Faculty of Engineering

DETERMINATION OF THE MOST POLLUTED RIVER IN AN OIL PALM PLANTATION IN SAMARAHAN DIVISION USING COMPOSITE PROGRAMMING METHOD

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Judul: **DETERMINATION OF THE MOST POLLUTED RIVER IN AN OIL PALM PLANTATION IN SAMARAHAN DIVISION USING COMPOSITE PROGRAMMING METHOD**

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VINCENT CHIEW KEE CHUONG

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To my beloved parents

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ABSTRAK

Umumnya, perladangan kelapa sawit boleh mengancam keadaan sungai secara mudah. Dengan itu, tindakan pencegahan amat diperlukan untuk mengelakkan pencemaran. Disebabkan perladangan kelapa sawit melibatkan keluasan tanah berskala besar, pengurusan and pemantauan terhadap semua sungai adalah amat sukar dan berkos tinggi. Keadaan yang negatif ini memaksa pemilihan sungai tertentu untuk dipantau sahaja. Antara sungai yang dipilih adalah yang banyak dipengaruhi aktiviti manusia atau industri. Namun demikian, pengenalpastian sungai tersebut adalah tidak mencukupi. Perhatian yang lebih mendalam adalah diperlukan terhadap sungai yang lebih dicemari. Prosedur ini memastikan kos diperuntukkan untuk kegunaan yang paling berkesan. Dalam kajian kes ini, terdapat satu perladangan kelapa sawit memperluaskan tanahnya ke lot 1238-1243, kawasan Sedilu-Gelong, Kota Samarahan, Sarawak. Kawasan hilir sungai adalah salah satu daripada alternatif yang dipilih untuk dipantau. Bagi semua kawasan yang dipilih, penyusunan dibuat dari segi tahap pencemaran yang dikesan. Sungai yang mempunyai keadaan pencemaran yang paling teruk ditentukan dan perhatian yang lebih mendalam dipastikan terhadapnya. Kaedah untuk menentukan kedudukan ini adalah kaedah pengaturcaraan komposit, di mana data pencemaran sungai diperolehi dan dikenakan penilaian. Timbangan dan faktor perseimbangan dianggapkan untuk membantu penilaian kedudukan. Penyusunan kedudukan sebenarnya sangat dipengaruhi oleh dua faktor ini. Dalam kajian ini, lokasi WS1 ditentukan sebagai lokasi yang mempunyai keadaan terburuk dalam hal pencemaran dan memerlukan perhatian yang besar di antara semua lokasi yang dipilih.

ABSTRACT

In general, an oil palm plantation can easily and greatly threatens the state of rivers. At such, precautions and preventions are necessary to avoid pollutions. Since oil palm plantation involves great scale of land size, it is difficult to manage and monitor every single rivers presented in the plantation. Moreover, it can be costly. In such conditions, areas of rivers, those are easily and knowingly affected by pollutants, are selected and became the alternatives for monitoring purposes. An example of these areas is a zone nearby to residential, industrial or commercial activities. Still, having identified all alternatives is not enough. Attention of greater degree is to be given to the most critical condition. The procedure will ensure budget be allocated to its most efficient usage on preventing pollution. In this case study, a hydroflow oil palm plantation is extending its size into lots 1238 – 1243 of Sedilu-Gelong land district, Samarahan Divison, Sarawak. Downstream areas are among the alternatives chosen to be monitored. From these selected areas, that require special attentions, a ranking is made so that the worst condition of all choices can be determined and more attention is put on it than the rest of choices. In such way, rivers are treated to their most sufficient and satisfactory levels. Method to determine the ranking is the composite programming method, in which river parameters and data are obtained and studied. Weights and balancing factors for each selected locations are estimated to assist the ranking assessment. The final ranking actually is greatly influenced by these two factors. In this study, location WS1 is determined as having the worst condition in term of pollution and needing the most attention among all locations selected.

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LIST OF ABBREVATIONS

BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
CP	Composite Programming
DID	Department Irrigation and Drainage Sarawak
DO	Dissolved Oxygen
DOE	Department of Environment
FL	Fuzzy Logic
MCDM	Multi-Criteria Decision Making
NH^3- N	Ammoniacal Nitrogen
NO^3- N	Nitrate Nitrogen
NWQS	National Water Quality Standards
NREB	Natural Resources and Environment Board Sarawak
Sg.	*Sungai* / River
TCC	Total Coliform Count
TSS	Total Suspended Solids

LIST OF SYMBOLS

S_i	-	Normalized ith fuzzy indicator
Z_i	-	Value of ith fuzzy indicator
Z_{i+}	-	Maximum possible value of ith indicator, and
Z_{i-}	-	Minimum possible value of ith indicator
L_j	-	Composite distance in group j
$S_{ij}^{p_j}$	-	Normalized fuzzy value of indicator i group j
n_j	-	Number of indicators in group j
$\propto_{ij}$	-	Weight expressing the relative importance of indicators in group j
p_j	-	Balancing factors among indicators for group j
L_k	-	Composite distance for second-level group k
$L_{jk}^{p_k}$	-	First-level composite distance between group j and k
m_k	-	Number of elements in second-level group k
$\propto_{jk}$	-	Relative importance among elements in second-level group k
p_k	-	Balancing factor for second-level group k
L	-	Composite distance characterizing the actual state of the system
L_1^p	-	Composite distance for one group
L_2^p	-	Composite distance for the second group
L_n^p	-	Composite distance for the nth group
p	-	Balancing factor

CHAPTER 1

INTRODUCTION

1.1 Background

Since year 1975, oil palm plantation has being expanding in Sarawak. According to the World Sustainable Palm Oil Conference 2008, total area of oil palm plantations was only covering 14,091 hectares of land in Sarawak. Up to year 2008, the number is then increased to 725,359 hectares. As oil palm is a cash crop with good-term prospects, Sarawak natives who are involved in this plantation benefit socially and economically.

Oil palm cultivation, however, results in the destruction of important habitats, changes the hydrological regime of region, and contributes to waterway pollution in terms of increased suspended solids and elevated levels of agro-chemicals. As industrialization on oil palm progressed and diversified over large land areas, so too did the impacts of destruction. The impacts are becoming regional in nature. In year 1995, the Department of Environment (DOE) has identified that palm oil processing industries are one of the biggest water polluters. Therefore, in order to counter and manage these environmental impacts related to plantation development, implementation activities need to be subject to holistic planning.

Some of the few measures that can be implemented are granting tax relief or exemptions for industries that implement pollution prevention measures and technologies, allowing loans specifically for environmental projects such as water disposal or recycling plants, providing financial incentives for minimizing impact on the environment, etc. Unfortunately, even though the assessments have attempted to demonstrate throughout, many plantation zones still face pollutions with their environment, especially the rivers. Figure 1 in the following page shows that most of the rivers in Sarawak are getting polluted. Major cause is due to the concentrations of mitigation measures being directed inaccurately. Therefore, management from overall aspects is essential so that those, in need of greater attention and actions, can be attended to efficiently. With that, management on system rankings by using multi-criteria decision making (MCDM) approaches is favorable as it can effectively identify priority river issues.

There is numerous numbers of techniques for MCDM. They work the same, in which they help an individual decision maker or decision group, who contemplates a choice of action in an uncertain environment, to identify and make a choice among a set of pre-specified alternatives. MCDM processes rely mainly on the information about the alternatives. The information can be in the form of scientifically-derived hard data to subjective interpretations.

Over the century, different theories and methods of MCDM have been proposed and developed. In multi-objective optimization in water resources planning, David and Duckstein (1976) have used ELECTRE theory; Keeney and Wood (1977) used multi-attribute utility theory. It is their fundamental theories that lead to our latest mathematical model formulations. The results of transformations and improvements are the optimization tools - linear programming method, dynamic programming method, goal programming method, fuzzy composite programming method, analytical hierarchy process, etc.

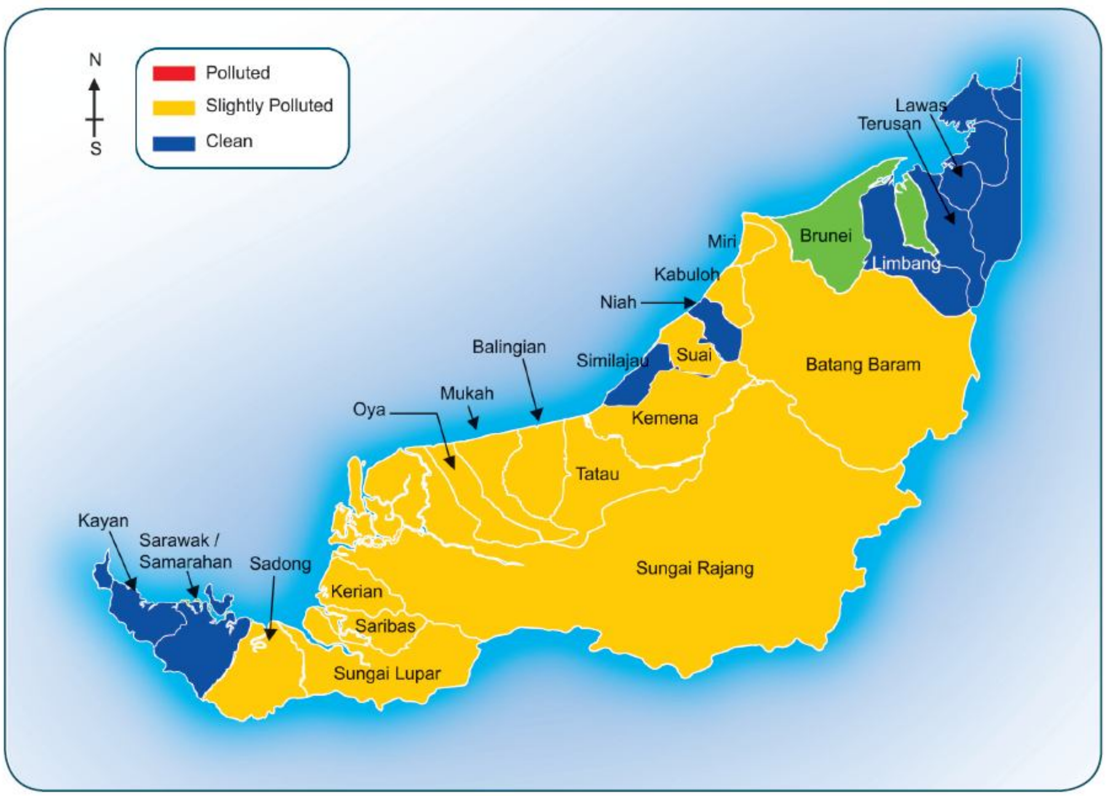

Figure 1.1 : Water Quality Status for River Basins of Sarawak, 2008 (Extracted from Malaysia Environmental Quality Report 2008)

1.2 Overall Review

Water resources (rivers) systems are biological, physical, sociological, economic, political, legal, geological and agricultural as well (Ait-Kad, M., 1998). Therefore, since analysis of MCDM using optimization tools or techniques require mathematical progress, these aspects need to be quantified so that techniques can actually be applied and analysis be done precisely. From here, it is clearly known that optimization tools and techniques are essential in doing estimations relating to water resources systems by converting non quantified aspects into numbers that can be easily referred and included into mathematical analysis. In line with that, a wide range of impacts from economic, ecological, environments, etc is considered, which is beneficial to all individuals as a great number of aspects or multi objectives is being satisfied accordingly. Quality of decision making is definitely improved since decisions are made objectively. These optimization techniques help to make the best possible use or function of available productive resources.

In the study of risk-cost analysis for sediment-control management at the upper Mississippi River conducted using Fuzzy Composite Programming (Supiah, S., 1992), there were five alternatives being reviewed. After undergoing a thorough analysis, the fifth alternative was made as the best choice, which was to establish stream erosion controls by using geo-textiles material and other soil conservation methods along the river and dredge a sedimentation trap at the Chippewa River mouth. The decision making was done in conjunction to its objective. From the analysis, this alternative was the cheapest if compared to other alternatives which involve dam construction or expansion. At such, it can be seemed that optimization tool is functioned to help in minimizing cost usage for this situation.

1.3 Concept of Study

This study is to review on a multi-criteria decision making approach, which is the composite programming. This technique is then being applied on a case study of environmental impact assessment for the proposed extensions to the hydroflow oil palm plantation, on lots 1238 – 1243 of Sedilu-Gelong land district, Samarahan Divison, Sarawak. Three river points are being studied, evaluated and ranked with this method. The ranks proposed will be determined as the prioritization of concerns and applicable for the purpose of preservation and mitigation potentials. In all, it is to determine the most critically polluted river in the plantation, so that actions are to be taken and attention to be greatly given.

1.4 Objectives of Study

Generally, objectives of study are as follows:

1) To identify and obtain basic indicators for the environmental impact assessment on the rivers in an extension of a hydroflow oil palm plantation in Samarahan

Division, specifically the data required for the analysis of rivers involved – economy, quantity and quality.

2) To rank the rivers involved using composite programming (CP) approach and identify the river that is the most critically polluted if compared to the other rivers. The greatest distance from the ideal point is the worst and lowest in ranking.

1.5 Outline of Study

Further information on the optimization tool and its word concepts will be elaborated in the following chapters. The technique is then being practiced for analysis. Analysis data is gained from their respective organizations. Numerical and graphical results are gained and shown accordingly.

CHAPTER 2

LITERATURE REVIEW

2.1 Definition

2.1.1 Optimization

In mathematics and computer science, optimization, or mathematical programming, refers to choosing the best element from some set of available alternatives.

In the simplest case, optimization means solving problems in which one seeks to minimize or maximize a real function. It is done by systematically choosing the values of real or integer variables from within an allowed set. The simplest example is through using a scalar and real-valued objective function to solve problems. As data is getting fuzzy, specific optimization theory and techniques are developed into other formulations comprises a large area of applied mathematics. The evolution is to improve the quality of handling problem solving issues. More generally, this evolution is regarding on finding "best available" values of some objective function given a defined domain, including a variety of different types of objective functions and different types of domains.

Historically, the first term to be introduced was linear programming, which was invented by George Dantzig in the 1940s. The term “programming” in this context does not refer to computer programming (even though computers nowadays are used extensively to solve mathematical problems). Instead, the term comes from the use of “program” by the United States military to refer to proposed training and logistics schedules, which were the problems that Dantzig was studying at the time.

2.1.2 Water Resources Engineering

The subject of water resources engineering has a very wide field. The related sections are as follows: hydrologic and hydraulic related to the planning and design of remediation; water supply, flood control and navigation facilities or hydraulic structures; ground and surface water flow and quality monitoring; feasibility and environmental impact analyses for various water-related projects; and designs of appurtenant hydraulic structures. There is numerous numbers of equations and models available in water resources engineering. In analysis, they range from empirical or analytical equations to simple or sophisticated computer models, depending on the requirements of specific projects. The designs may include preliminary and final sizes of various components of a hydraulic structure. From the viewpoint of a practicing