"INTEGRATION OF SYSTEM DYNAMIC AND SPATIAL DYNAMIC MODELS TO SUPPORT REGIONAL DEVELOPMENT PLANNING"
(Case Study in Java Madura Bali)

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ABSTRACT

Nowadays, development planning in Indonesia needs to consider more spatial and environment aspects to reach sustainability development goal optimally. One of group islands located in Indonesia is Java-Madura-Bali, which it's improvement planning based on Sector which it's relation of one area to others still less be focused. In supporting development planning system that focused on regional and sector aspects, supporting spatial data and approaching that integrated between dynamic and spatial system is more needed.

Planning based on system dynamic model shows each variable connected to certain area system can be determined one to others which this matter close to real situation. This Point of view would be remained us about real life that the connection of those variables is an object to occur the changes.

The approaching of system dynamic has done to obtain landuse needs based on simulation of behavior from phenomenon occur in a system. Simulation is conducted by inputting policy factor/ intervention (based on scenario used) to system dynamic model frame. The Change of policy will be influencing to other variable so it will be affected performance system in reaching a required landuse need.

Spatial model represent development behavior from spatial pattern of a region system. By Modelling Spatial, it can be used to simulate a goal in improving an area by viewing the changes that happened periodically. By this case, it can be used to predict the beyond needs about the changes that probably happened in one area.. Spatial modeling Technic which is used based on raster analysis (grid-based spatial analysis). In every cell has a value representing many kind of location quality such as : elevation, slope, etc. Value change which is owned by cell is a main key in spatial dynamic model. Probability model with regretion logic is one of technics that is useful to result grid probility. The Value of probility is determined by many kind of characteristic or variable that can be grouped as driving factors.

Spatial dynamic modeling result is focused to obtain land availability allocation which every grid executing has done based on existing landuse (image satellite interpretation result and thematic maps) by using probability method consider some driving factors. Spatial dynamic analysis can show grid change (land allocation) time to time so that can be used also for forecasting and prediction in the next future.

Integration of system dynamic and spatial dynamic in developing Java-Madura-Bali Development Planning Model use waterfall method, generally called as System Development Life Cycle (SDLC) diagram. This diagram is designed to acquire a system to be flexible, adapting and can be develop following new technology trend.

The result is a spatial dynamic model of Java-Madura-Bali Islands as integration of system dynamic and spatial dynamic that show comparing between landuse needs and land allocation based on kinds scenario simulation.

Keywords: System dynamic, spatial dynamic, modelling, development planning

1. INTRODUCTION

The Placement of Regional Development Planning (RDP) Model in Java, Madura and Bali is pointed as elaboratod and feedback for National Development Planning and also to support sustainable Development. Model of RDP – Jamali is show relationship among main variables system based on Strategic Environment Assessment (SEA). This model is built by 3 main components, such as : system dynamic, spatial model, and SEA.
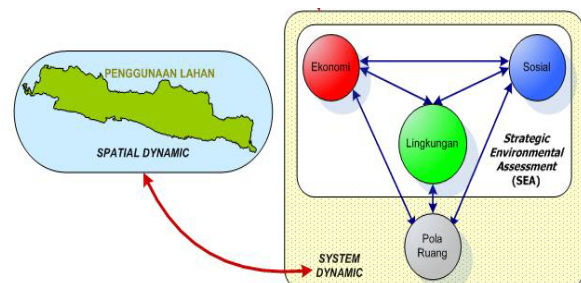
Fig 1. Main Structure of Regional Development Planning

System dynamic method is tightly related to questions about dynamic tendencies of complex system. The use of system dynamic methodology more be emphasized on goals of our understanding about how does the behaviour exist from policy structure in a system.This is very important case in planning policy effectively.

The matter which is exact modelled by using system dynamic methodology is a matter that has dynamic character (change time to time); and it's structure contains less than feedback structure.

In methodology of system dynamic which is formed is information structure system that contains actors, information sources, and connection of information flow that connect both. Physic analogic and math for information structure can be made easily. As physic analogic, information source as a storage, while decision is in-out flow from storage. In math analogic, information source stated as state variable, while decision is derivative variable of condition.

Spatial model is a model based on spatial that described behaviour improvement of spatial pattern from region system. Spatial model arranged by using some of Geographic Information System (GIS) softwares or other spatial model ware. Spatial dynamic model is a model that draws an information like spatial relationship (time and space) to any geographical phenomenon.

Spatial model can be used to simulate a goal in developing certain area that is viewing the change that happens from time to time, so it can be applied for prediction need about the change may be occured in certain area.

2. OBJECTIVE

Generally, this activity is pointed to provide idea for preparation of National Development Plan, and specially is focused to build:
1. Spatial dynamic model for Java-Bali
2. Create spatial database for Java -Bali

3. METHODOLOGY

The working execution phase of utilization data in Java, Madura, Bali uses several Phases that follows waterfall method called System Development Life Cycle (SDLC) diagram. SDLC diagram designed to obtain a flexibility of system, adaptable, accorded, and can be developed – change based on new technology. The arrangement of spatial dynamic model is part of design system or logical design. (Fig 2).
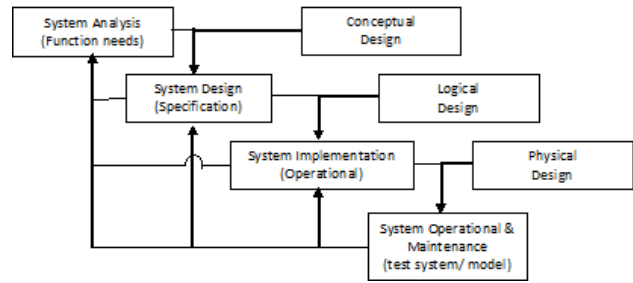

Fig 2. SDLC Diagram

3.1. Inventory Data

To conduct RDP activity of national model, the first step to reach development plan perfectly should have to do collecting the secondary data. Any kind of this secondary data can be grouped as social condition data, economical condition data, ecology data/environment, and land use.

3.2. Analysis Model Method

Mostly, Data collected has been formed as an an analysis result, for example : Input-output National, inter-regional (IRIO), Social Accounting Matrix (SAM), Computable General Equilibrium, Analysis Result of Linier program, Analysis Result of double goal Program, Analysis Result of Regretion about relationship between Changer and patial Aspec,t So the Data Analysis mostly is not done by itself, but if data and information both needed is not formed as Analysis data, then Analysis will be done according to requirement.

3.3. Validation and Sensitivity Model Test

Validation is aim to recoqnize the match between simulation result to symptom or imitated process. Model can be stated positif if the faults of simulation result to symptom or process is less. Model is stated valid if verification result suitable with field data. The result is considered to be applied to simulate on changing situation that predicted occurs during next 10 years.

In other occassion, Sensitivity verification is executed on Parameters both Functional intervence or Structural. This Verification is done after simulation on Scenario executed. This Scenario mean as placement that happens in future that known as external factors and uncontrolled variables.

3.4. Simulation and variable related to intervence policy

Behaviour model of system dynamic is determined by unique structure model, can be caught from result of simulation model. By simulation will be emerge behaviour of symptom or process that happens in a

system, so analysis appliable and prediction of behaviour symptom or process in a future.

Simulation is carried out by putting policfy factor/intervence policy into model that has been built. The change of policy will be affecting to other variable so in whole once will influence performance system. This condition is a figure about real condition may be occured. The result of this change will be surveyed on table or variable graphic required. Some figures below about landuse change (Fig 3) :
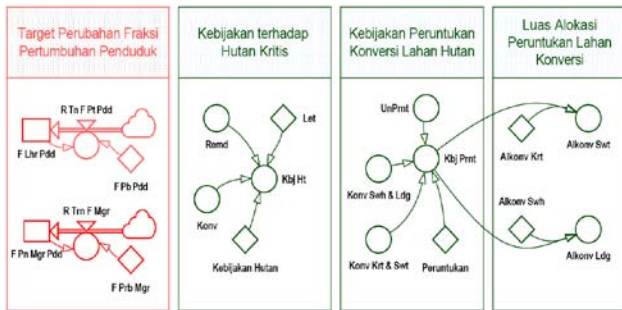

Fig 3. Diagram plan of landuse change policy

Surveyed variable is grouped into social, economic, and ecology aspect. These every aspect will be considered it's variable which is very dominant influence to behaviour system.

3.5. Analysis GIS Method
Any detailed phase and analysis data in GIS as explained below :

3.5.1. Spatial Data Inventory: The result of spatial data is inserted into database that is built to fulfill the need of RDP Model. Inventory activity included data collection from related instance, whether as a data or analog. Collecting data is done for working area in Java, Madura, Bali.

3.5.2. Regional Development Planning Spatial Model Diagram: The Change of landuse from one land to be other land is very related to factors such as : bio-physic, socio-economy, environment and goverment policy. Those factors determine how big the change happens and limitation. To browse these changes need a model that explains and formulates which measurement will effect the land change. Spatial dynamic model requires data as input or idea to get the result of model that is named allocating spatial of landuse change.

Spatial dynamic model applies spatial analysis technic to factors that will be effect the landuse change. Spatial model included process of spatial location from landuse combined with inserting data from analysis result/

submodel non spatial included landuse area (landuse needs).

Model that is applied for this spatial dynamic using logistic regression model to breed probability of landuse spatial location. By logistic regression model, it has been obtained coeficient of independent variables represented location factors that is effect the allocation of spatial from landuse change to determine landuse change location.

Result of logistic reggression in determining process of landuse spatial location is pointing how big is a probability one location to be one type of certain land use. This probability depends on coeficients value and variable values from it's driving factor. In every type of landuses will have diverification of coeficient values.

In this activity, in-out data of model in raster form is grid cell which has certain value in every cell/pixel. In every cell has certain colour that states a value associated with one information, for example : landuse types. Spatial resolution will be used for model matched with a goal and used for that model itself.

For implementation, this spatial dynamic model will apply landuse projection on T_n as variable input. By the landuse projection on T_n , spatial distribution will be searched by using this spatial dynamic model.

By searching this bursting landuse on T_n , in every pixel probability calculation will be used on land use that is exist on $t_1, t_2, ..., t_n$, Probability existence in every land use in each pixel will be calculated by applying logistis reggresion equitable. Logistis reggression equitable used as below :

$$ Log\left(\frac{P_i}{1 - P_i}\right) = \beta_0 + \beta_1 X_{1,i} + \beta_2 X_{2,i} \ldots\ldots + \beta_n X_{n,i} $$

Which:
- P_i is Probability of grid cell value on certain location
- X's is variable state as driving factor that influence spatial alocation
- β's is coeficients value of driving factor that reached from landuse time series data

3.5.3. Landuse Change Allocation Procedure: The most probability value of landuse on pixel that has been analyzed will be allocated as landuse that exist on t_1. The Calculation of landuse allocation on t_1 will be conducted on every area pixel which will be analyzed. After getting new landuse on t_1 , the number of landuse exist will be compared with landuse projection on t_1 , if number of landuse calculation is not still match yet with it's landuse projection, so iteration should be done, hence the number

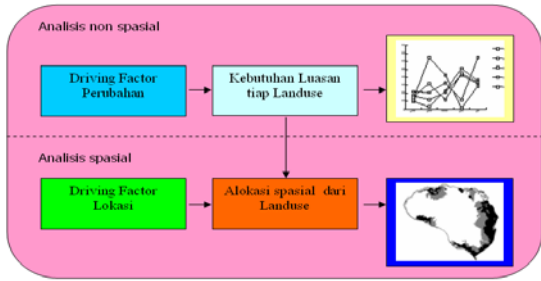of landuse t_1 will be similar with land use projection on t_1.

Fig 4. Non Spatial and Spatial Models Relationship

3.5.4. Arrangement specification of land change conversion: An arrangement specification of land change conversion is stored into matrix conversion form which states able or disable a land use change to other land use type. This subject as a matrix n X n which n is number land use type proceeded how its change.

Conversion matrix for this specification can be shown on this figure below :

Penggunaan Lahan Masa datang → Masa Sekarang	Hutan	Pertanian	Permukiman	Pertambangan	Infrastruktur	Utilitas	Sempadan Air	Perairan
Hutan	+	+	+	+	+	+	+	+
Pertanian	-	+	+	+	+	+	+	+
Permukiman	-		+	-	+	+	-	-
Pertambangan	-	+	+	+	+	+	+	+
Infrastruktur	-	+	+	+	+	+	+	+
Utilitas	-	+	+	+	+	+	+	+
Sempadan Air	-	+	+	+	+	+	+	+
Perairan	-	+	+	+	+	+	+	+

(+) Kemungkinan berubah bisa
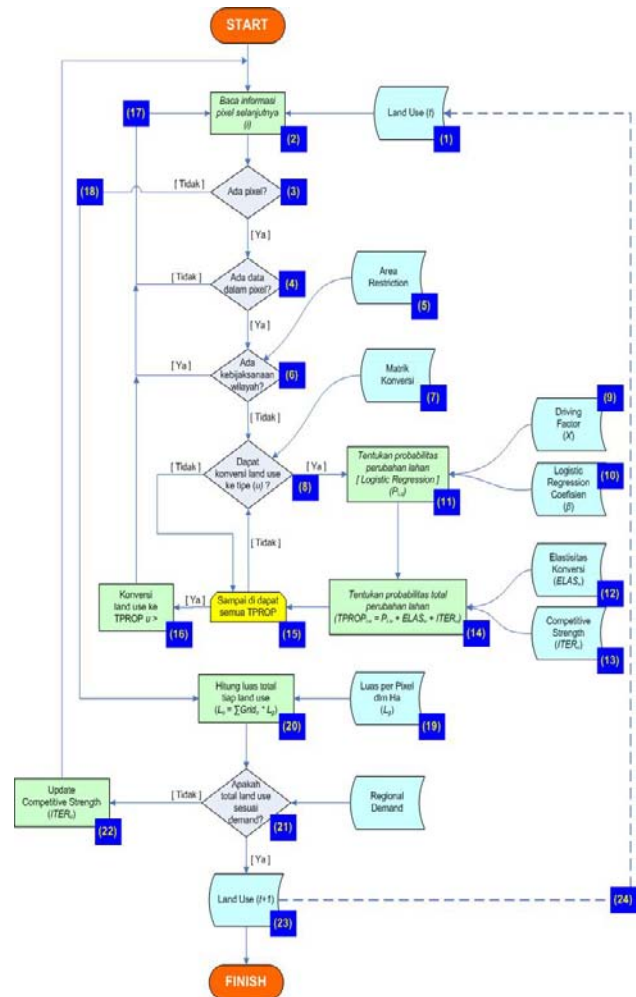(-) Kemungkinan berubah tidak bisa

Fig 5. Matrix Conversion

Fig 6. Algorithm to determine landuse allocation on t_1, $t_2,..t_n$

4. THE RESULT OF SPATIAL DYNAMIC SIMULATION MODEL

As a final result of improvement model phase according to phases, can be made output spatial dynamic model in Java-Bali as shown on Fig 7. This result which shown is still spatial dynamic model that uses market scene. By This Scene, the land conversion process determined by how's much the requirement of land that is elasticity combined, competition power and protective area policy. In other hand, it has not been accommodated by Regional Development Planning yet as a factor which has influenced in spatial model.
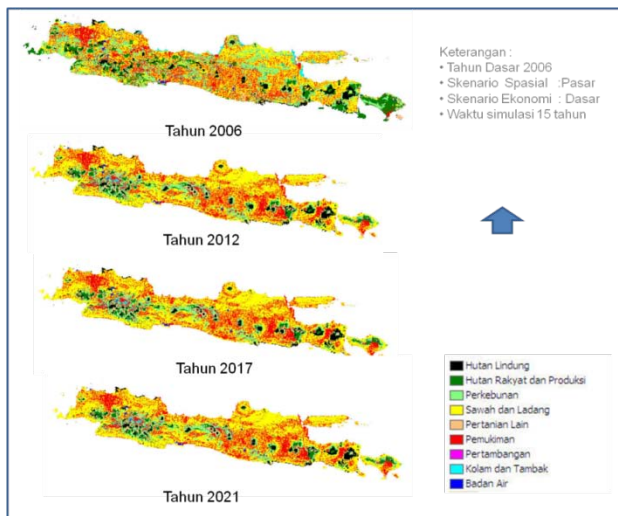
Fig 7. Result of spatial dynamic simulation by market Scenario

5. CONCLUSION

Spatial dynamic model has been developed generally, arranged based on 2 (two) apparoaching ideas : system dynamic and spatial dynamic. In this activity, has been conducted intergration both model, so the output not only related to quantitativ, but evaluated direction and location as well.

The specified process of arrangement model RDP Java – Bali is conducted by collecting statistic data and spatial to study behaviour system form.

Result that is obtained from arranging this model is one package model RDP In Java – Bali which can be used to do simulating of improving plan with many changable parameters key. To simplify this use it has been arranged interface for user so it may be applied easily. Eventhough, in system dynamic model, is not allow to change parameter model and it's structure model as well.

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