SYSTEM DYNAMICS APPLICATION TO SUBURBAN DEVELOPMENT

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Abstract

Under the situation of rapid movement of the "Information Technology" world, planning and decision making for any condition should respond to new conditions in the proper manner. Problems existing in a community interact swiftly and more complicately than in other communities. Suburban areas nowadays have become more than the edge of the big cities. They are a place to live and earn income for a large part of the population. Non-reported immigrants become a hidden population for whom the local government office must bear the social and environmental costs without extra-funds from the central government. Coping with such problems in the suburbs needs systematic and dynamic considerations which respond to the rapid population movement of the area. System Dynamics Method is introduced as a tool for policy planners to examine and make judgements in the current situation. Former study of the rural Klong Luang area is raised to highlight more factors applying to the suburban areas.

1. Introduction

By focussing on economic growth for decades in Thailand as in other developing countries , several imbalances and distortions of development between urban and rural areas have become clear. While the urban areas are generally the center point of economic, commercial, and administrative life, the rural areas are for the majority poor. Due to the emphasis on industrial growth of the former National Economic and Social Development Plans since 1960, large amounts of rural laborers have kept on moving to earn their income in the cities especially in Bangkok and its vicinity. Factories have become their workplaces while suburbs have become their residential areas. Hence, the suburbs have population growth more than the natural growth rate.

Although this in-migration means a growing labor force, a large community without appropriate planning implies social and environmental problems. It relates to the development of the rural areas and the country as a whole. Based on the former study of System Dynamics (SD) approach to the rural changes focussing on the factors of changes and their impact to Klong Luang [1], this paper will introduce SD application to suburban population movement. Klong Luang district, Pathum Thani province will be utilized as a case study since it has been urbanized at a very rapid rate.

2. System Dynamics

In general, a system is defined to be a collection of entities which act and interact together toward the accomplishment of a particular purpose. In practice, it depends on the objectives of a particular study which may be only a subset of the overall system. It is called dynamic if its interactions cause changes over time especially when it is not in a state of equilibrium [2].

System Dynamics principles and mechanics were first worked out in 1940-50's. It is an analysizing method for the behavior of complex systems to show how the system structure and the policy used in the decision making control the behavior of the system. Until now the technique has been used to understand many diverse problems in many fields such as

management, environment, socio-economics, medicine, engineering etc.

Forrester [3] identified System Dynamics as a closed system since it has a feedback loops structure that brings results from past actions of the system back to control future action which is shown in Fig. 1.
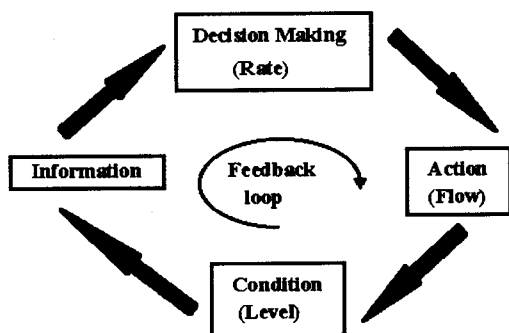

Fig. 1. System Dynamics Model Principle

Also he pointed out the typical steps necessary to accomplish a computer simulation for System Dynamic method as in the following:

- Identification of the problem and planning the study
- Data collection
- Formulation of the mathematical model
- Construction of a computer program for the model
- Pilot runs
- Validation of the model
- Design of experiment
- Execution of simulation runs
- Analysis of output results
- Documentation and implementation of results

Nowadays, with the support of rapid technology development, computer and various software play an important role to facilitate the model builders. In the past, the "DYNAMO" program was used for building up a System Dynamic model in the computer. However, in the present day, particular software has been produced and used for particular purposes.

3. Suburban : the Connection between Urban and Rural

Urbanization has been concentrated in Bangkok and big cities in the regions, then sprawled its arms rapidly to the vicinities. Although the urban population in other regions grew around 1.3-1.7 per cent per annum, the number of people migrating into Bangkok is much more than in other regions. As a result, degradation of the environment, traffic congestion, inadequate infrastructure services, and slums have become major problems in Bangkok and its vicinity [4].

Suburban Klong Luang is a case of fast movement to live close to the city. Generally, the development plans always mention urban and rural development, since they are clearly distinct from each other. The problems existing in the suburb need special and careful treatment which may be different from the problems of urban and rural areas. Since it is a door to transfer resources between two areas, it can also be used as the index of city and rural growth. The development plan of urban or rural areas applied to a suburban area may lead to the "half done" situation. Zoning and regulations which apply to this area have become mixed up and somehow contradictory to one another. The plan and policy applied to a particular area should be specifically designed.

4. Model Application to Klong Luang Area

4.1 Klong Luang District

Klong Luang is one of seven districts of Pathum Thani province (one of the five provinces of Bangkok vicinity), covering an area of around 298 sq.km. It is located in the central plain, on the east side of Chao Phraya river, at 14° North latitude and 100° East longitude, and is 2.30 m above mean sea level. The district consists of 7 sub-districts and 106 villages. A sanitary area covers two sub-districts close to Highway No.1 [5]. Around 1902 an irrigation system was developed in this district for agricultural development and raising the price of land. However, this becomes a landmark boundary of its villages and sub-districts (as shown in Fig. 2).

Since Klong Luang was designed to be a huge paddy field connecting the neighbor dis-

tricts (which was called "Thung Rangsit"), land use pattern has changed due to the current development emphasizing industrial growth. Large land pieces have been turned over to factories, residential and commercial areas, and waste land waiting for land price speculation. The main occupation of the local people has turned to rely more on other work besides farming. Many industrial factories have attracted the young generation here to work as employees. More immigrants from the neighboring provinces have been coming to live and earn their incomes both in the short and long-term period. Based on the official report, population is over 94,518 in this district [6]. However, it is accepted by the district government provincial officers that there are around 300,000 factory workers stay in Klong Luang without any official registration.

4.2 SD Model and Klong Luang Situation

Based on the application of System Dynamics to rural changes [1], such a study has divided the structure of Klong Luang by production sectors which were agriculture, industry, and services. Those sectors are connected with the structure of population, labor force, migration, income, investment and land uses. Following the principles and methodology of System Dynamics model establishment, about 562 parameters were built up for the whole system. The reference data (the collected census etc.) during 1960-1990 was used to compare with the simulation resulting from the established model to verify the accuracy of the model. Moreover, a sensitivity analysis method was used to confirm model reliance. The model and some equations of the population model from this study are highlighted here to illustrate the whole system as shown in Fig. 3 and in the following equations.

Token population model equations for the simulation process

$$POP1(t) = POP1(t-dt) + (PIN 1 + PBR - PDR1 - POT1 - AR1)*dt$$

INITIAL POP1 = 6712

inflows :

PIN1 = (GPIN*POP)/GPOP

PBR = BF*GPOP

outflows :

PDR1 = DF1*POP1

POT = (POP1*GPOT)/GPOP

AR1 = POP1/AF1

Notice :

t	=	present time
dt	=	time interval
POP1	=	Population aged 1-14 years old
PIN1	=	Number of in-migration population of the 1st age group
POT1	=	Number of out-migration population of the 1st age group
PBR	=	Population birth rate
PDR1	=	Population death rate of the 1st age group
AR1	=	Rate of population aqed 15 years old
AF1	=	Fraction of the 1st age group (1-14 years old) that will turn to be 2nd age group in the following year
BF	=	Birth fraction
DF1	=	Death fraction of the 1st age group
GPOP	=	Gross population in the area
GPIN	=	Gross in-migration in the areas
GPOT	=	Gross out-migration in the areas
INITIAL POP1	=	Population aged 1-14 years old, in 1960

It was found that the model could explain the system behaviors well enough byan acceptable closeness to the reality. The results are shown in graph in Fig. 4.

It is found that SD can be applied to study the changes of suburban movement as well as of the rural area. However, for very rapid change situations, the use of old factors from a long time back may mislead the application of the model. For example, almost 40 years ago traffic jam and land speculation were not important factors in the model. Nowadays, these factors are very serious problems for the movement.

5. Conclusion

Since this paper concentrates on the result of the model and its application to see suburban movement through population growth, the result of the former study is raised to consider the

impact of the various factors. Comparing with the real situation of Klong Luang in present day, it is found that globalization has rapidly brought changes to the study area as well as to other suburbs. The conditions of the system are determined by a large amount of new information. Decision making process and actions are continuously governed by more complex factors. A System Dynamics model which has been well formulated in the past 30-40 years may not be modern enough to explain the recent changes in the particular system. New factors and new feedback loops should be added to the system for the sake of accurate simulation. Some reasons which can be used to explain such changes in Klong Luang are raised as in the following:

1. Investment and industrialization of the country have followed closely to the urbanization process. Rural community has been urbanized by the infrastructure and the materials. However, such development has not been evenly spread through the whole area. In the case of Klong Luang, such development has been concentrated in the areas along the National highway due to the ease of transportation.

2. Although in the former period Klong Luang was designed to be agricultural land for the nations stability, land rights mostly belonged to the landlords. When the situation of land use changes, investment in farms is not as attractive as in other sectors. Land has been left unused, waiting for rising prices. Local farmers partly move out or get other jobs in the factories or elsewhere, while the newcomers live in the new residental areas. Irrigation canals are used mainly for serving the daily purposes instead of effectively distributing water into the paddy fields.

The pattern of the settlement nearby the waterways for farming purpose have been changing to be away from the waterway for less investment in bridging the land. Regarding the problem of traffic jams, land price and location from workplaces, these are other important factors which have become more serious nowadays. The impacts from these should not be over looked in the model. However, factors such as traffic jams, land price speculation, urbanization etc. were not severe in the former days. Adding these factors to the model running

for 30-40 years to the same degree may not reveal the real present situation. Applying System Dynamics to the rapid dynamic movement system should be based on the recent pattern of changes.

3. Klong Luang can be raised as a case of rapid people movement of suburban. To apply System Dynamics to other suburban areas should include recent factors to see the impact of rapid movement in these areas. However, the information will play a very important role to judge the accuracy of the model. The old census of Klong Luang may be best used to predict the future population in the official report. However, large group of the hidden population may be excluded, if the involved factors are not put into the model.

6. Reference

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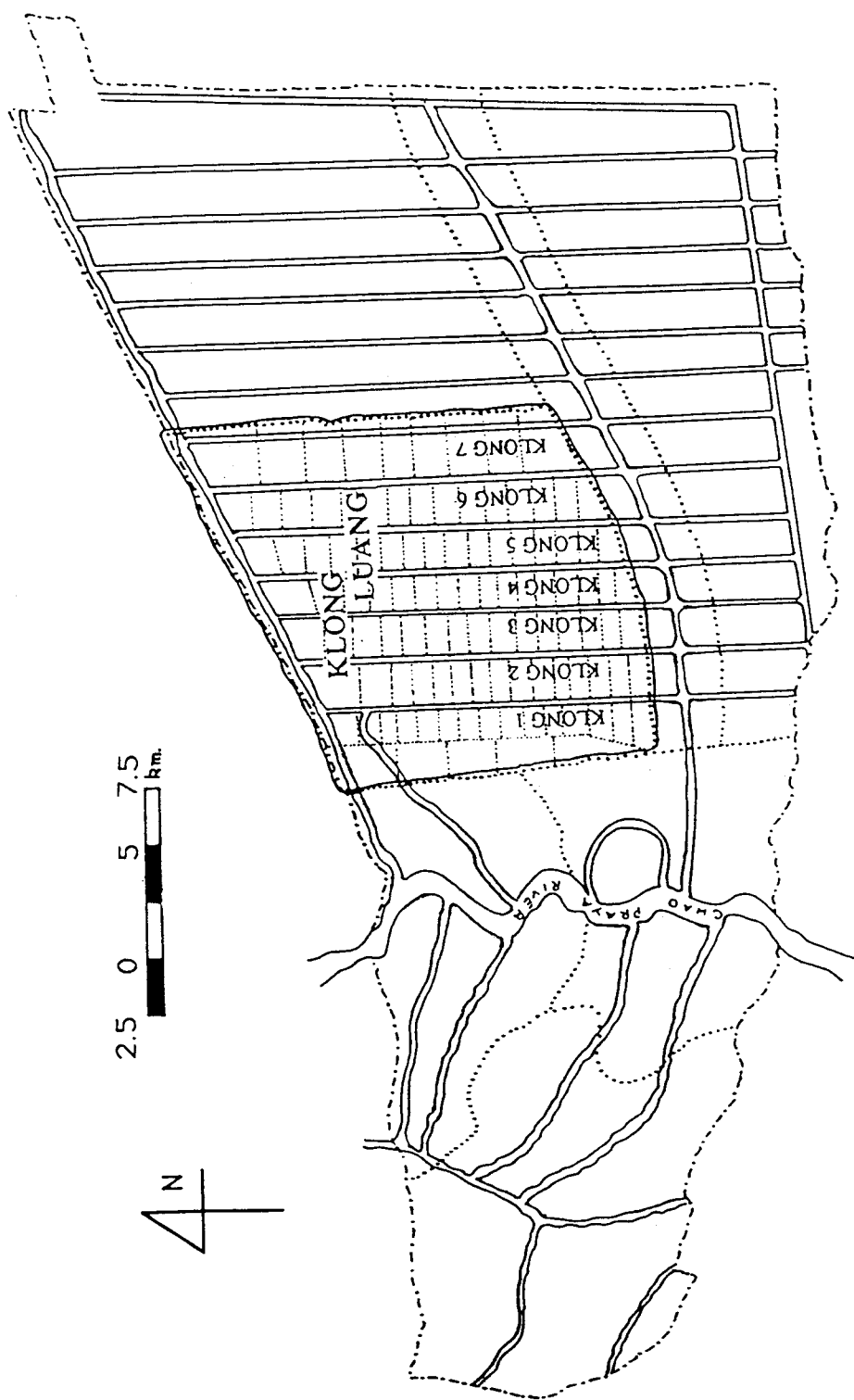[6] Patum Thani District Office. 1996. Report Paper on Klong Luang District. Patum Thani District Office (in Thai).

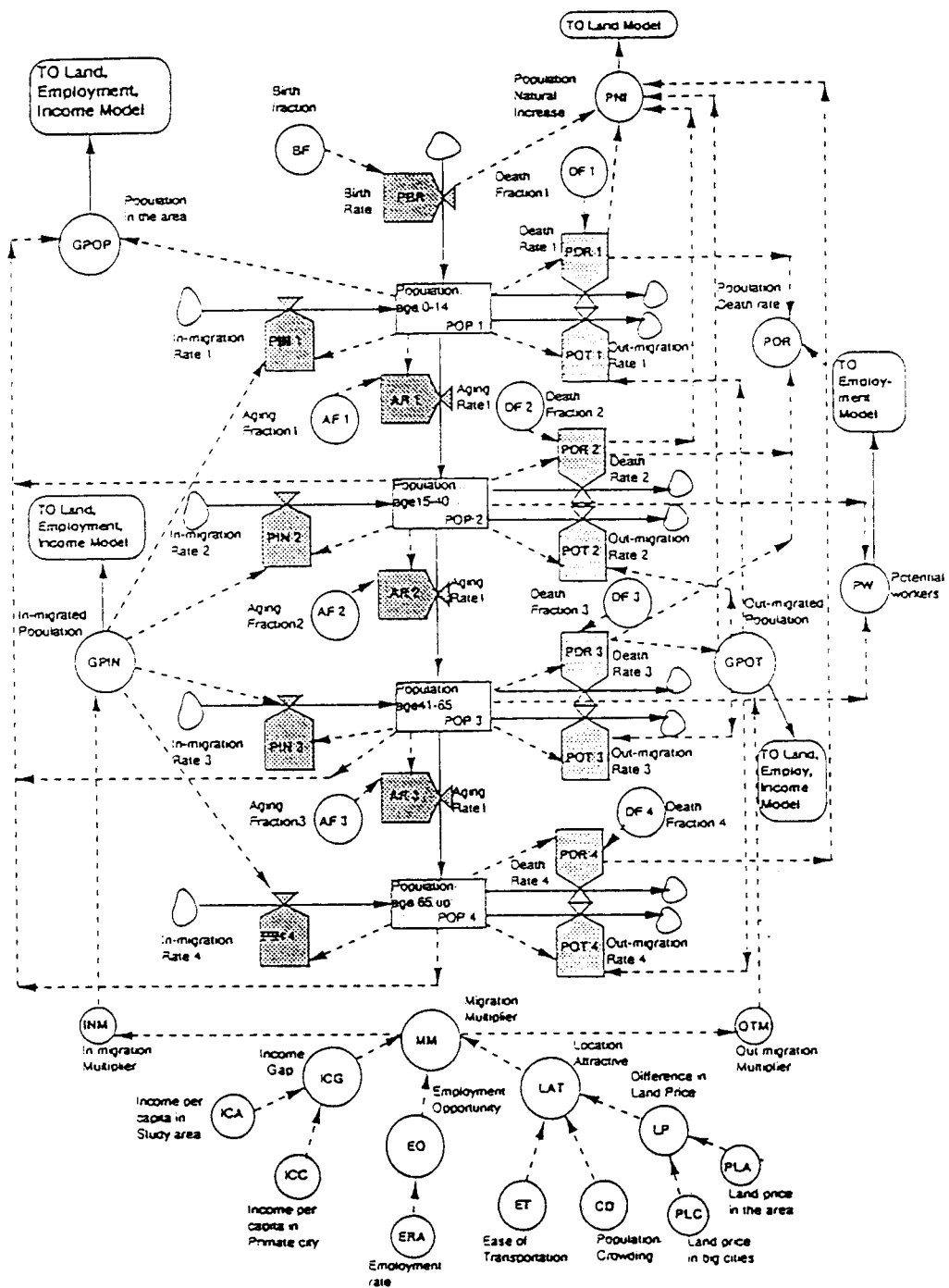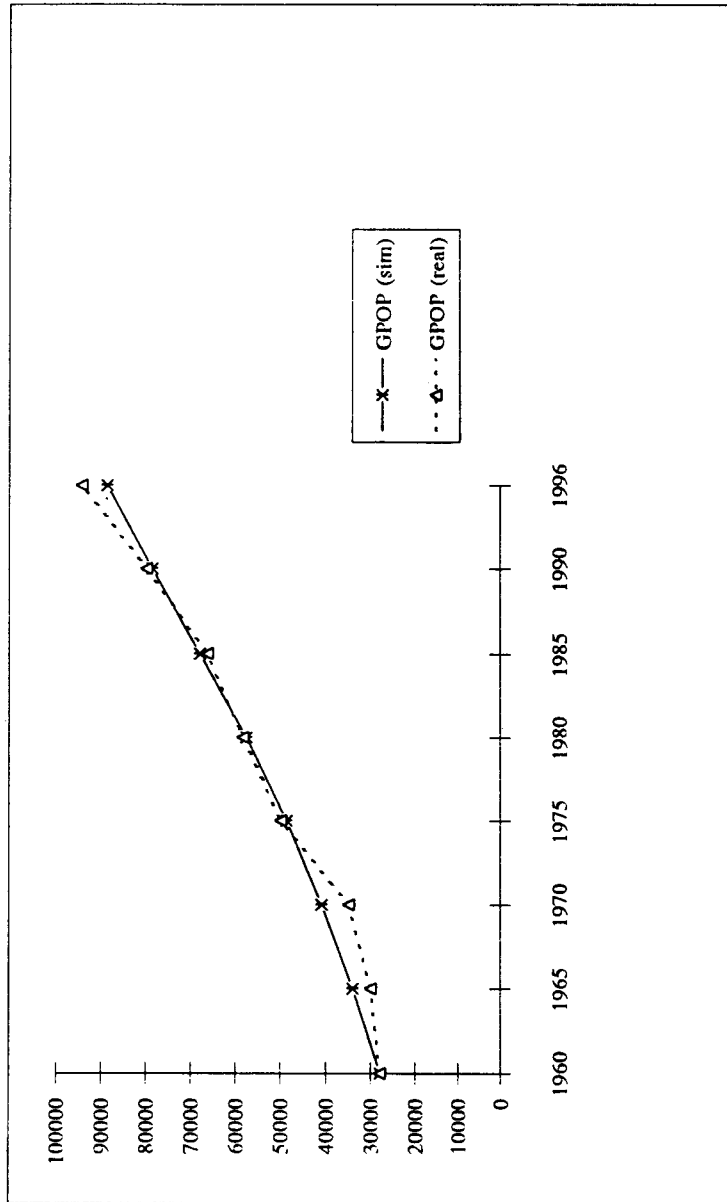**Fig. 2. Pathum Thani province and Klong Luang district**

Fig. 3. Population model

Fig. 4. Comparison of population simulated results and real data