Urban Systems Model with Refernce to Essential Environmental Facilities of Developing Country

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Abstract

Urban management in the developing world has been snarled in the tangle of urban complexities. Phenomenal population growth, heightened urban poverty, insufficient essential environmental stock, over utilization of the meager facilities and consequent deteriorating living environment, escalating public welfare and protection cost, persistent financial constraints due to inadequate revenue, non-objective orientation of urban development programs, in efficient urban management system and chaotic social-political fabric are the common features faced by the urban areas of many developing countries.

Particularly in the case of the developing world it becomes important to understand the trade off between urban pressures and strive to find analytical tools which could separate feasible improvements from Utopian failures to reduce the widening gap between planning and management.

When the factors relating to the area of engineering and economics are combined with social factors, the System Dynamics approach is the most valuable tool.

It is within this context an attempt has been made to in this study to formulate an analytical tool which could address the problems of population, economic activity, essential environmental facilities and the urban development programs needed to redress the situation prevailing in the urban area of a developing country.

Towards this end, an attempt is made to formulate an urban development model and application to Madras city of India to assess the functional validity of the model.

1. Introduction

The migration of rural folks to urban area has primarily been for a better job and living conditions. The unproductive low level of skills often land them in jobs which are informal in nature and can not be classified as gainful employment. Yet the surge of people into the cities continues as the income levels in the urban areas are better than what they otherwise would gain in rural areas. Nevertheless, the income level in the cities is not commensurate with urban living standards demand and they can ill afford all the services they are provided with. Thus the huge concentration of people in a city crushes all attempts to improve the Essential Environmental Facilities (EEF) in terms of quantity and quality. Facilities utilized beyond their designed capacity often warrant greater investments for regular maintenance and replacement resulting in very low level of investments on creation of new stock.

While the non-affordable characteristics of a vast majority of population bring in less revenue to the coffers of the City

Government, there has been increasing demand for social welfare and public protection. Diversion of huge segment of the city budget for such welfare schemes has not brought about any significant level of improvement neither in the quality of life nor in the general economy. It has been similar to filling up a bottomless pit. The principle of economic prosperity lies in the sustained economic growth of a city. Instead the low level of literacy, affordability and consequent environmental degradation have been a deterrent for any economic improvement (Yamamura 1983, 1984, 1985, 1986).

Besides the specific nature of economic activities that characterize an urban area, it is the infrastructure and services that are available to the dwellers that make it an urban organism. At least, that is how an urban dweller often conceptualizes his life as different from rural living. Implicit in this concept is a better standard of living which includes other than higher economic opportunities, better housing standards and EE facilities. Several schemes intended to ameliorate the living environment of the less fortunate section of the population proved to be of no effect. Efforts made towards alleviating one problem aggravated another. Thus it is no longer advantageous to manage the cities according to a set of Utopian objectives and dealing with problems in isolation as they arise.

In recent times, time and again, the short comings of the 'Crists Management' mode of operation has become more evident inspire of the undesirable experiences gained in attempting such management measures. As a result, now, many cities of the developing world are found entangled with problems that seem to be totally out of control. Particularly in the case of the developing world it becomes important to understand the trade-off between urban pressures and strive to find analytical tools which could separate feasible improvements from Utopian failures to reduce the widening gap between planning and management.

The pertinent question, therefore, is what should be the form and content of a comprehensive approach and what is the appropriate tool to analyze the existing system and formulate policies for future needs within the socio-economic constraints prevailing in the developing countries. It is within this context an attempt has been made to in this study to formulate an analytical tool which could address the problems of population, economic activity, EE facilities and the urban development programs needed to redress the situation prevailing in the urban area of a developing country.

There have been wide spread contentions that the system dynamics approach, when applied to urban development context and simulated over a long period does not reflect the reality as the urban areas are always in a state of flux. Yet the only valuable too that is available to deal with multivarious complex factors of developing country, the system dynamics approach is the most appropriate tool. Further, when the factors relating to the area of engineering and economics are combined with the Social factors the System Dynamics approach is the most valuable tool (Forrester, 1974a, 1974b; Thirumurthy, Yamamura and Kagaya 1987).

Under the present context of a developing country and the socio-economic fabric, any attempt made towards formulating an urban development model needs a long range perspective. Drastic results are not expected to be realized in a short span of time. Since the attempt in this study is to formulate a system to enhance the affordability level of the less affordables, which has been the prime factor in not influencing the enhanced improvements to the living environment, the system dynamics approach has been considered most appropriate in this

study.

The experiences of Third world countries in identifying the fundamental systems particularly relating to the urban dynamics is minimal (Alex, Kagaya and Yamamura 1989). Though several studies were conducted by local experts, international institutions and individual resoarchers on specific problems of urban areas, a comprehensive system which could describe the urban areas of a developing country has been a much needed tool. It is within this context an attempt in this study is made to formulate a system to identify and assess the shortfalls in each component of the urban system and to understand the future efforts needed to be focused. The system thus formulated is tested for the city of Madras, the fourth largest city of India (Developing country).

2. Methodological Framework of the Study

In consonance with the identified problems faced by an urban area of developing country the urban organism or the system has been conceived as illustrated in Figure 1. The conceptualized framework essentially address the developing country situation. Although similar problems are faced by developed countries also, the magnitude of the problem, the factors influencing each component of the system and the system of urban management and the economy are totally different from that of developing country. The comprehensive approach involves, inter-action among the parameters controlling each component of the system in a dynamic state. Each component and its related parameters state are identifiable at every desired stage so as to give leverage for applying the policy options deemed fit to orient the model in the desired direction. The system is also designed to function with suitable sectorial modulators so as to avoid greater oscillation within the model and also to be realistic with the practical situation.

The Figure 1 illustrates the complex factors influencing the urban system components and their interaction and also the interaction among the components parameters.

(1) Population component

The population component includes the socio-economic factors or parameters. The total population is classified into three groups namely, LIG(Lower Income Group), MIG(Middle Income Group), and HIG(Higher Income Group) based on the affordability characteristics. Each group is again stratified according to the typical age group as applicable to planning and development of different EE facilities. Each group is influenced by the demographic characteristics of Natural Increase and the Social Increase (Michael, W. L. 1974;MMDA 1981). The Natural Increase includes the birth rate and the death rate. The natural transfer of population that takes place as the population ages from one age group to another is also included. The Social Increase included the In and Out-migration of the population relating to all age groups of the three population groups.

The population sector also includes the transfer of people from one age group on a population group to the corresponding age group of another population group due to the upward mobility of population from lower affordability group to the higher affordability group. However all these demographic characteristics are inter-related to the improvement in the Economic activity the EE facilities and the Urban development program components of the urban system.

(2) EE facilities component

The EE facilities component of the system includes all the sectors considered under the 'Basic Services' and 'Supplementary Services' Figure 2 (MMDA 1974). Every sector under consideration comprises of
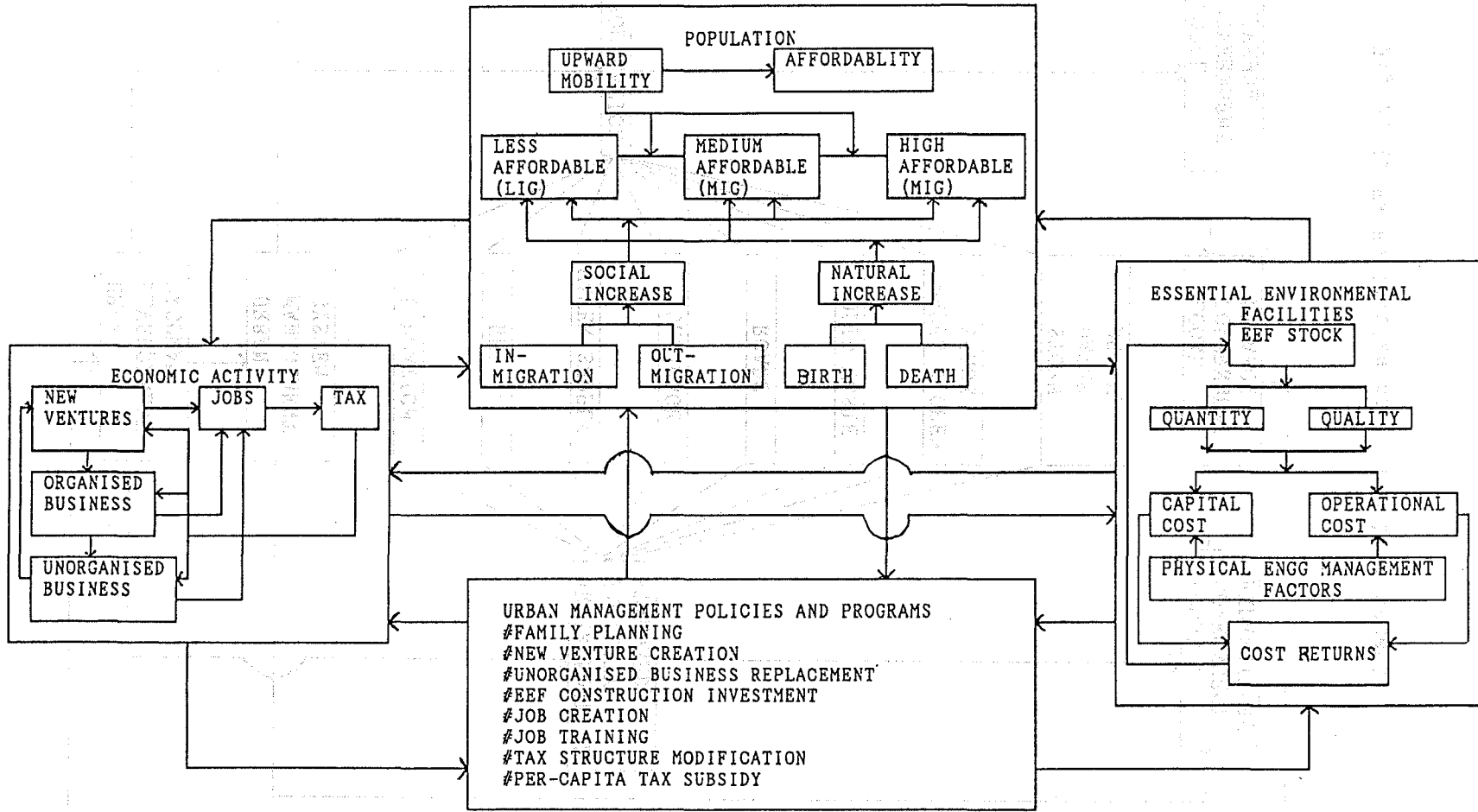
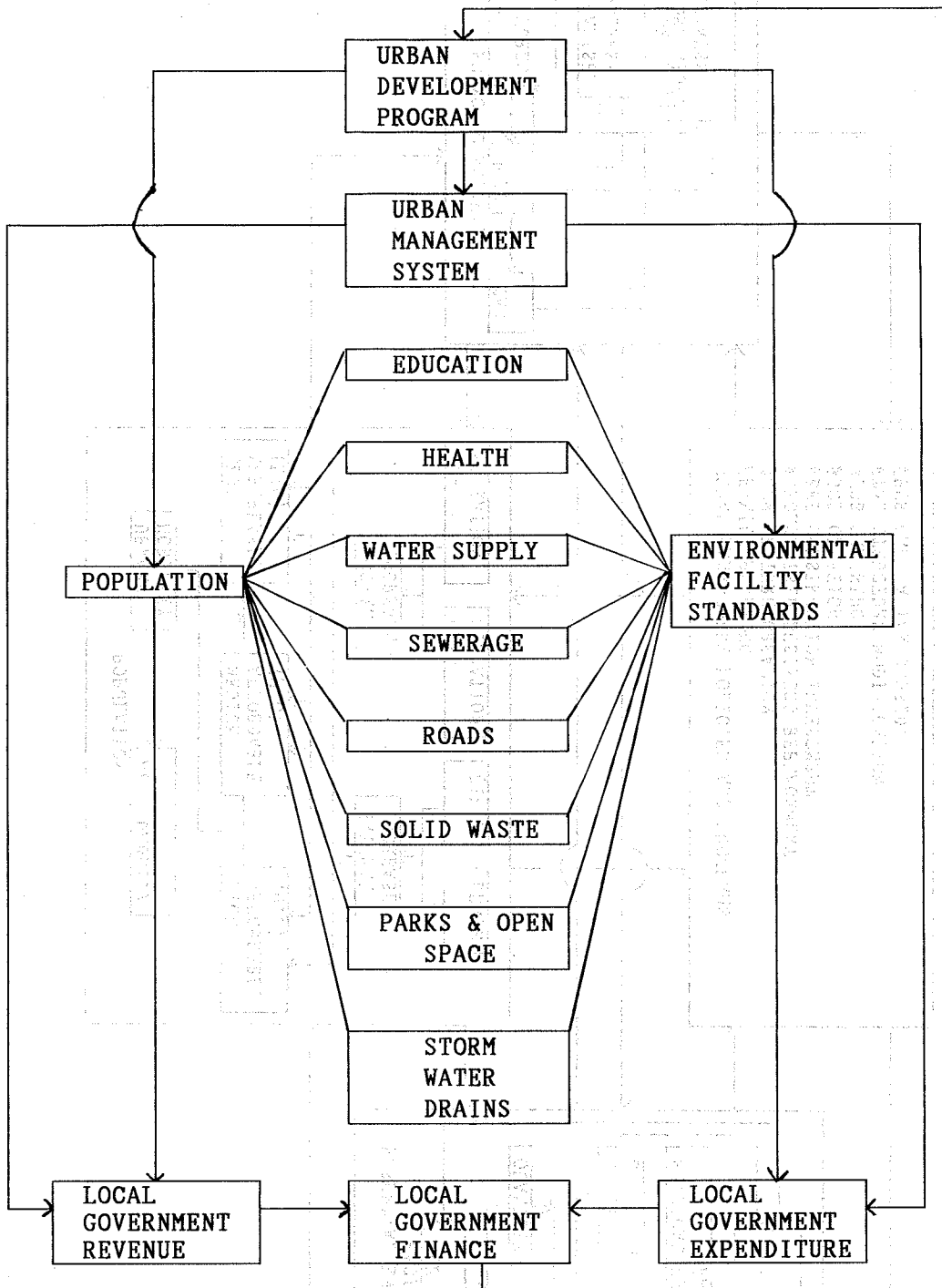Figure 1. Urban Development Components Interaction

Figure 2. EE Facilities and Urban Development.

socio-economic, physical, engineering and administrative factors
influencing the sector. The financial aspect relating to each sector
is considered under two categories of investments, namely, Capital
Investment and Operation Investment or the running cost. The cost
returns from the individual population group is related to the
affordability level of the population group and the level of the
facilities availed by the individual groups. The private sector
involvement, particularly in the supplementary sector is also
incorporated to assess the extent of private involvement in
delivering such facilities when the upward mobility and the consequent
affordability level increases.

(3) Economic activity component

The basic premises with which the model is conceived relates to
the upward mobility of the population in terms of affordability., the
Economic activity component deals with the key sectors of economic
activity namely, the New venture Sector, the Organized Business sector
and the Unorganized or the Informal Business sector (Michael, R. G.
1974a; Nathaniel 1974). New ventures during their growth phase provide
for greater employment opportunity and over a period of time they
attain a stage of maturity beyond which their employment potential is
leveled off and they fall into the category of organized sector. As
the general economic conditions improve and the application of
technology increases, there begins a pronounced change in the market
forces and the organized sector over a period of time declines in its
vitality and falls into the category of Unorganized sector or the
Informal sector.

When the city faces less construction of new ventures and sharp
decline of organized sector culminating into Informal sector, the
stage is diagonised to be the economic stagnation stage. When the
stagnation in the economic activity sets in, urban revival policies
are of paramount importance to revitalize the economy and to foster
sustained economic growth. To state the obvious it is not easy to
bring in such a revitalization in a short period of time particularly
in the case of developing country unless, measures pertaining to
restructuring the taxing system and development of Man power resource
need to be attempted on a massive scale. Specific urban development
programs like construction of sites and services programs and job
creation of new job opportunities should also be attempted
simultaneously (MMDA 1978).

(4) Urban development program

The basic premises with this model is conceived relates to the
improvement of the affordability level of the different cross-section
of the population. Such an attempt needs a comprehensive urban
development program. It is not an easy task to improve the
affordability level over a short period of time given the socio-
economic fabric of the cities. And therefore the model assumes that,
when the general economic level improves there will be a simultaneous
and gradual improvement in the affordability level of all groups of
population and when there is a concerted effort to increase the upward
mobility of the population, by virtue of reaching a better economic
standard the affordability will also increase. Thus, the model is
built to accommodate the improvement in the affordability level at two
stages, one within the population group itself and the second, when
the upward mobility increases.

Specific urban development programs identified in accordance with
the stated objectives to stimulate the economic activity are as listed
below;

     i. Family Planning Program
    ii. EE Facilities Investment Program

     iii. New Venture Construction Program
      iv. Unorganized Business Replacement Program
       v. Job Training Program
      vi. Job Creation Program
     vii. Tax Restructuring Program
    viii. Tax Per-Capita Subsidy Program

It is obvious that these specific urban development programs are intended to stimulate all the component parts of the urban development program. The urban development programs are incorporated in the model in such a way that any one of the program or all of them can be instituted at any point of time within the plan period. Importance can be imparted to any program or multiple programs depending upon the severity and the priority needs of the problem.

3. Simulation Analysis

The first simulation attempts to establish the possible trends and changes that are likely to occur over the horizon year (2005) on continuation of the current level of urban development activities relating to all sectors under consideration as given in the base model. In the second simulation special urban development programs designed to enhance the economic activity and the affordability levels (the most urgent needs) are introduced. The reason for introduction of such programs is based on the principle that when the levels of afore said components increase there will be simultaneous increase in the levels of EE facilities (due to increase in demand), revenue and reduction in the population due to increased awareness of the need for the family planning programs. Reduction in the population can be achieved once the education and economic levels of the society particularly the LIG are increased.

In the third simulation run considering the findings of simulation 1 and 2 and the grave environmental conditions prevailing in the EE facility sectors, programs designed to enhance the quality of the facilities in tune with the increase in demand have been introduced having the simulation 2 model as the base model.

The results of simulation 1 clearly establishes the deteriorating conditions in all sector of the Madras urban activities. The LIG population increases manifold, the MIG and HIG population exodus is pronounced, decrease in the revenue is increasingly felt, the EE facilities deteriorate further and the whole urban scene depicts a chaotic situation beyond any means of reversal.

On application of the suggested urban development programs, there is a pronounced improvement felt in all the sectors, with greater reduction in the birth rate, improvement in the affordability levels and consequent availability of better stock of EE facilities. Enhanced revenue to the government coffers will drive the government to invest more on the EE facilities proportionate to the rise in demand, which again will induce greater employment opportunities. Continuance of such urban development program at the appropriate time and scale will set the urban economy rolling on the desired level so that the EE facility stock is maintained to the desired standard.

In the second run, the model however shows and increase in the population. This increase is mostly attributed to the increase in the MIG and HIG population. The LIG population is considerably reduced due to reduced birth rates, less in-migration and higher mobility rate. This is the most favorable condition to launch any further urban development programs towards achieving better environmental standards. However, towards the end of the plan period, the new venture growth does not show significant rise and the consequent effect is felt in the HIG workforce out-migration. This however does not provide the

favorable atmosphere to maintain adequate quality of services. The reduced mobility of MIG population to the HIG, at the end of the plan period does not also provide for conducive atmosphere for sustained economic growth. These imply that unless large scale investments are made in projects which are capable of providing for large scale employment opportunities the urban system will again delve back to the original conditions prevailed in 1981.

Further implications of such decline in the economic activity at the end of the plan period imply that, the tax structure should be revitalized commensurate with the demands for high order service facilities and the subsidy programs have to be restricted to the most vital sectors such as Education and Medical sectors.

It is also imperative that, while the quantity of the EE facilities is enhanced, the quality of the facilities must also be substantially enhanced since the Education sector, Water supply sector and the sewerage sectors suffer from unacceptable quality. Current efforts towards Family Planning have to be enhanced for more desirable level of population growth.

In Simulation 2 the maximum reduction that has been achieved in the birth rates in all groups of population is only 5%. Unless concurrent efforts are taken to reduce the population growth irrespective of religion and other influences, any amount of public investment will not bring in the desired results. By virtue of improved service facilities there will be a significant reduction in the death rate which again will increase the total population.

The regional development and small and medium size city developments programs should be vigorously perceived to lessen the burden on the Madras city. These programs certainly will have greater influence on the growth of Madras city, however the growth of Madras city itself is not anticipated to have overwhelming influence on other area of the State.

The simulations 1 to 3 illustrate the salient features of the simulation 3. When compared to the results of simulation 2, there has not been major changes observed. However, there is marginal increase in both LIG and MIG population and decrease in the HIG population. The observed changes are due to the marginal increase in employment opportunity for LIG and MIG and consequent proportional increase in the in-migrants, and reduction in the death rate.

While the mobility of MIG to HIG has increased due to increase in the organized sector activity, the reduction in the unorganized sector replacement and new venture creation have reduced the LIG to MIG mobility and HIG population (increase in out-migration). Though programs intended to enhance the quality of service have been introduced the construction rate of EE facility has not been effected through the modulating constants in view of the financial burden on the local government and therefore influence on employment is very less. However on increasing the construction rate and the tax rates there will be a significant change achieved. This could form the basis for the subsequent simulation runs. The significant changes achieved in this simulation are; reduction in birth rates and enhancement in the EE facility level.

4. Conclusion

The simulation results of the present study thus establishes the imperative need to identify the most probable dynamic changes expected during a foreseeable future in order to frame appropriate urban development policies to direct urban development in the desired direction rather than trying to direct urban development in the desired direction rather than trying to achieve a balance among the

urban activities over a long period and to understand the urban complexities.

The analytical urban development model framed to address the urban system (Madras City) of developing country and the simulation results have clearly established the functional validity of the model. Since the present model is the true representation of a developing country and provides for deeper insight to the various facets of urban problems found common in the developing world, application of this model to similar urban areas will prove to be valid with moderate modification in the structure of the model rather than the governing principles. It is strongly established by this model that, it is vital to concentrate on programs intended to enhance the upliftment of the urban poor, for successful implementation of programs directed to ameliorate the living environment and to rectify the failures of Utopian approaches hitherto followed (Yamamura 1989a, 1989c).

References
 1. Alan, K. G. 1974. Understanding Urban Dynamics:An Analysis of Garn's Interpretation-. *Readings in Urban Dynamics*.1:121-138
 2. Alex, B. A., Kagaya, S and Yamamura, E. 1989. Dynamic Assessment of Housing Investment Options in a City in a Developing Country - the Case of Kumasi City, Ghana, Africa.*Proceedings of Hokkaido Branch of Civil Engineer Association*. 45:433-438.
 3. Alex, M. 1975, Housing and Migration in Urban Dynamics. *Readings in Urban Dynamics*. 2:49-60.
 4. Forrester J. W. 1974a. System Analysis as a Tool for Urban Planning. *Readings in Urban Dynamics*.1:13-28.
 5. Forrester, J. W. 1974b. Control of Urban Growth *Readings in Urban Dynamics*. 1:257-272.
 6. Louis, E. A. 1975. Urban Dynamics Applied to an Old Industrial City. *Readings in Urban Dynamics*. 2:203-218.
 7. Michael, R. G. 1974a. Aggregation and Definition : The Underemployed, a Case Study. *Readings in Urban Dynamics*. 1:59-64.
 8. Michael, R. G. 1974b. Two Modifications to the Tax Sector of Urban Dynamics. *Readings in Urban Dynamics*. 1:169-174.
 9. Michael, W. L. 1974. Dynamic Migration Model. *Readings in Urban Dynamics*. 1:75-86
10. Miyata, Y. and Yamamura, E. 1990. The Model Reference Adaptive System in the Dynamic Input-Output Model. *Papers of Regional Science Association*. 68:57-70.
11. MMDA. 1978. *Study on Slums and Low Income Settlements*. Madras City.
12. MMDA. 1974. *Madras Urban Development Project*. Madras City.
13. MMDA. 1981. *Madras Metropolitan Area Demography*. Madras City.
14. Nathaniel, J. M. 1974. Business Structure and Economic Activity in Urban Dynamics. *Readings in Urban Dynamics*. 1:87-102.
15. Peter, M. S. 1975. Multiplicative Formulation in Urban Dynamics. *Readings in Urban Dynamics*. 2:115-132.
16. Sethuraman, S. V. 1976. Urban Informal Sector, Concept Management and Policy. *International Labour Review*.114(1):69-82.
17. Thirumurthy, A. M., Yamamura, E. and Kagaya, S. 1986. Environmental Hazards of Flooding- An over view of Sapporo and Madras Experience. *Environmental Science, Hokkaido*.9(2):177-193.
18. Thirumurthy, A. M., Yamamura, E. and Kagaya, S. 1987. System Dynamics Approach for Objective Assessment of Essential Environmental Facilities and Their Policy Needs- Sapporo Case

Study. *Environmental Science, Hokkaido University.* 10(1): 53-70.

19. Walter, W. S. III. 1975. Urban management Actions. *Readings in Urban Dynamics.* 2:31-48.

20. Wilbert, W. 1974. Metropolitan Population Growth, Land Area, and the Urban Dynamics Model. *Readings in Urban Dynamics.* 1:103-114.

21. Yamamura, E. 1983. A Study on Model Reference Adaptive Control in Economic Development (I). *Environmental Science, Hokkaido.* 6(2):281-300.

22. Yamamura, E. 1984. A Study on Model Reference Adaptive Control in Economic Development (II). *Environmental Science, Hokkaido.* 7(1):1-13.

23. Yamamura, E. and Iwasa, M. 1984. Quantitative Model Analysis of the Regional Population and Economic Changes Arising from the Industrial Development. *Environmental Science, Hokkaido.* 7(2):133-142.

24. Yamamura, E. 1985. Optimal and Reference Adaptive Processes for the Control of Regioanl Income Disparities. *Papers of the Regional Science Association.* 56:201-213.

25. Yamamura, E. 1986. A Study on Model Reference Adaptive Control in Economic Development (IV)- Discrete Polynomic Non-linear System. *Environmental Science, Hokkaido.* 9(2):151-161.

26. Yamamura, E. edited. 1988. *Human Settlement Environment in FELDA Schemes of Malaysia.* Hokkaido University, Department of Regional Planning.

27. Yamamura, E. 1989a. Model Reference Adaptive Theory on International Technology Transfer (I)- Transfer of Coal Mining Technology into Hokkaido: *Environmental Science, Hokkaido University.* 12(1):17-26.

28. Yamamura, E. 1989b. A Study on Transport Policy Models for Redistribution Location. *Selected Proceedings of the Fifth World Conference on Transport Research.* IV:17-30.

29. Yamamura, E. 1989c. Model Reference Adaptive Management Theory (I)- Focus on Meiji Era of Japanese Management- *Environmental Science, Hokkaido University.* 12(2):29-43.

30. Yamamura, E. and Miyata, Y. 1989. A Study on Model Reference Adaptive Processes of Japan's Regional Development in 1970's. *Proceedings of Japan Society of Civil Engineers.* 407(IV-1):117-128.