

DIGITAL MAP AS PRE-READY GIS USING QUASI-ANALYSIS TECHNIQUES

Fahmi AMHAR

Center for Mapping & Spatial Planning
The National Agency for Surveying and Mapping of Indonesia (Bakosurtanal)
Jl. Raya Jakarta-Bogor Km. 46 Cibinong Indonesia
Tel. (+62-21) 8751655 Fax: (+62-21) 87901254
famhar@plasa.com

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ABSTRACT

Data from digital mapping project, which is carried out by the National Agency for Surveying and Mapping of Indonesia (Bakosurtanal), consists of seven main layers, i.e. relief (interpolated by digital elevation model), settlement, landuse (vegetation), transportation network, hydrography, administrative boundary and geographical names. Analytical photogrammetry with photo scale 1:50.000 and 1:30.000 (for urban area) produce these data with some additional data from field check.

Even the data is prepared mainly for mapping purposes, almost potential users request geographical data for GIS application, which need more external data not yet contains on aerial photograph, such as demography, soil, climate etc. So some additional data - and additional field surveys - are needed. But the search of expensive external data could be minimized by smart way, using so-called "Quasi-Analysis Techniques", using interlayer analysis and some modeling, which result in a so-called "Pre-Ready GIS". Objective of the research is how far the quasi-analysis techniques and pre-ready GIS can support decision-making, how is cost benefit ratio and where is the limit of the method. The approach will be applied in some applications, i.e. determination of consider highrisk places along a street, optimal positions for microhydro power plant along a river, until a 3D-simulation of environment quality in a big city.

1 INTRODUCTION

Since 1993, Bakosurtanal has been beginning a new era in topographical mapping with the digital-mapping project. All of the production steps within this project use digital technology, since photogrammetric compilation, editing, database generation, cartographic design, until preprint color separation (Bekkhus, 1996;).

Data in this project will be separated by their finishing level, and each must pass quality control (see Figure 1). There are four types of database: Initial Database (DB0), Topographic Database (DB1), Geographic Database (DB2), and Cartographic Database (DB3).

- DB0 is raw product of photogrammetry. Objects visible in the aerial photo would be plotted in five classes (relief, settlement, infrastructure network, vegetation area, and hydrography) which will be detailed in more layers.
- DB1 is DB0, which is edited for topographical consistency. The data in class "relief" -i.e. regular height points and structure-lines (breaklines, riverlines, etc.)- will be interpolated to build DEM. Afterthat contours will be derived from DEM.
- DB2 is DB1, which is completed by field check reports, i.e. invisible object on aerial photo will be added, identified, classified, verified or corrected. Abstracts data of classes actual administrative boundaries and geographical names will be added. DB2 is a completed digital base map that is ready to use as input for GIS.
- DB3 is DB2 which is cartographically processed (symbolized, generalized) and color separated for presentation or paper map production.

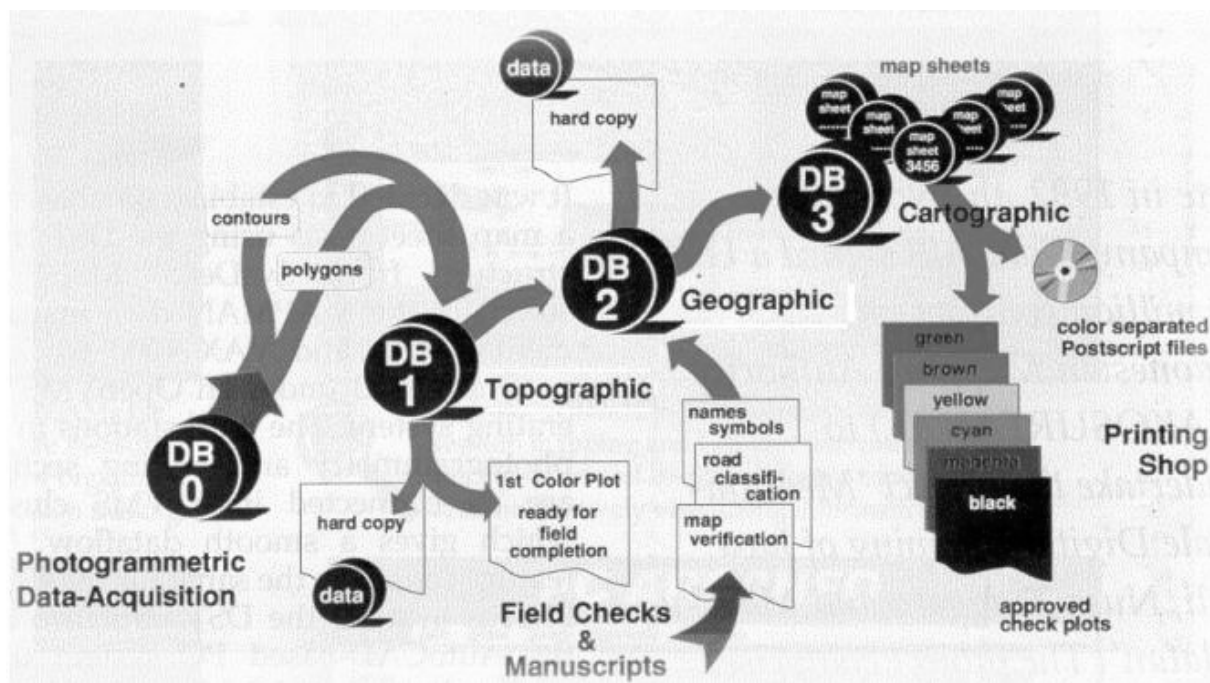


Figure 1: Production process in Digital Mapping Project

The following Figure 2 shows a printout sample of a digital map (DB2).

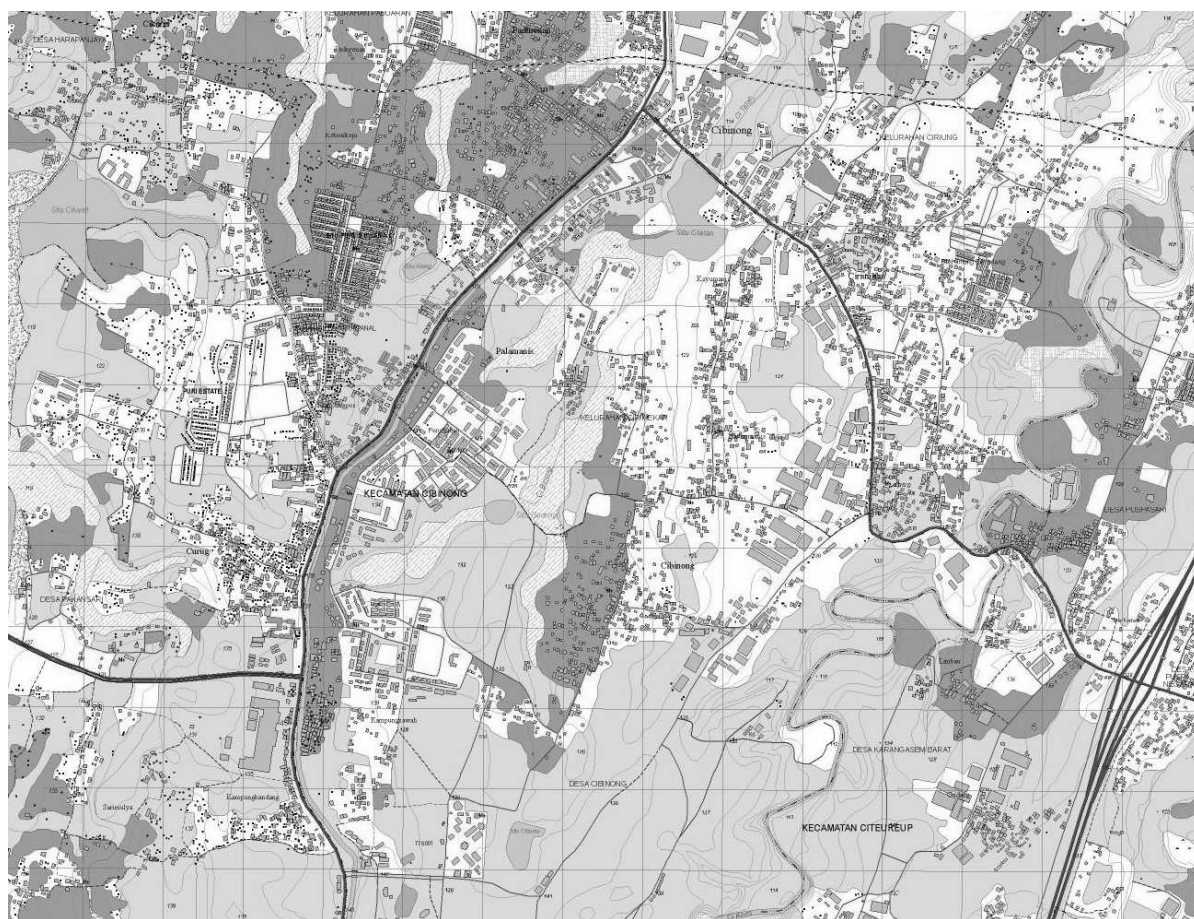


Figure 2: A printout sample of a digital map

2 RESEARCH

It is shown that the final product of digital mapping project (DB1 or DB2) is a general purpose digital map data, but does not yet contain external data such as soil, meteorological, geological, economic, or demography that is normally used in GIS analysis. However, it will be shown that DB1 or DB2 is useful already for a wide spread of application, using a so-called Quasi GIS Analysis. (Amhar, 1999). It is an analysis with DB1 or DB2 using interlayer techniques to make operational thematic map, which useful for decision making. The research has to prove how big is the effort, which must be given, and where is the limit of the method.

The thematic maps, which will be experimentally generated by Quasi GIS Analysis, are:

- Map of consider highrisk places along a street
- Map of optimal positions for microhydro power plant along a river
- Map of environment quality in a big city.

The methods are dependent on the theme, which would be generated, but commonly are:

- Building a mathematical and geometrical model. This is the most difficult part of Quasi GIS Analysis;
- Software development since common existing GIS software does not yet provided the needed model;
- Data preparation;
- Vector & Raster analysis, which is able using common GIS package;
- Cross check with data from another source or another analysis to calibrate and refine the model.

Tools used in this research are CAD package (e.g. AutoCAD, MicroStation), DEM generator (e.g. SCOP, Surfer, TIN), Vector GIS (Arc/Info, AutocadMap), Raster GIS (e.g. IDRISI, ER-Mapper, etc), and Software developer / compiler (Visual Basic, Borland C++, Delphi Pascal, Autolisp, etc).

3 EXPERIENCES

Experience shows that the produced information and a lot of saving in fieldwork compensate the effort for Quasi Analysis Techniques. The methods are working with some limitation. Pre-Ready GIS can support decision making with satisfied cost-benefit ratio.

3.1 Determination of Consider Highrisk Places along a Street

Experiences show that street positions with most accident are mostly:

- steep street (brake is not work, engine not strong enough or speed change too late)
- street with sharp curve (obstacle not visible, curve cutting)
- straight street without separator / not highway (overspeed, sleepy)

Those are geometrical problem, which are mapped in the pure data of digital topographic map. Data, which might be needed, are street network and relief (DEM).

In the first case, the algorithm is

- from DEM a raster slope map will be generated;
- slope are divided in five classes;
- street vector will be overlaid and rastered on slope map ;
- high risk places are street with certain slopes;

An example of result can be seen in Figure 3, which is near Puncak in West Java.

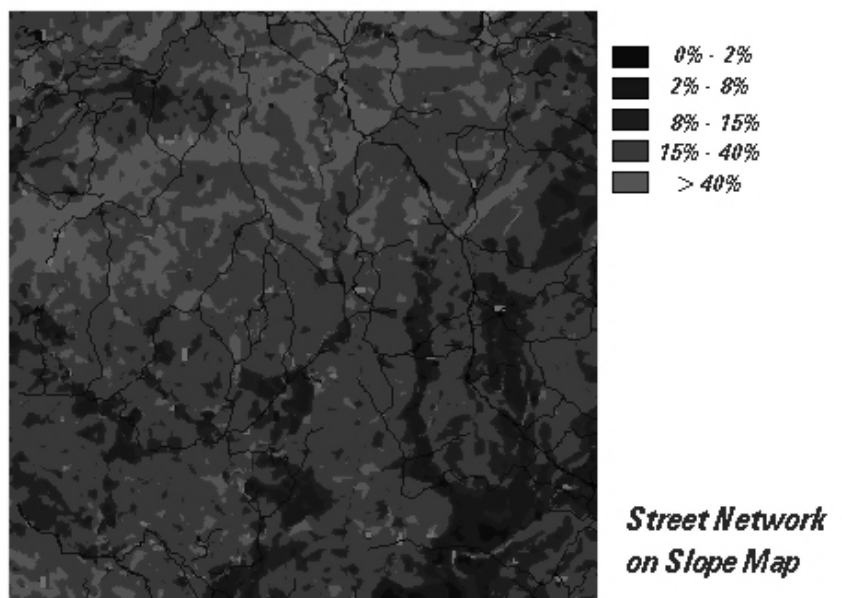


Figure 3: Street network on slope map

In the second case:

- the algorithm traces the street from one end to another end;
- in each vector point the gradient from two points before and after will be computed;
- a high-risk place is street with a gradient more than certain value.

In the third case, segment length and gradient of each street segment will be computed. A street will be seen as straight (and therefore highrisk) if the segment length is more than certain value and there is no significant gradient.

These pure geometrical models just give an approach for highrisk places along the street. A field check must be done to capture some external data such as street condition, traffic density, vehicle safety etc., but surveying work could be saved only surround places, which physically are detected as highrisk.

3.2 Optimal Positioning for Microhydro Powerplant along a River

Indonesian recent economic crisis and political reformation makes Microhydro Powerplant (MHPP) an attractive alternative as sustainable energy source. Its scale is small enough and its investment is low, so that it is suitable to build decentrally by participating of counties or villages people, and its operation and maintenance will be more transparent. Therefore, a map for optimal position of MHPP for a county will be an attractive matter in the time of current district autonomization in Indonesia.

Using pure data from digital topographical map, only geometric model of optimal position of MHPP can be build. The algorithm could be:

- data conversion for river (vector) to 3D-raster;
- river tracing from upper reach to the rivers mouth;
- a dam will be “built” along of river with certain interval and certain height difference;
- the dam has certain height upright to the rivers direction;
- the dam width will be extended until touch a DEM-cell in its direction with higher elevation;
- the “flooded area” can be computed;
- location with maximum potential energy and the minimum flooded area is geometrically optimal.

Figure 4 shows an example of dammed are in a river in West Java.

This geometric model can be upgraded if data higher resolution is available so that river width and depth also known. External data like geology, vegetation quality in the watershed area to guarantee water supply etc. will improve also the quality of the model. Integration of DEM-derived slope and vegetation give information about erosion-potential, which has influenced also to the lifetime of MHPP. A continuously meteorological data of the watershed over years can give security of the water debit and the model could be used also for flood early warning system and for flood avoiding plan.

However, the optimal position by pure geometric model can be a starting point to make a selective fieldwork to catch the external data.

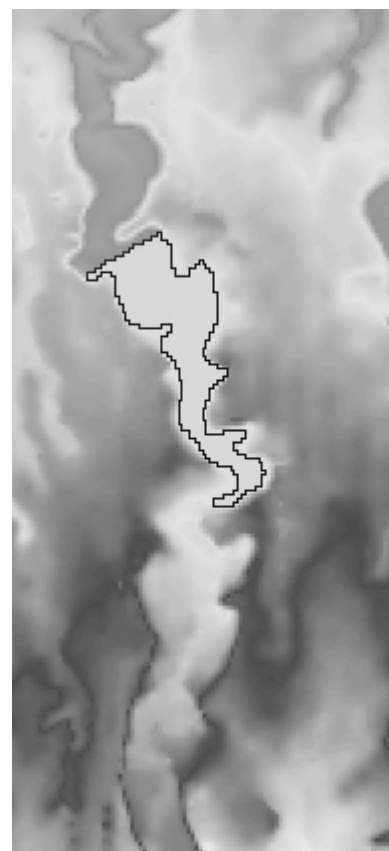


Figure 4. Dam model over river

3.3 3D-simulation of environment quality in a big city.

With increasing of population density environment in big cities is going worse. Heat, air pollution, and noise will be closer with them. Seeking of comfortable environment is a big job and location with this has a high value. For this purpose, a simulation of heat, noise, and air propagation is necessary. As data source is buildings model of the city (3D-City Model), landcover (vegetation), and street network. Facts show that street vehicles are the biggest source of heat, noise, and air pollution in a city.

The value of comfortable environment (V_{ce}) could be modeled as $V_{ce} = F(S,C,V,B)$ or a function of distance to street, street class (assumed street density), absorption of vegetation and reflection by buildings (modeled by 3D-City Model). Figure 5 shows an example of 3D-city model. Some model parameter must be measured on site. And the model will be complete if some social and security factors are also introduced. Nevertheless, the geometric model is a starting point to use these criteria and it is also a good basic to 3D-GIS (Fritsch, 1996).

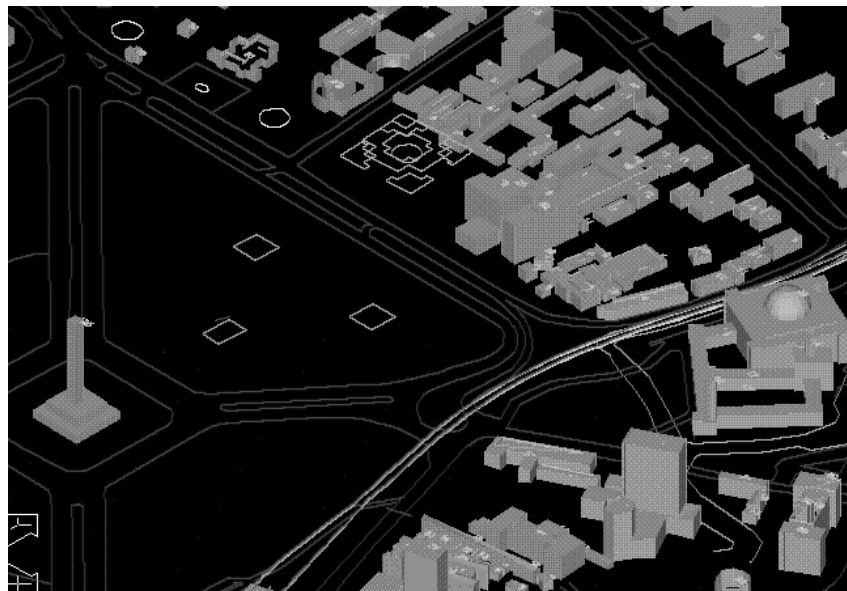


Figure 5: 3D-Digital City Model

4 CONCLUSION & OUTLOOK

The result quality of Quasi GIS Analysis depends on the mathematical model and the quality of the available data. Recently, research and development in applicative innovation of digital mapping product are in progress with funds from Bakosurtanal and National Research Council (DRN). Experience shows that the produced information and a lot of saving in fieldwork compensate the effort for Quasi GIS Analysis.

In near future, quasi GIS analysis techniques will be tried on natural community grouping or enumeration, which are needed by some public service institution, from electricity, post service, medical healthcare until for statistics and election purposes.

Mapping of natural poor district using quasi GIS analysis techniques will also follow. The reason of this research plan is that current data of poor districts are inaccurate, since there are no distinction between poverty by natural reasons or by not natural (politics, law, cultural) reasons.

5 REFERENCES

- Amhar, F. (1999): Quasi Analisis SIG dengan Data Murni Hasil Pemetaan Digital. Prosiding Pertemuan Ilmiah Tahunan ke-8 MAPIN (Indonesian Remote Sensing Society). T 44 - 50.
- Bekkkhus, R. (1996): Digital Mapping in Indonesia (Part 1), GIM 10/1 January 1996: 47-51.
- Fritsch, D. (1996): Three-Dimensional Geographic Information Systems - Status and Prospects. International Archive of Photogrammetry & Remote Sensing Vol. XXXI/B3: 215-221.

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