 m within the length of secondary block of 3200 m. As can be seen in Figure 5 that home yards are situated in the corner of secondary canal and the tertiary canals (Suprianto et al, 2009; Susanto. 2003, 2007).

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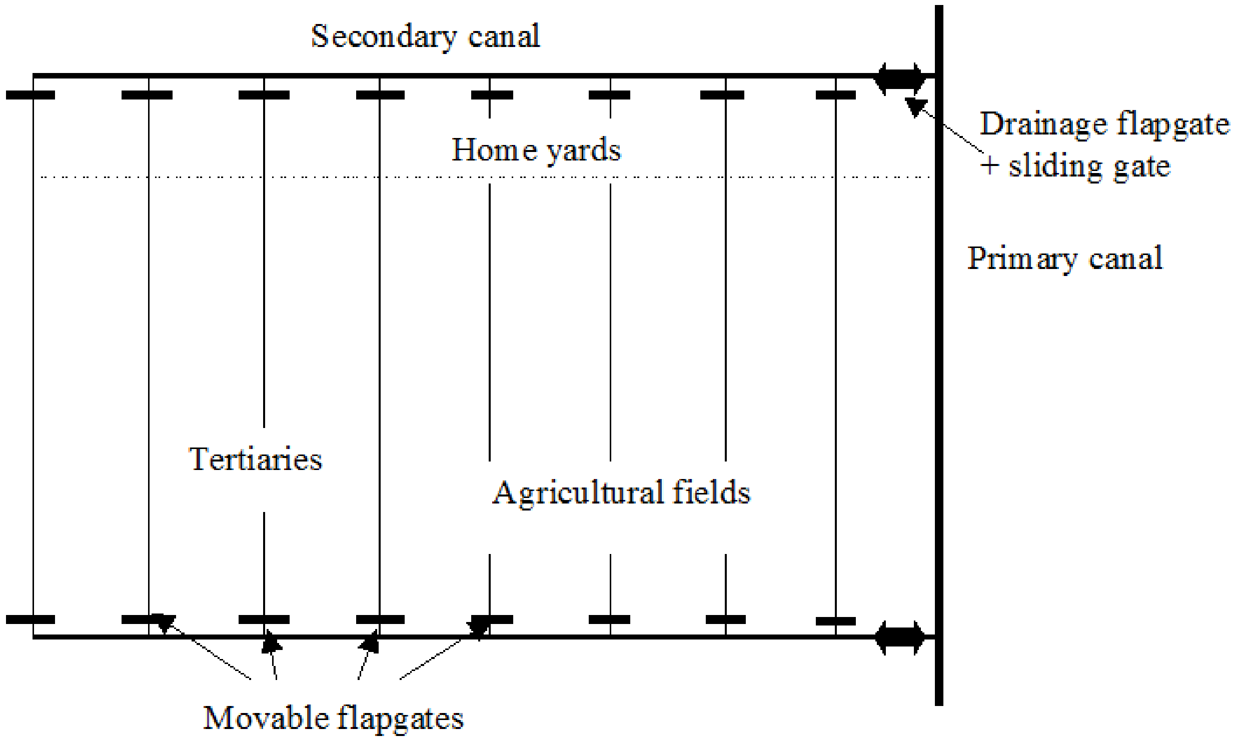

Figure 5. Example of a secondary block with water control structures

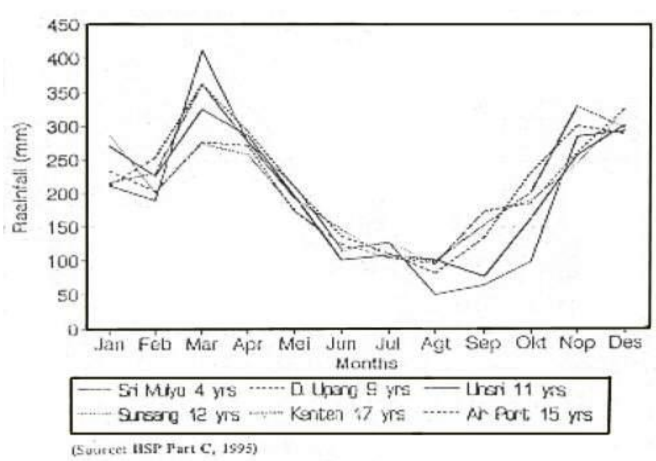

Figure 6. Monthly Rainfall recorded at several station in the lowlands of South Sumatra

Monthly rainfall in the eastern part of South Sumatra lowlands can be seen in Figure 6. Rain normally high above 150 mm per month from November until March while in June – August the monthly rainfall is lower then 150 mm per month. If the recorded water table fluctuation in the farmers field (Figure 7 and 8) are analyzed, the high water table condition are normally found during the rainy season

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of November until March in every year. Water table during this period is about the soil surface in Type C area, flooded during the high tide in B type area, and being flooded in most of the tide in type A area. The use of hydraulic infrastructures such as canals, water gates, and earth bund (embankment) are very useful in managing water for the crop growth and development (Susanto, 2007; Ngudiantoro et al, 2009).

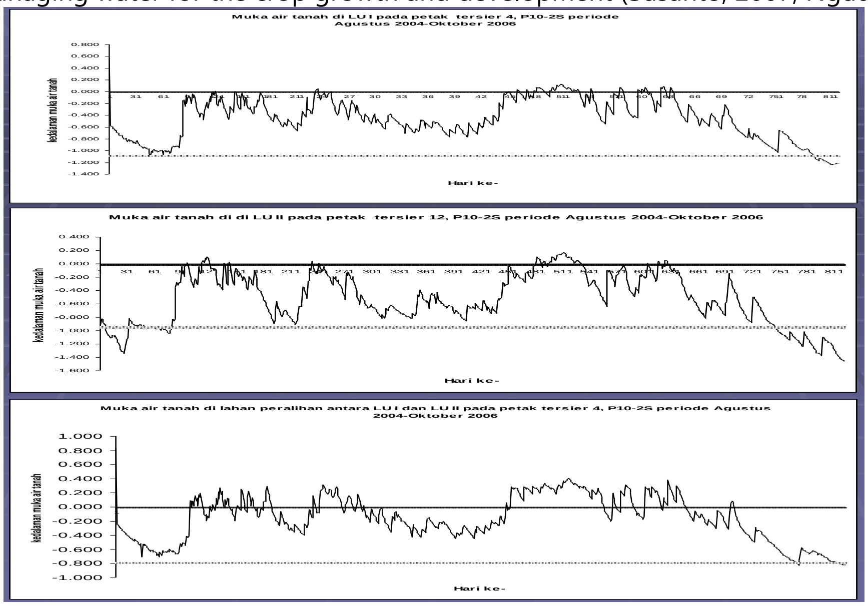

Figure 7. Water table fluctuation at secondary block P10-2S, tertiary block 4 and 12, August 2004 – October 2006, Delta Saleh, Banyuasin, South Sumatra.

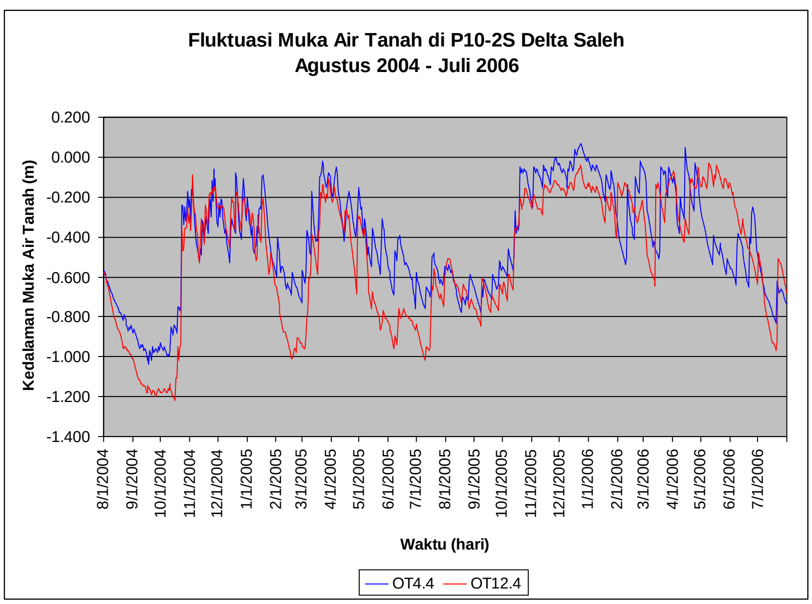

Figure 8. Water table fluctuation at secondary block P10-2S, tertiary block 4 and 12, 2.00 – 2.25 m (C), > 2.25 m (C), August 2004 – October 2006, Delta Saleh, Banyuasin, South Sumatra,

Food Crops Development, Water Management and Aquaculture. An estimate of more than 1 million main house holds and additional ones living on each of 0.25 home plots. Each of the family has at least 2.0 ha of land planted with rice, corn, beans or tree crops. Experiences in Telang I, Muara Telang sub-districts, and Telang II, Tanjung Lago sub districts (Figure 2), schemes in Banyuasin districts of South Sumatra have shown that rice-rice-corn, rice-corn-water melon cropping patten can be achieved depend on the hydrotophographical (A, B, C, D type) condition of the areas. At the lower area of type A where the tidal water can easily penetrate to the land (land less then 1.5 m above the mean sea level) food crops such as: rice-rice-corn per year can easily be grown. Land with type B of 1.5-2.0 m above mean sea level where only high tide in the rainy season can flood the soil surface has rice-ratton-corn or rice- water melon- corn cropping pattern in one year.

Increased farmers income and standard of living have made the improved houses or even the new ones are made. Earthen soil to rise the house floor was taken around the home plots resulting the formation of small to medium size water ponds. These water ponds are later used for aquaculture with different degree of success. Water table fluctuation of the soil together with the rainfall and tidal data are very usefull on this regards. The hydrotophography concept is useful for planning, organizing, actuating and controlling the fish culture on such areas.

Fish pond culture at the rural areas can help to improve the farmers living both on food nutrients and their income. Reclaimed lowlands area for transmigration settlement has 0.25 ha of home plots for each of the family. The farmer normally dig soil around the house to increase the house floor to avoid flooding, As the results, there is small water pond with difference size around the house. Rainfall and tidal water are the source of water for this pond. Water quality for this pond is not always in a good condition for fish culture. Soil with high organic matter and or potential acid sulphate layers may cause the acidity to the water in the fish pond. In addition, run-off water from the surrounding may also contribute to the acidity. Water quality management on such fish pond is really needed. Flushing with the existing rain water or tidal water movement will be of help to reduce the water acidity in the fish pond (Fitrani, 2013; Marsi and Fitrani, 2014; Yusuf et al, 2014). Fish ponds dimension resulted from the field observation within the research sites in Tanjung Lago and Muara Telang districts are such as follow in Table 2.

Table 2. Fish pond dimension based on the land typology and source of water (Fitrani et al, 2014, presented at ISFM 2014

Type of land	Source of water	Size of pond (m^2)	Depth of the pond (m)
A	SPD	32 - 325	0,90 - 1,00
< 1.25 m	KTH	24 - 400	0,30 - 6,50
1.25 – 1.50 m	Quatenary/ Tertiary	35 - 195	0,20 - 1,00
Amsl	Canal		
B	SPD	32 - 162	1,00 - 1,50
1.50-2.00 m	KTH	24 - 266	0.50 - 1,30
Amsl			
B/C	KTH	18 – 54	0,45 - 1,00
2.00-2.25 m			
Amsl			

Notes : SPD = Village canal; KTH= Rainfed pond; amsl = above mean sea level

Flushing of the fish pond is adapted from a similar approach applied for the agriculture lands (rice or corn) or estate crops (oil palm, pulp wood) activities. The use of good rain water and tidal water mechanism will help to improve the bad quality of water in the fish pond. A better development of fish can be achieved with this approach (Fitrani, 2013; Marsi and Fitrani, 2014).

Table 2 shows that the depth of the fish ponds of type A, B, C areas varies from 0.3 m up to 6.5 m. Sources of water for the ponds came from rainfall and canals water both from secondary canal (SPD) and tertiary canal. These canals have been used for years to manage the drainage and irrigation water for agricultural (food crops) at the agricultural field (Susanto, 2003; Supriyanto et al. 2009). All of the fish ponds are located at the farmer's home plots which are at the intersection of the SPD secondary and tertiary canals (Figure 5). At the type B and B/C areas, the depth of ponds are up to 1.5 m. Connecting the existing ponds with submerged pvc pipe 6" to the tertiary canals will provide fresh tidal water for the ponds.

Results from Fitrani *et al.* (2014) show that high ammonia, high soluble iron, can be leached out from the ponds using the tidal water influence in the month of May-September. The survival rate of Nila fish increased from 22 to 43 percents with growth rate increased from 1.03 to 4.66 gram with the flushing implemented. Water quality condition will certainly better in the rainy months and high high tide of November to March.

Figure 2 indicate that hydrotopographic type A and type B are the majority in Telang II with 25 potential secondary blocks, Tanjung Lago and in Telang I, with 60 potential secondary blocks, Muara Telang districts as far as aquaculture concern. If within one secondary block there are 128 families within 128 home plots of 0.25 ha, then there are 85 x 128 home yards. If there are 2-3 water ponds in each of the home yards then there are 85 x 128 x 2 possible potential fish ponds can be utilized.

There is a need of improvement on each of the water ponds to be used for aquaculture. Improvement can be made by deepening and reshaping the ponds, embankment (earthen bunds) of the ponds, connecting the ponds through the sub-merged PVC pipes to the tertiary canals. Figure 7 and 8 about the water table fluctuation within the tertiary block explained that drainage and sub irrigating of the fish ponds is certainly possible to refresh the water in the ponds for aquaculture

CONCLUSIONS AND RECOMENDATIONS

Hydrotopograpic concept, where land height and tidal penetration are related, classifies the reclaimed lowland to type A, B, C and D. This land types is certainly related with the water table fluctuation in the area. In type C areas of < 2.25 m amsl for example, water table fluctuation during the year showed that the water table is nearly at the soil surface during the rainy season and high tide condition. It is normally happen in November until March every year. During the dry season of June until August, the water table is much lower to a depth of 1.00 m below soil the surface. Water table position in land type B and A during the seasons are much closer to the soil surface than the C type land. An average depth of water pond of 1.00 – 1.50 m at the home yard, at type A, B and C land, is potential to manage the water quality of the pond in the dry season. It is especially due to the pond position near the tertiary and secondary canals, provided submerged pvc pipes implemented.

One secondary block of reclaimed lowlands of 256 ha, with 128 house holds of 0.25 ha home yards, has mostly 1-3 water ponds potential to be improved and managed for aquaculture purposes. Improvement of water pond can be done by reshaping, embankment, connection with the tertiary canals, and conducting the flushing of water during the tidal water influence. Hydrotopographic map of the area will help in planning, organizing, actuating and controlling such fish ponds during the rainy or dry period of the year. It is especially as far as the water quality concern. The development of reclaimed lowland for settlement and food crops production has been so far improved the farmers of living. Availability of water ponds in the farmers home yards is certainly very potential for aquaculture development on such areas to provide more income and nutritious food for the family.

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