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System Thinking and System Analysis in Urban Planning

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ABSTRACT

Cities are complex social-economic and ecological systems. An overall aim of this study is to re-evaluate alternative approaches to the analysis of urban systems and assess their relevance to contemporary planning problems in radically changing political and economic environments. The classical systems concepts are linked with contemporary approaches to urban modelling to better understand the complexity of urban growth. This is a logical prerequisite for evidence-based planning of sustainable development. The study shows that system analysis should be recognised primarily as a process of rational thinking supporting human judgment. A rational model of systemic planning derived from scientific method, combined with the computer and other techniques, is a very useful for planning profession. It can also be concluded that, from current methods of urban modelling, some methods are still in theoretical stage or applied for artificial city analysis and need very good data infrastructure. Each method has its own merits and shortcomings, in respective data requirements and application domains. The selection of methods should depend on the demand of the analysis, the feasibility of the techniques and the availability or limitation of data framework. Due to complexity of urban systems and dynamic interaction at varied spatial and temporal scales, current methods of modelling. Thus, it can be suggested that in general framework of system thinking and system analysis urban development modelling needs to focus mainly on spatial complexity understanding such as CA-based dynamic simulation, ANN-based pattern analysis and fractal-based morphology analysis. Chaos theory and MA model have not been widely applied for planning practice.

Introduction

Systems Thinking in Planning Literature

Urban planning is a complicated subject that lends itself to a systems approach. Systems thinking is hardly new. According to Bellinger, Descartes and Bacon developed an analytic framework for understanding, as well as the scientific method [1]. Newton, with the discovery of the laws of motion and gravity, provided us with a clockwork paradigm understanding the universe. His incomplete paradigm embodies essentially a linear cause-and-effect relationship, a short-term perspective for understanding how things really work. Some see the emergence of modern systems thinking in 1956 when J. W. Foster at MIT applied his knowledge from electromechanical research toward corporate management [2] Senge (1990), brought systems thinking to the fore by making it into a management pillar, "the Fifth Discipline" that complements "personal mastery," "mental models," "shared vision," and "team learning"[3]. When we go beyond the linear cause and effect paradigm to study behavior patterns and then to study systemic interrelationships among parts of systems, we develop a much deeper understanding about the way things operate. Planning, by definition, is a systems-based effort to integrate various facets of resource allocation in a community into a holistic blueprint for

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future activities. Yet, planning has been hobbled by the view that it is restrictive, not constructive or creative like infrastructure development [4] Even so, planning activities grew markedly across the United States during the 1920s. The Great Depression helped emphasize the importance of planning [5].

Systems thinking in general, has had a key influence on planning. Friedmann in a table listing key influences on American planning, has a column labeled 'systems analysis' arising in the late 1950s from the 'systems engineering' intellectual tradition. In the same table, however, he links 'engineering sciences' to various authors across the whole scope of planning beginning with Saint Simon and August Comte in the early 1800s. There is a pervasive, 'systems thinking' influence throughout the history of planning that is based on the engineering control paradigm [6]. More recently, addition of systems analysis to the rational model, has created the sense of a more exact, scientific approach [7]. This particular approach has been integral to planning, especially within institutional frameworks, though to a substantially lesser degree in radical forms of planning. When considering this influence of systems thinking on planning, however, it is critical to recognize fundamental differences between the 'engineering' paradigm and newer approaches based on complex systems concepts. Application of 'new' systems thinking (e.g., self-organization, complexity) to planning seems to be quite limited as yet in the formal literature only a few papers have appeared in key planning journals. who speaks primarily of prescriptive procedural planning, uses some ideas from chaos theory [8]. Some work has arisen from simulation, such as Allen's (e.g., 1982,1994) work on urban systems [9]. Introduces some of the concepts from the non-linear paradigm on a theoretical level [10].

There have also been a number of systems thinkers concerned with planning issues, Simon (e.g., 1996) is a key example, although his work is based more on the engineering tradition [11]. Others publishing in systems journals include Beer (1991) and other cyberneticists [12]. Within the area of natural resource planning and management, a few authors use complex systems thinking to suggest approaches for coping with complex systems [13]. Despite this lack of application of new systems thinking, the trend toward alternative planning approaches suggests a growing recognition of planning's sympoietic nature, regarding both the subjects, and processes, involved. Many of the newer approaches are employing sympoietic characteristics. The flexible, adaptable, communicative, transactive, collaborative characteristics espoused by a host of planners reflect the characteristics of sympoietic systems [14].

Complexity and Dynamic Nature of Urban Systems

A system is defined as any set of interdependent or temporary interacting parts. Parts are generally systems themselves and are composed of other parts, just as systems are generally parts of other (higher order) systems). Cybernetical defines a system approach as a way of integrating the analytic and the synthetic method, encompassing both holism and reductionism. The city is a system capable of counter intuitive responses which can be properly understood and controlled only if the interaction between the basic urban sub-systems are fully taken into account. In other words, the main question is not to better understand the individual sub-systems (population, transportation, recreation), but also to appreciate how they act together, and how they are harmonized into this entity so called city or town [15]. The issue of harmonization implies that a system includes more than just interacting component parts assembled together, but also some agencies that facilitate the efficient and effective linking of what may be inherently conflictual sub-systems. Some of those harmonisation agencies presumably include:

I. Markets (for goods, services, ideas). These are essentially independent, albeit within rules set by governments to facilitate free exchange. The well-known Nobel prize-winning economist, Friedrich von Hayek, called this Catallaxy. In effect, it is self organisation, self harmonisation.

II. Governments. The usual have the to legislate powers for themselves or their client agencies to perform harmonisation tasks, with or without consultation with affected parties.

III. Civil society. A raft of social, cultural, economic (business), and/or environmental organisations that frequently work together but sometimes against each other. Some can be explicitly planning related, such as progress associations; neighbourhood defence committees; store-front planners in low-income neighbourhoods; the Planning Institute of Australia, the Urban development Institute of Australia, or the Property Council of Australia; AHURI; the NSW NRMA; and so on.

Any urban region is a very complex social, economic and ecological system whose main characteristics are:

a) In urban system, problems involve the relationship of a great number of variables associated with a plurality of goals that simultaneously are operative.

b) Social, political and economic phenomena, constantly subjected to interaction.

c) Many of variables and sub-system are controlled by feedback relationships.

Moreover, each of these systems is made up of component variables including infrastructure (the skeleton of the city), industries, social and recreational facilities and so on. These can be structured as:

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a. Reticulist infrastructure (mainly linear networks serving hydraulic transport, energy, or communications functions)

b. Buildings

c. Open (recreation and ceremonial) space

d. Industries, social facilities, and administration (public or private) occupying b and c

e. Sets of past or future interests (with items a to d representing present arrangements); past interests include heritage items of public value, but cities also include much of private sentimental value; future interests include future constraints likely to arise from increasing scarcity or resources, people who would like to occupy developments proposed by developers, or lifestyle options awaiting liberation by new (but as yet unknown) technologies

f. Harmonisation agencies (as discussed above) and a raft of unreconciled individual, group or organisational conflicts that may have no resolution! The balance between harmonising forces shifts over time. The 1970s (around the time that systems ideas were formally introduced to planning) marked the apogee of government control of and intervention in western societies under a form of creeping socialism. That had been going on for the best part of the twentieth century. Within 20 years, several countries swept away a substantial portion of that control or modified its form, especially in Anglophone countries like Australia, New Zealand and Britain. All relied increasingly on market forces as the dominant organising principle, although interestingly, urban planning remained as largely a government activity. Public participation in urban development remained but shifted its focus from heartfelt to grudging!

g. A dynamic component. Systems are dynamic and always work in progress, often reflecting slow adjustments to past changes. In practice, this means that problems detected may well be the subject of on-going remedial change and that new, but currently unknown, problems will shortly emerge.

h. Different power and importance relationships between system elements: components are unequal. Effective system management probably requires a focus on major variables, subject to #i below

i. Item #h is complicated by the existence of feedback loops, where process outcomes modify original causal variables. Feedback magnitude is akin to a system multiplier, and on rare occasions change induced by an apparently minor variable could be substantial if the speed of reaction is fast in both directions or mediated via an active third party

j. The speed of system change is monotonically accelerating in response to rising knowledge (and information), wealth, creativity, globalisation, new technologies (including the internet), and increasing market sophistication that accelerates the velocity of the circulation of capital (and Schumpeter's "gale of creative destruction")

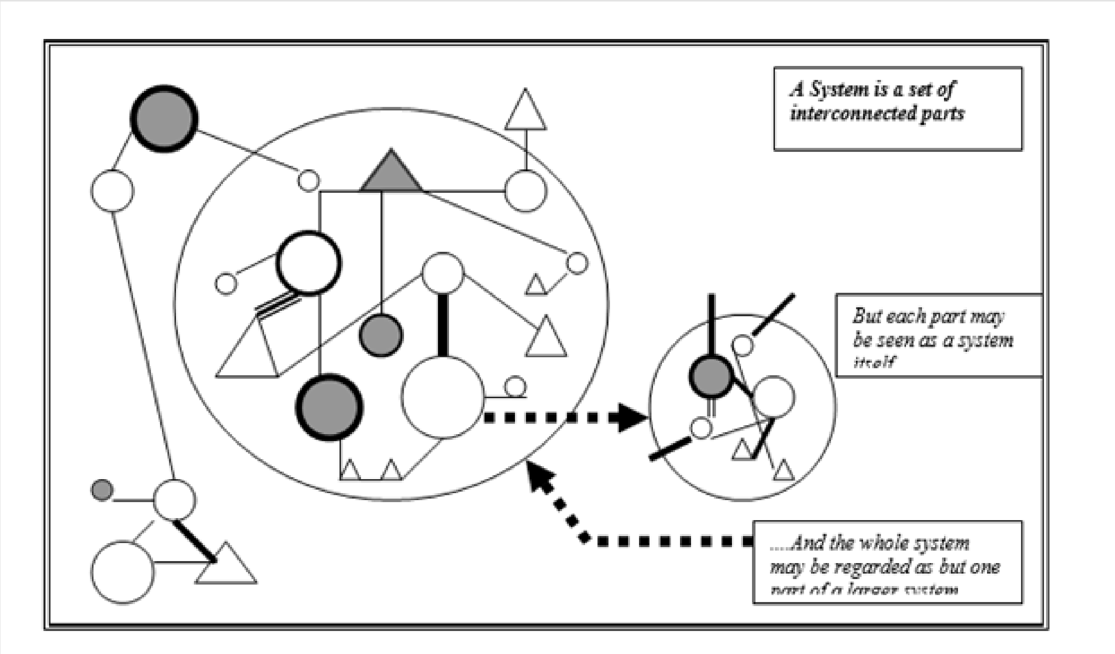
The dimensions of system complexity, therefore, needs to be emphasized. We remarked earlier on sub-systems within cities and even systems of cities. Even this is becoming more complicated as we add international dimensions e.g Sydney's dual economic face, but this is a local variant of a global phenomenon. Shanghai performs that role in China; London in Europe; New York in North America; or Tokyo in Japan; Mumbai in India. Paris, Milan, and Los Angeles do the same for fashion or Silicon Valley for computer technology. The world is full of functional hubs leading the way to the future, and the critical point is that their roles emerge (or collapse) through competitive processes that tend to incorporate or ignore local circumstance according solely to its productive usefulness. Sentiments in this field change fast, and with-it planning issues. Some systems are more amenable to analysis than others. It seems plausible that simple systems, defined as follows are inherently easier to analyse than those that are not and correspondingly more policy friendly. Simple systems have:

- Few easily measured variables,
- Limited interconnection between them,
- Small internal range,
- Slow pace or change (or little dynamism)
- Few points of social, economic or environmental disagreement (they are uncontentious),
- Clear responsibility allocated to government, the market, or civil society

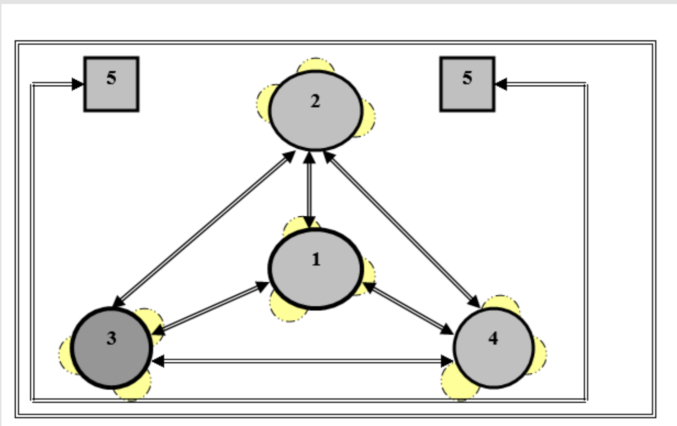
The interaction between sub-systems gives rise to the dynamic behavior of urban system. The dynamic nature of urban systems also derives from the fact that the feedback relationships operate continuously and over time. A basic requirement of a realistic simulation, therefore, must be ability to incorporate time as a variable in the structure of a model, in order to be able to trace the performance or behavior of the system through time. Moreover, as various actors with different patterns of behavior are involved in the process of urban development, scientific understanding needs to be based on elaborated complexity theory and multidisciplinary framework (Figures 1 & 2).

Complex System Theory and Complex System Thinking

A body of theory emerged over the last two and half decades that explicitly addresses the complex, uncertain and inherently pluralistic nature of human socio-economic and biophysical systems. The new science or complexity theory refers to a group of interrelated theories (catastrophe theory, chaos theory, information theory, hierarchy theory and self organisation theory) that have been derived in several scientific disciplines including planning. It is argued by complex system theories that complex systems exist at a threshold between order and chaos, too complex to treat as machines and too organised to be assumed random and averaged. Newtonian and Stochastic conceptual tools, for the sake of mathematical tractability, seek to eliminate the very complexity and uncertainty (by assuming mechanistic liner causality) as well as macro-level order (by assuming chaotic or random distribution) that characterise complex system. The interrelated theories of complexity: Catastrophe theory, chaos theory, hierarchy theory, and theories of self-organisation, do not attempt to reduce the complexity or uncertainty inherent in complex phenomena by either assuming linear causality or attempting to aggregate, assuming a completely chaotic system. Complex system thinking as a mode of reasoning and set of heuristics, have been gleaned from complex system theory and include not only properties and heuristics listed and discussed below, but has also embody a constructive, process-oriented philosophy, methodological pluralism and on an operational level, a set of principles for the practice of intervention that reflects a process-oriented relationship between knowledge and intervention.



Note: Source: Mcloughlin 1973.
Figure 1: An Alternative Representation of a System and Sub-systems.



Note: Source: Steiss 1974.
Figure 2: Two Dimension representation of 5 Systems.

- Social Value Systems: i.e. religion, ethnic groups, lifestyle, etc.
- Economic Activity Systems: i.e. sectors of economy e.g., industry, services, public/private sectors, employment/ unemployment, production, market failure etc.
- Physical Activity Systems: land uses, green spaces, farmlands etc.
- Abstract Civil Society System: i.e., style of government, institutions, political parties, etc.
- The Ecosystem: i.e., water resources, forests, dissertation, greenhouse effect, global warming, etc.

Properties of Complex System

Several key properties of complex systems are outlined below. From these properties several key heuristics can be gleaned:

a. Non-Linear: Behave as a whole, a system. Cannot be understood by simply decomposing into pieces which are added or multiplied together.

b. Hierarchical: Are holarchically nested. The control exercised by a holon of specific level always involves a balance of internal or self-control and external, shared, reciprocating controls involving other holons in mutual causal way that transcends the old selfish-altruistic polarising designations. Such nesting cannot be understood by focusing on one hierarchical level (holon) alone. Understanding comes from multiple perspectives of different types and scales.

c. Internal Causality: Goals, positive and negative feedback, autocatalysis, emergent properties and surprise.

d. Window of Vitality: self organisation

e. Multiple Steady Stats: Multiple attractors can be possible in a given situation and the current system state may be as much a function of historical accidents as anything else.

f. Catastrophic Behavior: Sudden discontinuity and moments of unpredictable behaviour.

g. Chaotic Behavior: Difficult to predict due to sophistication [16]. These properties or heuristic devices can be used to describe, and arguably prescribe intervention in many types of complex systems.

Critical System Thinking

Emerging from what [17] calls the emancipatory and postmodern system approaches and what [18] calls "third Wave" of system thinking comes the branch of system research known as critical system thinking. According to [19] review of the current literature, critical system thinking has three main tenets or commitments: critical a awareness, emancipation or improvement and pluralism. Critical awareness involves two major themes, theoretical critique and social awareness. Theoretical awareness underpins strengths and weaknesses of available system models, tool and techniques from which critical systems thinking has drawn heavily from social theory. Emancipation defined in terms of bringing about those circumstances in which all individuals could realise their potential He also interprets the notion of pluralism in the broadest sense as the use of different methodologies, methods, models and techniques in combination.

Overview of System Approaches

The implication of complexity thinking has been explored in some depth in various fields including sociology, the study of human organisations, urban planning, ecological economics, bilogy and ecology etc. Recent works) provide loose categorisations of the system and critical system thinking literature as applid to different fields of study, from operations research and management science to ecosystem approaches to ecological integrity. Jackson, (2000) breaks down the vast and varied range of approaches into four categories based on their philosophical underpinning, including [19].

a) Functionalist System Approach

b) Interpretive System Approach

c) Emancipatory System Approach

d) Post Modern System Approach

Functionalist Systems Approaches

Jackson (2000) describes the functionalist system perspective as one in which system appear as objective aspect of reality independent of us as observers. Using the methods of the natural science can be gained in this way, the knowledge can be used by experts to improve the technical efficiency of the system and/or its long-term ability to adopt and survive. As example of functionalist systems approaches includes hard systems approaches, cybernetics, even complexity theory and autopoietic theory. These approaches share a few key characteristics that can be seen as both strengths and weaknesses. They are generally: objectivist, studying systems from the outside; they generally prefer quantitative techniques and treat most structures and phenomena as being understood scientifically; and regulative in that they seek understanding of the origins of order in systems, how it can be maintained with the goal of better prediction and control.

Interpretive Systems Approaches

In the contrast to functionalist approach, an interpretive system approach concerns basically with perceptions, values, beliefs and interests. It accepts that multiple perceptions of reality exist, and sometimes come into conflict. Interpretive theories adopt a subjectivist approach to systems thinking and practice. They do no seek to study objective facts or to search for regularities and causal relations in reality. Interpretive system thinkers are known as soft systems thinkers [20].

Emancipatory Systems Approaches

All emancipatory systems approaches are suspicious of the current social order and seek to radically reform it. They see society, as presently constituted, as benefiting some groups at the expense of others which are suffering domination or discrimination. The divides in society which lead to inequality may be along class, race, gender, age capability or other lines. Whichever of these areas chosen as the main foci of attention, the aim is to emancipate those who are suffering as a result of current social arrangements. The main objective of emancipatory systems thinkers is to use the tools of systems thinking to emancipate anyone suffering as a result of the current social order.

Post Modern Systems Approaches

Postmodern systems approach includes those that are aimed at the totalising and normalising tendencies of the discourses that dominate in modernism. All grand narrative whether referring to maximising the efficiency and effectiveness of systems or to the possibility of universal emancipation, are subject to debunking. In contrast to the emacipatory systems approaches, postmodern system approaches are critical, playful and in pursuit of self-emancipation. Looks at two distinct ways in which post modernism and systems thinking can collaborate. The first in in using various models, methods and techniques but in the spirit of post-modernism. The second is some new method and tools which post modernism can provide and can assist the system practitioner [19].

Systems Approaches to Urban Problems

The spectrum of methodology available for the analysis and planning of urban systems points up both the potentials and limitations of systems-oriented approach. The inherent nature of urban systems do the same and two aspects should not be separated. However, available methodologies come out of both

(a) System structure and organization and

(b) The autonomous development of analytical methods. Having said that, intuition, judgment, and experience continue to play a critical role in major development decision in the urban environment.

Although, intuition, judgment and experience are necessary ingredients because of uncertainties in urban systems, if all dimensions of urban systems could accurately specified, there could be much less need for judgment because, linear programming or other techniques could be applied to optimize some objective function. Indeed, this is the whole purpose of systems specification and development of large data basis with their battery of analytical techniques. The analysis must, therefore, recognize the extent to which these factors can be taken into account in the techniques of various system approaches. When models of urban system are formulated, critical differences in modeling and system techniques also needs to be recognized. If the various systems approaches are viewed in relation to real-world situations, a continuum based on abstraction can be identified. As it is illustrated in (Table 1), there are different system approaches from analytical models to more comprehensive models which attempt to deal with complex, real world situations. At the present, much of the sophistication of analytical techniques is found at the right-hand side of the continuum, including the development of Critical Path Method, PERT, and the methodologies of operations research. The major thrust of basic system analysis models, such as cost-benefit or cost utility analysis and economic decision-making techniques, is toward sub-optimization within a fairly well-defined range of quantification. Proceeding toward the left-hand side of the continuum, the use of qualitative information in such techniques as social analysis, structural-functionalism, and operational exercises of simulation and gaming, serves to limit our present capabilities of measurement. Increasing the abstraction involved in modelling results increase in the applicability of quantifiable data, the predictability of consequences, and the speed of analysis, while increasing the realism of the model increase the complexity, decreases the certainty, and increases the risks and costs involved. For the propose of these study operations research, systems thinking and system analysis are discussed in the following sections [21].

Table 1: Systems Approaches Viewed in Relation to Real-World Situations.

Grand Optimum		Optimization		Sub-Optimization		
Complex Real-World Problem		Continuum Of Abstraction		Analytic Models		
System models	Conceptual models	Operational exercises	Optimization techniques	Systems analysis	Operations research	Network analysis

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General systems theory Cybernetics Information theory	Factorial ecology Social area analysis Structural-functional analysis Activity system models Spatial models	Gaming Simulation	Game theory Decision theory	Cost-utility analysis Cost-effectiveness analysis Cost-benefit analysis Factor analysis	Nonlinear and dynamic programming Allocation models Queuing theory Linear programming	Graph theory Account scheduling CPM and PERT Use of heuristics

Note: (Steiss, 1974).

Operational Research as a System Approach

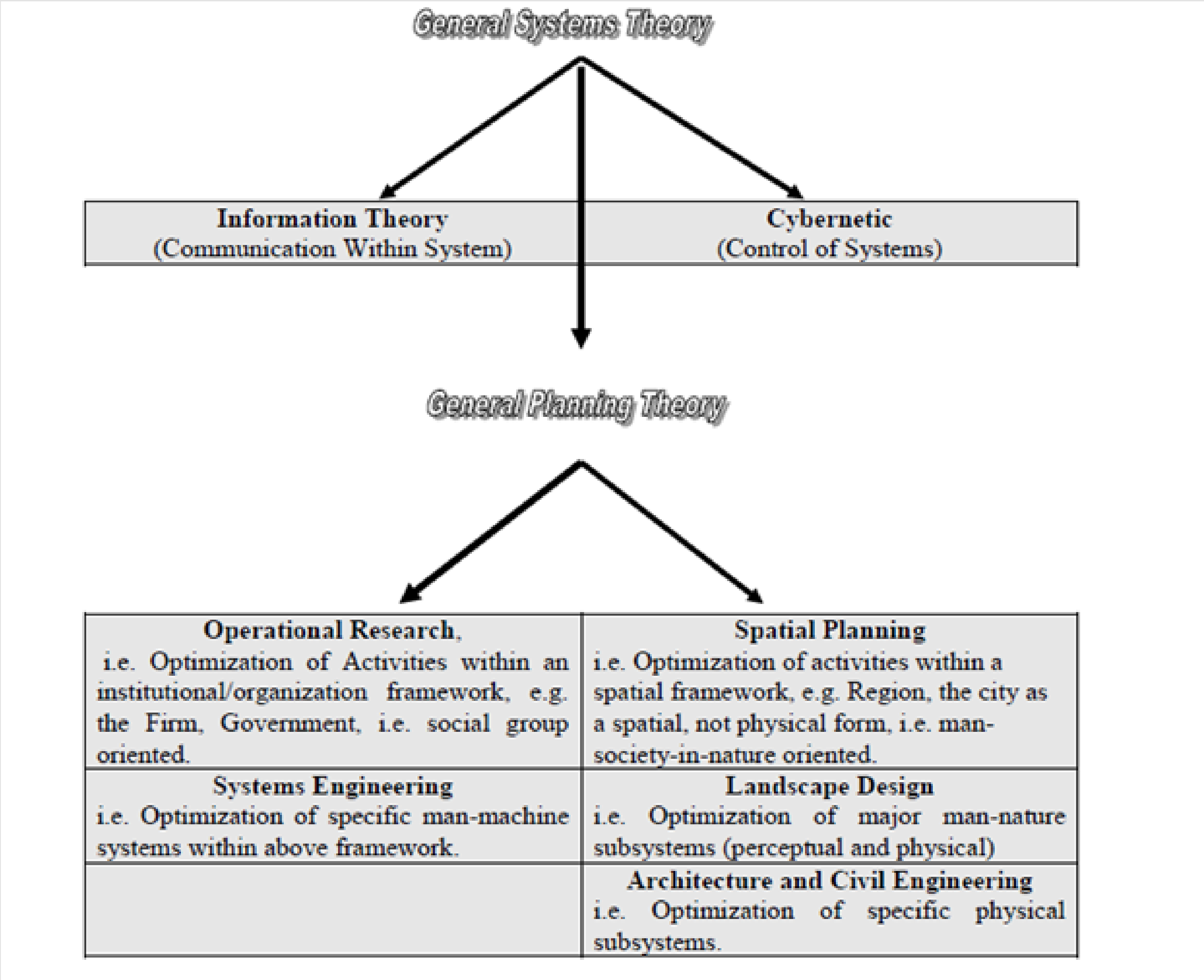

Figure 3: A Conceptual Systems Basis for Urban and Regional Planning.

Operational research is concerned with, optimizing the performance of a system. It involves the application of scientific methods, techniques, and tools to problems involving the operation of a system so as to provide those in the control of the system with optimum solutions to the problems. It appears most accurate to designate operations research as functional analysis, in which a pragmatic process is applied in the search of solution. Argues that developments in soft OR have much in common with current developments in system dynamics modelling practice, and therefore a dialog between them would be mutually rewarding.

The different phases of operations research are shown in (Figure 3) [22]. In the complex environment of modern-day society, the survival of any manmade system (i.e., organization) is dependent open certain screening devices, designed to alter the system to the presence of a problem or set of problems. Three data files lie at the foundation of an effective screening process:

1. An environmental intelligence system, to keep the organization appraised of conditions apparent in the broader environment within which it operates

2. An auto intelligence system, focusing on the internal working of the organization, its performance output, efficiency and effectiveness and so forth

3. A historic data file, i.e., the memory bank of the system, identifying the approach of problem to some threshold of tolerance, and thus altering the organization to take action before the problem reaches a more critical stage. The phase of operations research process has three major decision areas applicable to the analysis of urban system.

a. Identification of the problems of the clients (consumers of urban services) and others involved in various urban systems and the system taken as a whole.

b. Identification of the system under control of the participants plus their respective objectives and alternative courses of action; and

c. A choice of pertinent to be considered, including the specification of guidelines of effectiveness.

1. Initial problem identification.

2. Identification of principal participants in decision making process.

3. Determination of constraints of the problem.

4. Determination of goals to be achieved.

5. Determination of decision maker's objectives.

6. Analysis of the processes or operations involved.

7. Identification of other participants, including

8. Competition or adversaries.

9. Determination of objectives of the other participants.

10. Determination of alternatives courses of action available to other participants.

11. Determination of alternative courses of action available to client or decision-makers.

12. Definition of efficiency relative to each objective or goal.

13. Selection of common measure of efficiency (standard).

14. Definition of most effective best or optimum solution.

15. Construction of the model.

16. Testing the selected model to find values that maximize the system's effectiveness.

17. Testing models as to its ability to predict change.

18. Development of controls for modifying solution under conditions of change.

19. Solution implementation and performance evaluation [23].

The primary constrains for the application of operations research to the urban system are confronted at once in this first phase. The major constraint is the multitude, in number and verity, of consumers whose actions in the urban system constitute the full range of modern life. The only possible response to this enigma is to narrow down the range of variables considered, and in fact, this is what is done in the field by operations research. There are three possible ways of narrowing the range of urban problems including:

1. By focusing on a small enough subsystem within the urban system so that the participants of the subsystem can be identified.

2. By deliberately and arbitrarily limiting the study to a particular set of participants whose action can be rationally defined; or

3. By generalizing through the use of statistics.

Table 2: Characteristic of Dominany and Alternative OR and.

Characteristics of the Dominant OR	Characteristics of an Alternative OR
1. Problem formulation in terms of single objective and optimization. Multiple objectives, if recognized, are subject to trade-off on a common scale.	1. None-optimizing; seeks alternative solutions that are acceptable on separate dimensions without trade-off.
2. Overwhelming data demands with consequent problems of distribution, data availability, and data credibility.	2. Reduce data demands, achieved by greater integration of hard and soft data with social judgments.
3. Scientization and de-politicization; assumed consensus	3. Simplicity and transparency, aimed at clarifying the terms of conflict.
4. People treated as passive objects.	4.Conceptualise people as active subjects

5. Assumes a single decision maker with abstract objective from which concrete action can be deduced for implementation through a hierarchical chain of command.	5. Facilitates planning from the bottom up.
6. Attempts to abolish future uncertainty and pre-take future decision.	6. Accepts uncertainty and aims to keep options open for later resolution.

According to in search to overcome to above mentioned constraints, suggested alternative operations research which is both realistic and flexible. Some major characteristics of the OR paradigm and an alternative OR paradigm are presenter below: (Table 2)

10 System Thinking and System Analysis

System thinking is an approach to analysis that is based on the belief that the component part of a system will act differently when isolated from its environment or other parts of the system and argues against Descartes's reductionist view. System thinking is about gaining insights into the whole by understanding the linkage and interactions between the elements that comprise the whole system, consistent with system philosophy. System thinking recognize that all human activity systems are open systems; therefore, they are affected by the environment in which they are exist System Thinking recognize that in complex systems, events are separated by distance and time; therefore, small catalytic events can cause large changes in the system. System Thinking acknowledges that a change in one area of a system can adversely affect another area of the system; thus, it promotes organizational communication at all levels in order to avoid the silo effect. System thinkers consider that:

1. A system is a dynamic and complex whole, interacting as a structural unit
2. Information flows between different elements that compose the system
3. A system is community situated within an environment
4. Information flows from and to the surrounding environment via semi-permeable members or boundaries
5. Systems are often composed of entities seeking equilibrium, but can exhibit oscillating, chaotic, or exponential growth/decay behavior

Traditional decision making tends to involve linear cause effect relationships. By taking system approach, we can see the whole complex of bidirectional interrelationships. Instate of analysis a problem in terms of input and an output we look at the whole of inputs, processes, outputs, feedback and controls. System thinking also helps us integrate the temporal dimension of any decision. Instead of looking at discrete snapshots at points in time, a system methodology will allow us to see change as a continuous process.

System Thinking Uses a Variety of Techniques that may be Divided Into

1. Hard systems- involving simulations, often using computers and the techniques of operations research. Useful for problems that can justifiably be quantified. However, it cannot easily take into account unquantifiable variables (options, culture, politic, etc), and may treat people as being passive, rather than having complex motivations.

2. Soft systems- Used to tackle system that cannot easily be quantified, especially those involving people holding multiple and conflicting frames of references. Useful for understanding motivations, viewpoints, and interactions and addressing qualitative as well as quantitative dimensions of problem situations.

3. Evolutionary system- involves the integration of critical systems inquiry and soft system methodologies to create a meta-methodology applicable to the design of a complex social system. These systems, similar to dynamic systems are understood as open, complex, but further accounts for their potential capacity to evolve over time.

Hard systems thinking was privileged during 1950s and 1960s, while later on especially during 1980s and 1990s soft systems think was dominant. Lane (1994) summarized the characteristics of hard and soft systems thinking as below: (Table 3)

Table 3: System Thinking of the 1950 and 1980s.

Hard systems thinking of the 1950s and 1960s	Soft systems thinking of the 1980s and 1990s
1. Oriented to goal seeking.	1. Oriented to learning.
2. Assumes the world contains systems that can be engineered.	2. Assumes that the world is problematic but can be explored using system methods.

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3. Assumes system models are models of the world (ontology-based).	3. Assumes system models are intellectual constructs (epistemology-based)
4. Speaks of problems and solutions.	4. Speaks of issues and accommodations.
Advantages: Allows the use of powerful techniques.	Advantages: Available to both problem owners and professional practitioners. Keeps in touch with the human content of problem situations.
Disadvantages: May need professional practitioners. May lose touch with aspects beyond the logic of the problem situation.	Disadvantages: Dose not produce final answers. Accept that inquiry is never-ending.

Basic Characteristics of System Analysis

While system analysis basically is a derivative of the fields of operations analysis and system engineering, its application has become sufficiently universal to include a wide range of applications. In fact, it has become a "catch-all" perhaps for applied science in many quarters. A preliminary definition of systems analysis will reveal that it is a general term applicable to any explicit, theoretical, deductive and empirical approaches to problem analysis. In most common uses of systems analysis, inductive and empirical approaches are used as inputs, and both are very important. System analysis also requires both quantitative and qualitative aspects of analysis and operational definitions. There are five stages in the process of systems analysis as follows: (Table 4)

Table 4.

1-Formulation (The Conceptual Phase(	Clarifying objectives. Defining issues of concern, e.g. equity, efficiency etc. limiting the problem.
2-Search (The Research Phase)	Looking for data and relationships as well as alternative programs of action that have chance of solving the problem.
3-Evaluation (The Analytic Phase)	Building various models of predict the consequences likely to follow from each alternative, then comparing alternatives in terms of those consequences.
4-Interpretation (The Judgmental Phase)	Using prediction obtained from the models and whatever other information or insight is relevant to compare alternatives further, derive conclusions about them, and indicate a course of action.
5- Verification (The scientific Phase)	Testing conclusions by experiment (Experimentation by doing or social engineering e.g. experience of new towns in the planning field), disjoint incrementallism.

The basic elements of systems analysis also are important. They include the following:

1. Objective or objectives: the goals policy, or course of action for achievement.
2. Alternatives: The competitive means (or systems) by which the objectives are to be obtained.
3. Costs and benefits analysis: the expenditures (or resources) required to each particular alternative and expected benefits. Most costs and benefits can be measured in money, but their true measure is in terms of opportunities that they preclude.
4. Models: representation of reality which abstract features of the situation relevant to questions being studied
5. Criteria: (related to effectiveness scale): roles or standards for ranking alternatives in order of desirability or priority and indicate the most promising.

System analysis is a process explicitly treating the question of uncertainty in a complex environment arising from an extended time horizon of five, ten or more years (subject to scenario analysis). Systems analysis and integration model also provides a classification of system elements which can be divided into three broad categories:

1. Determinants: elements outside the operating system itself which determine the nature, form, and limits of the system.
2. Components: the moving parts of the system, including the mechanisms, men and facilities in the system.
3. System Integrators: elements that integrate the moving

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parts, these include operational sequences, communications, organization and the decision structure.

The essential elements of system analysis are little more than a statement of rather obvious, explicit, commonsense approach to problem solving. The explicit nature of system analysis can be helpful in exposing deficiencies that might otherwise have been overlooked or obscured. Applying systems analysis as a tool in the study of urban systems, suggests that six steps need to be taken:

1. Observe the behavior modes of a system to identify the symptoms of trouble.

2. Search for the feedback structure that might produce the observed behavior.

3. Identify the level and rate variables making up that structure and explicitly describe them in the equations of computer simulation model.

4. Using the computer model, simulate the dynamic behavior implicit in the identified structure.

5. Modify the structure unit components that resulting behavior agree with the observed condition in the actual system.

6. Introduce the modified policies into the simulation model and fined useable and acceptable policies that give improved behaviour [24].

System Analysis and Modeling in Urban Planning

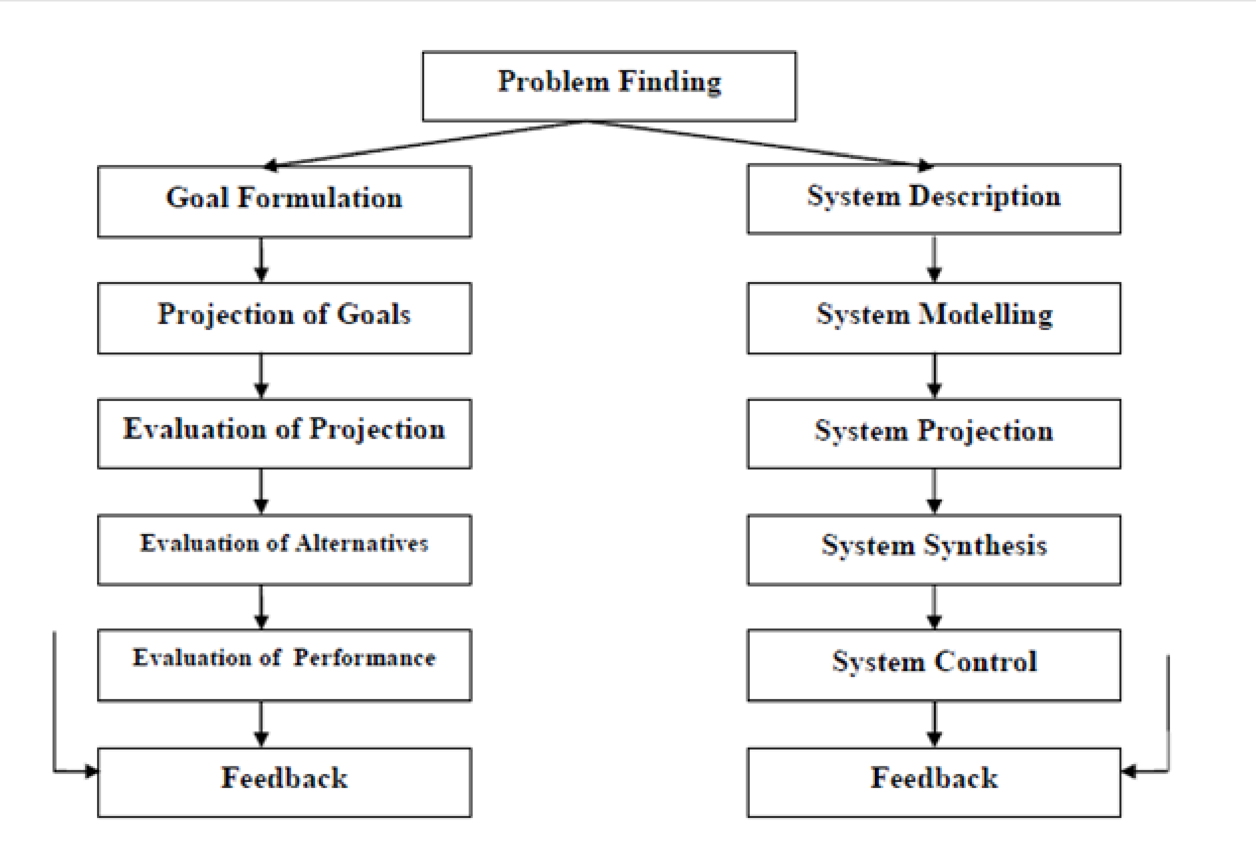
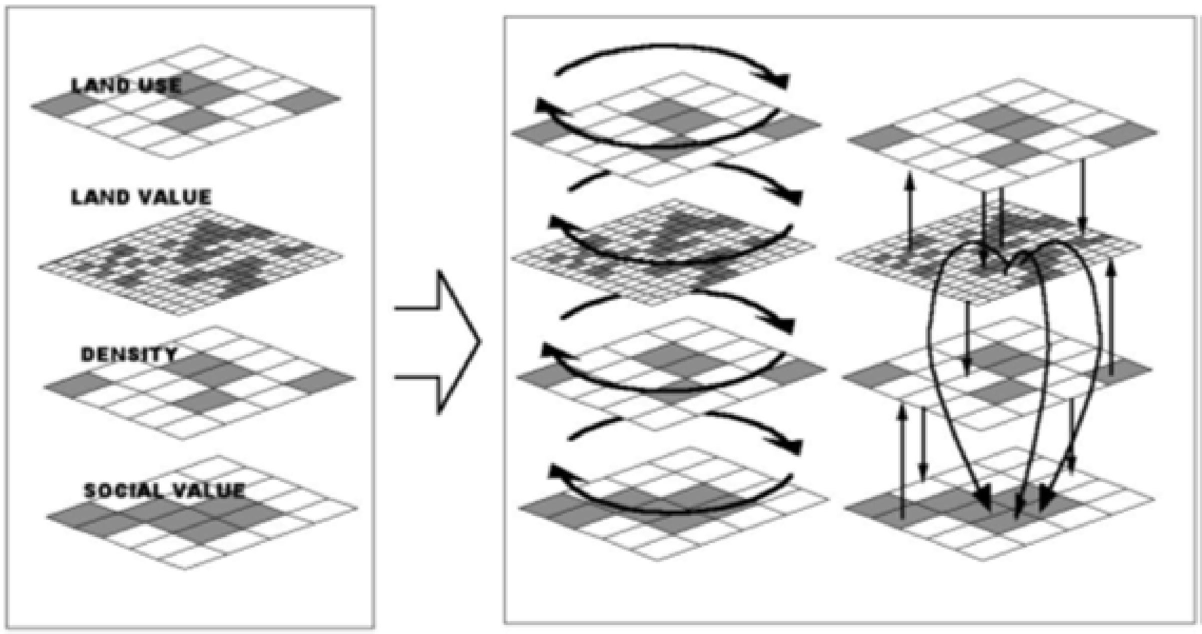


Figure 4: A Rational Model of Systemic Planning, Derived from Scientific Method (Chadwick 1978).

Planning is future-oriented and concerns with the prediction of future trends, and formulation of appropriate policies for resources allocation. However, prediction, without scientific understanding of the system under study lads to a certain degree of uncertainty due to the numerous unknown factors involved. Argues that in order to improve the quality of planning and set more appropriate priorities and policies, we have to improve our understanding and analysis of the interrelated components of the urban development process. This means that, in general process of planning or with dealing with particular issue, a specific real-world system or subsystem must be represented be a specific conceptual system or subsystem within the general conceptual system [25]. A conceptual system basis for urban planning is shown in figure 3 and a rational model of system planning derived from scientific method in Figure 4 [26]. Such a particular representation of a system is called model, and models can be regarded as having different characteristics dependent upon the way in which they are represent particular properties of real-world system. The process of allied Models haven been classified in different ways according to system completeness, dimension, and objectives of analysis. Having in mined the purpose of understanding the complexity of urban development they are classified into cellular automata modeling, multi-agent modeling, spatial statistics, neural network modeling, fractal modeling etc, according to methods available for modeling complexity and non-linearity (Appendix 1).



Appendix Figure 1.

Cellular Automata (CA)

Cellular Automata (CA) is an effective bottom-up simulation tool which help planners in two ways;

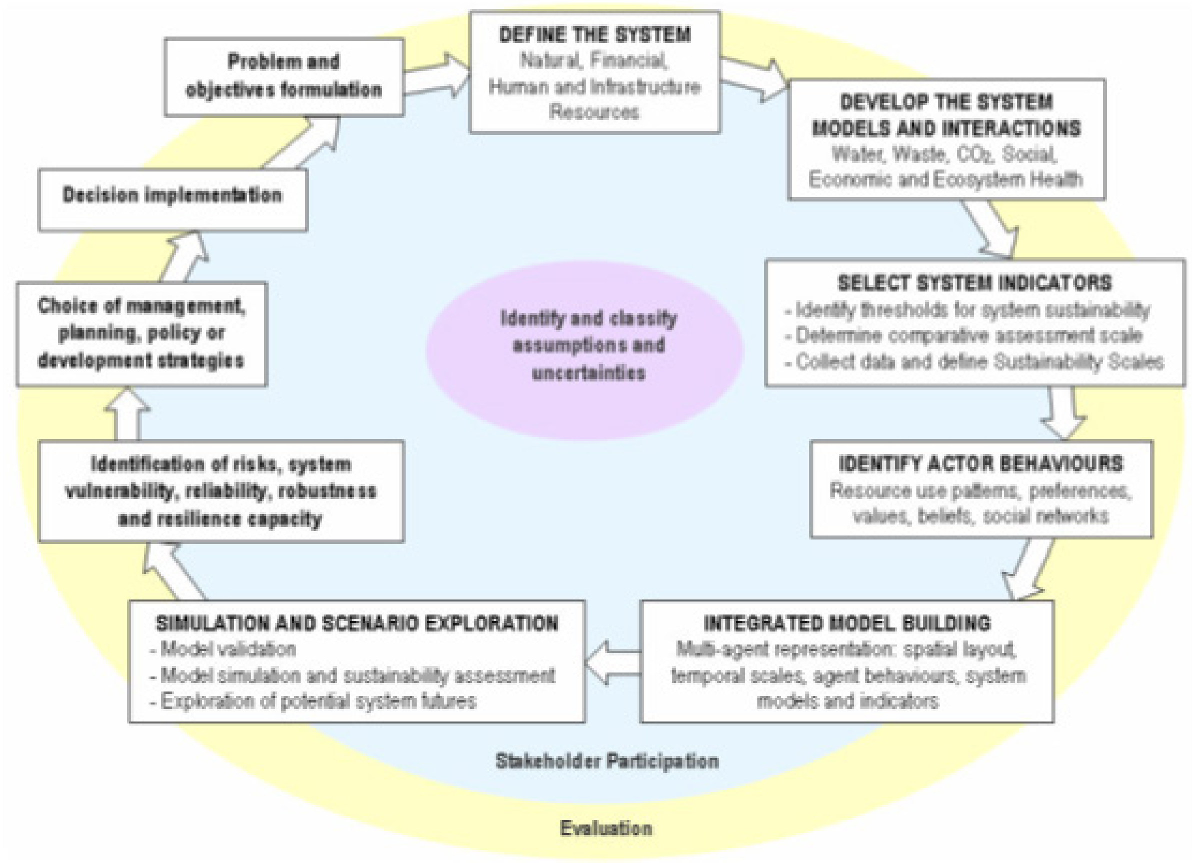
a) Provides new approach for dynamic process modeling and,

b) Provides a laboratory for testing the decision-making processes in complex spatial system.

CA based modeling are used in complexity and GIS theory theoretical urban studies spatial decision support system for simulation. In these applications, CA has been modified to incorporate urban theories and the understanding of specific practical issues of the study area. (See appendix 2 as an example of AC).

Multi Agent-Based Modelling

As adoptive interactions are mostly too complex to be captured by analytical expressions, computer simulation is most often used. The basic idea of such simulations is to specify the rules of behaviour of individual entities, as well as the rules of their interaction, to simulate a multitude of the individual entities using a computer model, and to explore the consequences of the specific individual-level rules on the level of population as a whole, using results of simulation runs. As the simulated entities are usually called agents, the simulation of their behaviour and interactions are known as agent-based simulation [27] multi-agent systems (MA) are designed as a collection of interacting autonomous agents, each having their own capacities and goals that are situated in a common environment. This interaction might involve communication, i.e., the passing of information from one agent and environment to another. From modelling point of view MA have interesting features. It can be used as a tool to implement self-organization theory such as straightforward way of representing spatial entities or actors having relatively complex properties or behaviors [28]. MA also provides easy way to capture directly the interactive properties of many natural and human systems, as well as complex system behavior that emerges from this interaction. Agent –based simulation is ideally suited to exploring the implications of non-linearity in system behavior and also lends to models that are readily scalable in scope and level. The approach is useful for examining the relationship between micro-level behavior and macro-outcomes (Appendix 3).



Appendix Figure 2.

Spatial Statistical Modeling

Traditional statistical models such as Markov chain analysis, multiple regression analysis, principal component analysis, factor analysis and logistic regression have been very successful in interpreting socio-economic activities [29]. However, these statistical models fail short in modeling spatial and temporal data. A major reason is that spatial and temporal data often violate basic assumption such as normal distribution, appropriate error structure of the variables, independence of variables, and model linearity. Two alternatives are frequently adopted. One is incorporating spatial sampling into traditional analysis and the other is developing new statistics based on spatial relationships such as spatial dependence and spatial heterogeneity. New methods for analysing spatial (and space-time) data include spatial data analysis, spatial econometrics, local spatial analysis and geographically weighted regression (GWR).

Artificial Neural Network

The development of the Artificial Neural Network (ANN) model requires the specification of any network topology, learning paradigm and learning algorithm. Unlike the more commonly used analytical methods, the ANN is not dependent on particular functional relationships, makes no assumptions regarding the distributional properties of the data, and requires no a priori understanding of variable relationships. The independence makes the ANN a potentially powerful modelling tool for exploring non liner complex problems [30]. Application of ANN has been shown in several studies. Used an ANN model to examine the relationship between socio-economic and demographic variables and travel activities. Another study by provides an overview of a parallel transportation-based land use modelling [31]. He concludes that to deal with complex urban dynamics instead of sequential modelling a parallel network model should be used. These models as ANN simulate the spatial process and spatial pattern of integrated transport/land use system. In urban growth, integrated ANN and GIS to forecast land use change, where GIS is used to develop the spatial predictor variables. Four phases were followed in their research:

1. Design of the network and of inputs from historical data.
2. Network training using a subset of inputs.
3. Testing the neural network using the full data set; and
4. Using the information from the neural network of forecast changes.

The applications have actually shown that ANN is an ideal method of understanding non-linear spatial patterns, on which short-term prediction may be based. However, the major drawbacks of ANN, including its black-box and static nature, result in a deficiency in modelling the urban development.

Fractal-Based Modelling

Fractals were originally used for natural objects such as coastlines, plants and clouds or ill-defined mathematical and computer graphics. These are essentially spatial objects whose form are irregular, scale-independent and self-similar. Recently, however, increasing analytical geographical analysis and analytical urban modelling have shown that planned and designed spatial objects such as urban forms and transportation networks can also be treated as fractals [32]. These studies have proposed that the complex spatial phenomena associated with actual urban system are rather better described using fractal geometry consistent with growth dynamics in disordered media .Tested a model that describes the morphology of cities, the scaling of the urban perimeter of individual cites and the area distribution of city system and points out that, the resulting growth morphology of cities can only be precisely understood if the interaction among the constituent units forming the urban region modelled using a correlated percolation model in the presence of a gradient [33]. A considerable number of studies report that fractal analysis can be applied for measuring the similarity between real and simulated spatial patterns created by cellular automata [34]. But it needs to be remained that fractal measures of spatial complexity of urban spatial patterns are only difficult to interpret due to the fact that the same value of fractal dimension may represent different forms or structures. It is also limited in urban process modelling as the temporal dimension is not incorporated in modelling.

Chaotic and Catastrophe Modelling

Catastrophe theory and theories of bifurcating dissipative structures attempt to model urban changes. But they have been pitched at traditionally macro level thus it has been hard to develop coherent explanation of the kind of changes emerging from the smallest scales which subsequently restructure the macro form of the system [35]. Chaos theory effectively means that unpredictable long-term behaviour arises in deterministic dynamic system because of the sensitivity of initial conditions. For a dynamic system to be chaotic it must have a large set of initial conditions that are highly unstable. No matter how precisely you measure the initial conditions is these systems, your prediction of its subsequent motion goes radically wrong after short time. The key to long-term unpredictability is a property known as sensitivity to initial conditions. A chaotic dynamic system indicates that minor changes can cause huge fluctuation. As a result, it is only possible to predict the short-term behaviour of a studied system, especially for socio-economic systems such as cities. Although, chaos theory is able to explain the complex temporal behaviour of urban growth from a theoretical research viewpoint, the temporal scale of data available from urban growth is too limited to uncover its long-term behaviour [36].

Conclusion

The literature review about conceptual framework for system view approach it can be concluded that a good analysis depends on a broad knowledge of urban systems. Operations research and system analysis though very useful tools are applicable incretion sectors of urban system and fall short of scientific research. System analysis should be recognised primarily as a process of rational thinking supporting human judgment. A rational model of systemic planning derived from scientific method, combined with the computer and other techniques, is a very useful for planning profession. It can also be concluded that, from current methods of urban modelling, some methods are still in theoretical stage or applied for artificial city analysis and need very good data infrastructure. Each method has its own merits and shortcomings, in respective data requirements and application domains. The selection of methods should depend on the demand of the analysis, the feasibility of the techniques and the availability or limitation of data framework. Due to complexity of urban systems and dynamic interaction at varied spatial and temporal scales, current methods of modelling. Thus, it can be suggested that in general framework of system thinking and system analysis urban development modelling needs to focuses mainly on spatial complexity understanding such as CA-based dynamic simulation, ANN-based pattern analysis and fractal-based morphology analysis. Chaos theory and MA model have not been widely applied for planning practice.

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