Integrated Systems Analysis for Cities

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Abstract: General strategic planning principles for the growth of cities and mega-cities have not yet been formulated. Further, land use planning and planning for services (mainly water) urgently require the development of appropriate decision support systems (DSSs). To date, general population distribution patterns have been researched for Australian and Polish cities, towns and rural areas by the application of integrated systems analysis (ISA). Population of rural areas in both countries has remained almost constant, in Australia for the last 80 years and in Poland for the last 55 years. It may, therefore, be concluded that the carrying capacity of land and water resources is limited and, as a result, distribution of population is self-regulated and self-organised. ISA and general models of population distribution patterns improve understanding of the complex relationships between inputs ⇒ transformations ⇒ outputs. The prerequisite application of ISA requires transformation of population data for each country under consideration for the development of such a model. General models of populations in cities towns and rural areas may indicate growth, a declining population or stable population. Two models have been developed for advanced countries but there is a need to develop such models for developing countries. The paper also presents a definition of ISA. Growth of cities may be simulated by the adoption of population distribution patterns and projecting of population growth at a national level. The application of ISA which includes long-term population growth, distribution patterns, scenarios and uncertainty should create a powerful "tool" for managing the appropriate development of regions and cities.

Keywords: Cities; Systems analysis; Modelling; Distribution patterns; DSS

1. INTRODUCTION

Long-term land use planning and water resources strategies for growing cities cannot be satisfactorily addressed without consideration of population growth and definition of the anticipated distribution of population within a country. Some countries have developed a single mega-city, while others have developed multiple mega-cities, and such situations should be taken into consideration when strategies are developed. Yu-ping and Heligman [et al. 1994, p. 22-24] observed that Thailand, the Republic of Korea, Bangladesh, the Philippines, Indonesia, Pakistan, Turkey and Iran each contain only one megalopolis, and that each megalopolis is generally between three and four times the size of the next largest agglomeration in the country. Further, approximately one-third of the urban populations of the Republic of Korea, Bangladesh, and the Philippines reside in Seoul, Dacca, and Manila, respectively. Jakarta, Karachi, Istanbul, and Teheran hold between 15 and 20 per cent of each nation's urban population. In addition, over one-half of Thailand's urban population resides in Bangkok. In Australia [ABS, 1996a, 1996c,1998] 63 per cent of total population has lived in capital cities. It is possible to assume that such development illustrates a pattern.

An integrated strategy for managing urban water resources was widely discussed during Second World Water Forum in 2000 [UNCHS and UNEP, 2000]. However, principles for future growth of cities were omitted from considerations. It is postulated that a definition of constraints, relationships or a development pattern may be considered as bases for modelling of future growth and the development of decision support systems. A general model of population distribution pattern may be considered in relation to inputs ⇒ transformations ⇒ outputs, and such model is presented in Figure 1.

Currently population of rural areas in Australia is presented as percent of total population of the country [ABS, 2000] and such approach is misleading. In addition, world wide growth of cities is defined as anannual growth rate without reference to national growth or the time when

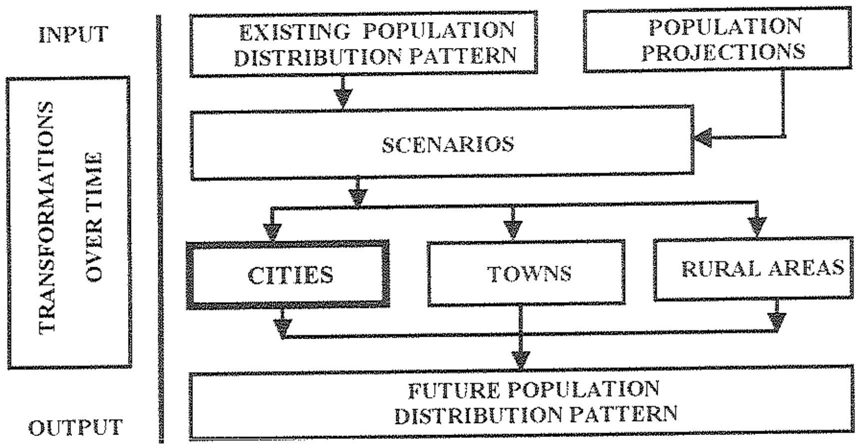


Figure 1. General model of population distribution pattern.

stable population of any country may be reached.

This growth is used for planning of water sources for cities for different time horizons adopted in the range of 15-50 years [ADB, 1994; UNPD, 2000] with a few exceptions where a longer horizon of 100 years has been adopted [Soroczynski 1999 and 2000]. However, these time horizons are not linked to population growth on a national level. The discrepancy between time horizons adopted as planning assumptions for cities and stabilisation of population must be noted. Demographers assume that the world population should be stabilised within the next 100 years [Lutz, 1996], however, for some countries this stabilisation will take much longer.

The author of this paper intends to explain trends of population distribution patterns which could be used for modelling of the future growth of cities. In addition, this paper puts emphasis on application of integrated systems analysis (ISA) and the consideration of population distribution patterns as aspects of self-organisation and self-regulation of systems within the boundary of a country.

2. INTEGRATED SYSTEMS ANALYSIS

2.1 Background

A *systems analysis approach* (SAA) [Miser and Quade, 1985 and 1988] has been defined as a tool for the resolution of complex problems. More recent examples of the systems analysis approach to larger and more complex problems are analyses conducted for the development of principles of Agenda 21, climatic change, and reduction of the impact of population on the environment [UNCED, 1993; IPCC, 1996; UN, 1995]. These reports have not referred specifically to SAA but the logic on which they are based may be attributed to the above way of thinking and analyses.

To date, in relation to the management of water systems a *systems analysis approach* has been applied to improving the development and performance of decision support systems. However, the relevant water systems have been analysed on the basis of catchments or regions, without data concerning population growth on national levels and distribution pattern of population within a country. It, therefore, appears that, to date, a systems analysis has not been applied to the integrated management of population, land and water resources in a broad long-term context. As a consequence, planning principles for sustainable management of water sources for cities have not yet been formulated.

Further, it must be noted that in a systems approach [Shaw et al, 1992] the concept of sub-systems was used and this issue needs to be elaborated. If the following examples are considered say; example 1- population, environment and climate; example 2- agriculture, environment and water quality, example 3- population, land and water resources and water quality; the question arises which systems need to be considered as sub-systems in relation to others? The above examples illustrate that all systems are component systems only and, as such, must be considered as integrated parts of a whole system. Therefore, in relation to the concept of sustainable development, the concept of sub-systems is a conceptual mistake. This approach needs further deliberation. Further, the explanation of a concept of *integrated systems analysis* is essential.

2.2 Definition of ISA

Soroczynski [1999 and 2000] researched the concept of integrated systems analysis (ISA) in relation to general population distribution patterns and land and water systems. Further consideration of sustainable development and sustainable systems requires that the previously adopted definition be revised again. The author now proposes the following definition:

Integrated systems analysis (ISA) can be defined as application of the scientific method for examination of complex problems impacted by interdisciplinary component systems. ISA, therefore, is a combination of theories and techniques for studying, describing and making predictions, on the basis of inputs ⇒ transformations ⇒ outputs of 'component systems' or 'components', which may be presented in the format of differing scenarios. Such analyses of component systems may need to be conducted individually, or may need to be integrated, and may also need to consider classification of systems, adopted time horizons, and uncertain conditions, where applicable. Further, these analyses may be conducted using advanced mathematical or statistical procedures. However, the essence of ISA is not found in a collection of quantitative techniques, but rather in a broad integrated output of scenarios needed for the development of appropriate decision support systems and strategies relevant to the maintenance of sustainable systems. To clarify this concept, the terms 'component system' and 'component' require elaboration and explanation. A 'component system' is almost synonymous with a sub-system. However, a 'component system' must also be understood to be an integral part of other related component systems. A 'component' is a factor which influences decision making eg; economic analysis.

Behaviour/performance of component systems or distribution patterns, need to be considered, where applicable in relation to sustainable systems. In addition, behaviour/performance or distribution patterns need to be considered over time. The time factor, past performance and future outputs of . changes are the forces which drive impacts on component systems. However, behaviour/ performance of component systems or distribution patterns need to be understood over time and they may indicate growth, a decline or stable conditions, see Figure 2.

Integrated systems analysis considers population growth on a national level, and scenarios for

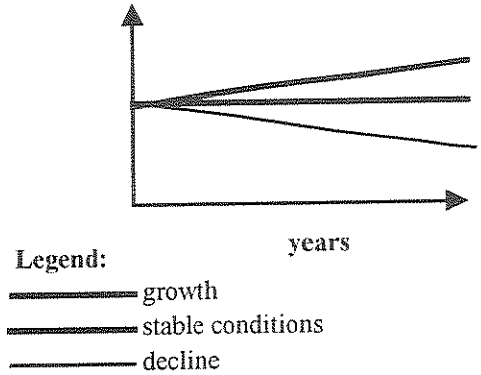


Figure 2. Possible behaviour/performance of component systems.

distribution of population within a country, under uncertain conditions. Scenarios may then be developed on the basis of current trends, appropriate selection of time horizons and the fact that people live in cities or mega-cities, towns and rural areas. The reality is more complicated than any general model and, as a general model cannot provide all answers, such models need to be periodically up-dated.

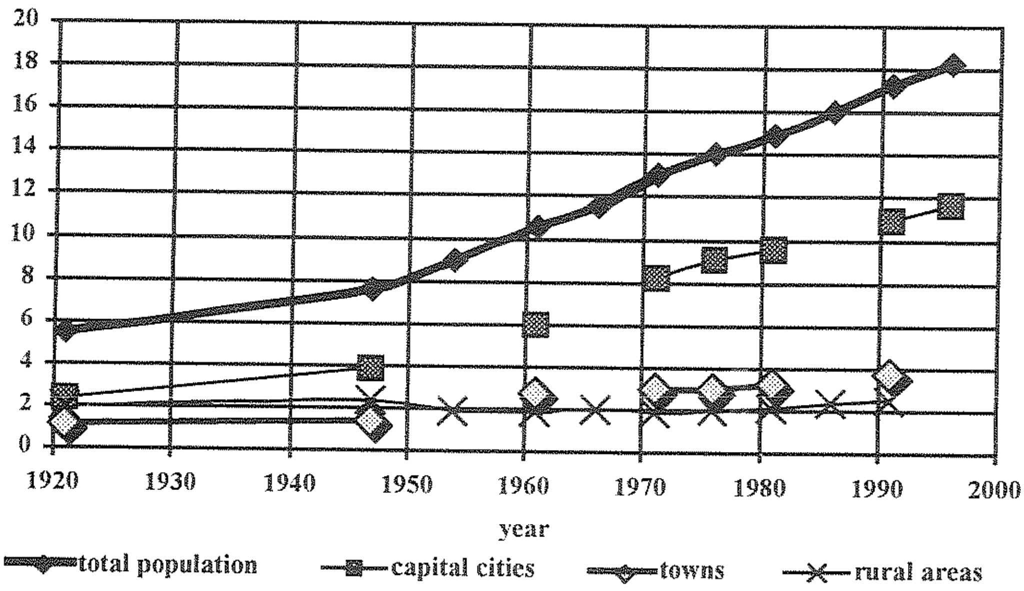
2.3 Time Horizons

Frederiksen et al. [1994] commented that a selected time horizon should reflect time at least equal to the useful life of the largest commitments. However, Frederiksen did not provide practical justification for the selection of a time horizon.

A definition of time horizons needs to be consistent with human perception of the future and also related to a demographic understanding of the futur. It must also be related to relevant disciplines in order to maintain sustainable systems. Soroczynski [1999] postulated that:

'Time horizons' may be understood to be mobile points or dates in time which need to be revised periodically and extended into the future. Such periodical revisions or extensions should be based on new databases for a population growth component system.

Demographers have been concerned with inaccuracy and uncertainty of world population projections. The world population has been projected subject to uncertainties related to the next period of 50-100 years. On the basis of Lutz's [1996] deliberations the following accuracies have been considered; i) projections for



Source: ABS [1996a, 1996c and 1998]

Figure 3. Population distribution pattern in Australia.

Table 1. Distribution of population in capital cities of Australia - population of Australia 30 and 50 million.

City	1996 population million	%	Population of Australia 30 million	Population of Australia 50 million
			Possible distribution million	Possible distribution million
Adelaide	1.079	9.27	1.75	2.92
Brisbane	1.521	13.06	2.47	4.11
Canberra	0.308	2.64	0.50	0.83
Darwin	0.820	0.71	0.13	0.22
Hobart	0.196	1.68	0.32	0.53
Melbourne	3.283	28.20	5.33	8.89
Perth	1.295	11.12	2.10	3.50
Sydney	3.879	33.32	6.30	10.5
TOTAL	**11.643**	**100.00**	**18.9**	**31.50**

Note: For the Darwin Region, uncertain development potential has been assessed and the region has been planned for a population of one million [NTG 1988].

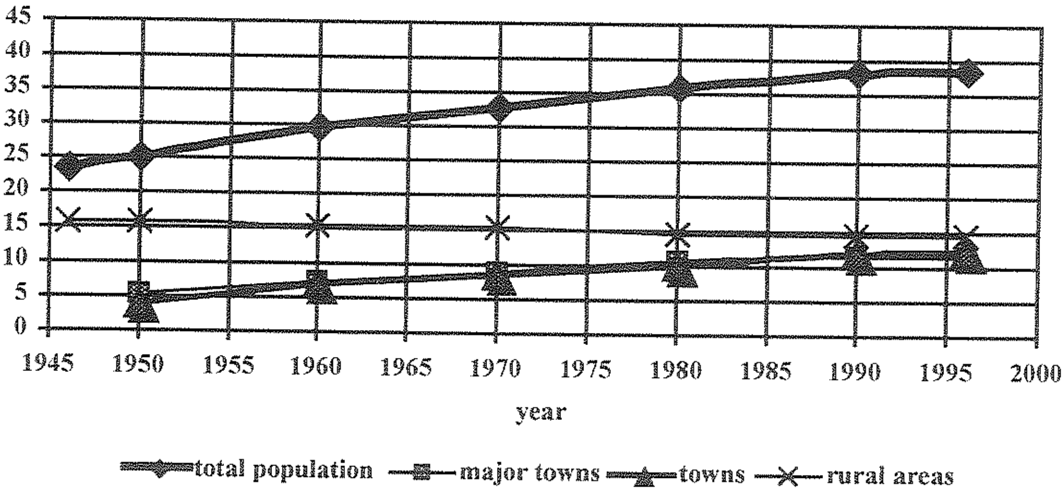
the current period up to next 50 years, ii) projections which include uncertainties for the next period of 50-100 years, and iii) speculation for the period beyond 100 years. Scientists who have analysed climatic changes have also adopted the time horizon of 100 years [IPCC, 1996].

It is postulated that for a country or a region the adopted time horizon/s should be related to long-term population projections. The adoption of a time horizon longer than 50 years [ABC, 1996b], say 100 years, could be an important step for the development of DSS and sustainable water systems.

Such approach should provide new challenges for demographers, regional planners, scientists, water provide new challenges for demographers, regional planners, scientists, water resources planners and politicians. Further, it is postulated that the following two stages should be adopted for the development of appropriate strategies:

- an implementation stage of up to 50 years;
- an uncertain growth stage for next 50-100 years or to time at which stable population will be reached.

The adoption of consistent time horizons for population growth and for management of land



Note: Major towns are towns with a population above 100,000.
Source: Glowny Urzad Statystyczny [1997 and 1998].

Figure 4. Population distribution pattern in Poland.

and water resources would be a considerable step forward in securing water for the cities and mega-cities of the world. The adoption of the above approach requires the development of population projections for 50-100 years, or until stable populations are reached in each country. This step will have to be followed by consideration of alternative scenarios for distribution of such populations.

3. POPULATION DISTRIBUTION PATTERNS

The following examples of population distribution patterns in Australia and Poland illustrate the need for the presented approach.

3.1 Australia

Australian population distribution pattern is presented in Figure 3. Most interesting is the fact that population of rural areas has remained almost constant at 2.6 million for the past 80 years.

The development of a basic scenario needs the adoption of assumptions such as:

- Australia may reach 30-50 million people within 100 years at an annual average population growth rate of approximately 0.5 per cent and 1.0 per cent respectively. Scenarios30-50 million were considered by the Australian Parliamentary inquiry [PCA,1994].
- The current distribution pattern of 63 per cent of population living in capital cities and rural population remaining almost constant at the level of 2.6 million may continue;
- Current distribution patterns of population between capital cities may continue.

Further, these scenarios are feasible subject to favourable performance of other impacting systems such as economic and political systems. In addition, Australia needs to be attractive to new migrants. Based on these assumptions, the distribution of 30 million Australians would be: capital cities 18.9 million, towns 8.5 million, rural areas 2.6 million and the distribution of 50 million would be: capital cities 31.5 million, towns 15.9 million, rural areas 2.6 million. Based on 1996 distribution pattern, population of capital cities is presented in Table 1.

3.2 Poland

Population distribution pattern in Poland is presented in Figure 4. In this pattern uniform distribution of population in major towns and towns must be noted. In addition population of rural areas has remained almost constant at approximately 15.0 million for the past 50 years.

Lack of more detailed population data precluded assessment of growth agglomerations such as Warsaw, Lodz, Silesia and Trojmiasto. Population of these agglomerations has been included in population of major towns.

4. CONCLUSIONS

Graphs of population distribution patterns clearly present growth of capital cities in Australia and uniform distribution pattern of major towns and towns in Poland. The concept of a population distribution pattern has been applied to more developed countries which experience relatively low rate of population growth at a national level. However, this concept needs to be further tested for developing countries which experience relatively greater rates of population growth at the national level. Further, distribution patterns of population may be considered to be a pattern of self-organising of systems, which may well continue and may be adopted as a model of future growth.

ISA and the consideration of population distribution patterns are prerequisite analyses which should be considered when planning for long-term population growth under uncertain conditions as defined by human perception of the future. The presented approach may be used as a powerful "tool" for simulation of growth of cities for countries with a single mega-city/city or several such cities and as a DSS. In addition, the approach may be used as an additional methodology to check strategies which have been developed on the basis of conventional approach. In addition, the adoption of a longer time horizons would improve land use planning in relation to securing water sources such as dams or borefields, where applicable.

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