
An approach to regional planning in India

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Abstract: The need for a more balanced spatial growth pattern in Karnataka is shown by applying Zipf's law to the Indian State of Karnataka, with the result demonstrating Bangalore's increasing urban primacy. The authors review the literature on promote more equitably distributed growth, primarily the European polycentric model, to conclude that it is a 'wicked problem' that requires multiple perspectives, including systems dynamics and institutional economics approaches as well as traditional regional and land use planning. This requires new participatory techniques, and simulation, computation, and games can provide increased opportunities for more diverse inputs and analysis. They argue for authorities to pursue their planning processes with a view of the region as a complex system with many interconnected parts, and to consider using computation as a means to enable participation and integration.

Keywords: system dynamics; engineering; complex systems; regional planning; Karnataka; India.

Reference to this paper should be made as follows: King, R.A., Rathi, S. and Sudhira, H.S. (2012) 'An approach to regional planning in India', *Int. J. System of Systems Engineering*, Vol. 3, No. 2, pp.117–128.

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1 Introduction

Urbanisation in India today is synonymous with booming unplanned and unsustainable megacities. There has been a concentration of population in the Indian megacities, while the population in medium and small towns has declined. According to the 2001 Census, nearly 63% of the Class I city population (about 108 million) lived in the 35 million-plus cities (about 39% of total urban population). Three cities have a population of more than 10 million. Four others cities have crossed the four million mark. Amongst the mega-cities, the top three – Greater Mumbai, Kolkata, and Delhi – accommodated over 65% (about 42 million) of the mega-city population (about 15% of the total urban population).

This form of urbanisation in India has led to a diminishment of the quality of life in the Indian cities. Major contributors to this wave of concentrated urbanisation are population growth and urban poverty induced by rural/small town migration to the mega cities. The rural poverty induced urbanisation has resulted in the shift of rural poverty to urban poverty, with the emergence of slums in all the major cities in India, where the urban poor live in dismal conditions, lacking basic amenities such as water, sanitation, safe shelter, and health facilities. According to the Global City GDP Ranking 2008–2025, by PricewaterhouseCoopers in 2009, Bangalore, the Information Technology capital of India, boasts of a GDP (PPP) of US \$69 Billion (projected to US\$203 Billion at 2005 PPP), with largest number of households with an annual income of Rs 10 lakh (Rs 1 million or approx. \$ 20,000) or more.

However, the Comprehensive Development Plan of Bangalore 2007 estimated that about 26% of the population of Bangalore metropolitan area live in squatter settlements and another 80,000 are homeless. According to McKinsey Global Institute (2010) estimates, the population of urban India is likely to increase from 340 million (30% of total India's population) in 2008 to 590 million (40% of total population) in 2030. It also projects that the states of Punjab, Gujarat, Tamil Nadu, Karnataka, and Maharashtra will be more than 50% urbanised.

With this immense urbanisation anticipated in India, along with the continued urban migration of the rural poor, a decent life in the major cities will become untenable for many. In fact, as indicated by the McKinsey study (2010), the current performance of all service sectors fall far below basic service standards. If current trends continue, it estimates that with the projected urbanisation, the demand and supply gap in all basic services sector will be huge (3.5 times in water supply, 2 times in private transportation and sewage, 4 times in solid waste, and a demand gap of 38 million housing units). It will be very difficult to sustain these current large metropolitan areas with the status quo mode in urban planning land use practices, which are ad hoc, isolated, and lack integration of development with other sectors in the spatial context such as utility infrastructure and transportation. To mitigate the impact of this urban explosion and plan for the future, it is crucial to balance the demands of high growth on one hand and sustainable growth on the other. It is imperative that economic planning is linked to spatial/regional planning, to come up with a comprehensive strategy on a regional scale that provides form for sustainable emergent systems.

As Sen (1999) notes, "Development has to be more concerned with enhancing the lives we lead and the freedoms we enjoy". Lack of integrated spatial planning looking into the development of infrastructure, basic amenities, educational and health needs in the rural areas, small towns, and cities has led to the 'rural push' factors which push

people from the rural areas, small towns, and cities into the large metropolitan cities, without the cities having the adequate, functional infrastructure to support the population. This has led to a demographic explosion and a progressive concentration of poor migrants in the cities. As a result there is coexistence of slums in these urban agglomerations with deplorable habitat conditions of the urban poor. The urban poor have been excluded even as big cities have developed. There has been little attempt to understand the institutional and social structures which inhibit and prevent access to shelter, livelihoods and mobility for the urban poor. In the same way, on a regional scale the inter-linkages between accesses to shelter, livelihoods and mobility have not been recognised in the smaller towns and cities. These areas have not been adequately developed and prepared in terms of economic, social, mobility needs to make them self-sustainable so that the rural push form of migration can be minimised. The provisions of employment, affordable housing and efficient public transportation links to jobs are key issues to be addressed as Indian cities, large and small, inexorably grow.

India after sixty years of independence is yet to establish a comprehensive and integrated approach combining economic planning, planning for human habitats, and environmental planning. The development strategies for economic planning and growth (the National five year plans) need to integrate demographic, economic, social, spatial, environmental, and physical elements into their infrastructure investments. There is lack of implementation of participatory planning processes which can help policy makers and the urban and rural poor engage in discussions to come up with policy options for inclusive and sustainable development.

2 Case study

2.1 Dynamics of city size distributions

The evolution of towns into cities and urban agglomerations raises interest in exploring any possible underlying pattern in the course of ongoing urbanisation. The hierarchical organisation of societies (towns and cities) by their city-size distributions confirming to some of the scaling laws as in biological systems, has been well studied. There is already considerable treatment on the applicability of scaling laws in urban systems and ranking of the organisation of societies (Pumain et al., 1986; Fujita et al., 1999; Gabaix, 1999; Gabaix and Ioannides, 2003; Batty, 2008). Recently, the scaling laws have been extended to develop a new class of metrics by applying them to wealth, innovation and crime across cities in the USA (Bettencourt et al., 2010).

Bangalore is the principal administrative, cultural, commercial, industrial, and knowledge capital of the state of Karnataka, India. Based on the Human Development Report 2001, the city has been identified as the country's 'Silicon Valley' and it is one of the technological innovation hubs with a score of 13 out of a maximum of 16- almost on par with San Francisco (USA), while Silicon Valley (USA) is number 1 with a score of 16. However, with all the hype about growth in IT and IT-based industries, Bangalore also houses numerous other leading commercial and educational institutions, and industries like textiles, aviation, space, biotechnology, etc. As an immediate consequence of this growth in the last decade, apart from creating a ripple effect in the regional and local economy, there has also been great pressure on infrastructure and resources like water supply, energy, public transportation, land, etc. Of late, the development and

growth in Karnataka has been concentrated in and around Bangalore due to various reasons. A prominent one is Bangalore's much better connectivity to other parts of the country as compared to other tier-II cities of the state, as well as lack of fast connectivity from Bangalore to tier-II cities.¹

One of the intriguing empirical facts in social sciences and economics is Zipf's Law for cities. Zipf had noted the regularity as an inverse geometric progression between the population P_i of a city and its rank R_i in a national set of towns and cities, giving an approximate size of one half of the largest city population for the population of the second city and one third for the third one, and so on. This 'rank size-rule' formulated as $P_i = P_1 / R_i$ has been generalised as a Pareto-type distribution of the number of cities according to their size, $P_i = K / R_i^\alpha$, where the parameter K has a value close to P_1 and α is around 1.

From the available literature, it is now evident that this model has been fitted many times to more or less correctly measured population series of towns and cities. Typically, the estimated value for the parameter ranges between 0.7 and 1.3 for the population of the urban agglomerations (towns and cities over 10,000 inhabitants) of each state in the world. Pumain (2004) remarks on the ill-founded conclusions based on Zipf's Law mainly due to small samples of observations and a lack of accuracy in empirical data. However, Fletscher (in Pumain, 2004) has demonstrated based on the data for early settlements that whatever the part of the world and the period of observation, for last 10,000 years when towns first emerged, the model of settlement size distribution have always been reasonably well approximated by a Pareto or log-normal distribution. Pumain (2004) further notes that often, the upper part of the size distribution, corresponding to the largest urban settlements, does not fit very well to any model. These cases of urban primacy (one to up to eight cities per state whose size exceeds the expected values) seem to be a generality rather than an exception. When this 'primacy index' is computed, as the ratio between the population of the largest and second largest city, it is found that in most states of the world it is much larger than the value of two, which would correspond to Zipf's rank size rule and the mean value for all countries of the world taken together is 5.2. The confirmation to the rank-size model (Zipf's Law) is also true for the top cities in India, almost mysteriously and similarly to most other nations of the world (Pumain, 2004).

Zipf's Law, or the rank-size rule, states that when logarithm of ranks and corresponding city sizes are plotted on a log-log plot, they would fit a straight line. In other words,

$$\ln(\text{rank}) = P_k - \alpha \ln(\text{city size}) \quad (1)$$

with high R^2 , where P_k is the population of the city with highest population (Gabaix and Ioannides, 2003).

2.2 Validation of Zipf's Law

An attempt to analyse the city-size distribution of towns and cities in Karnataka was made to validate the Zipf's Law. The state of Karnataka is one of the most urbanised states in India with 34% urban population. The analysis was carried out for the duration of 1901–2001, decadal census data. The model is estimated through the least squares

method. Accordingly, the model was estimated in the form of equation (1), which indeed revealed a high R^2 and increasing α (Table 1).

Table 1 Estimates for rank-size distribution model to towns and cities of Karnataka

<i>Year</i>	α	R^2	P_k	P_1
1901	0.83	0.93	177,976	163,091
1911	0.85	0.92	181,396	189,485
1921	0.85	0.95	209,419	240,054
1931	0.85	0.96	243,477	309,785
1941	0.88	0.95	333,558	410,967
1951	0.87	0.97	462,989	786,343
1961	0.90	0.97	619,737	1,206,961
1971	0.92	0.94	895,520	1,664,208
1981	0.93	0.98	1,294,733	2,921,751
1991	0.96	0.98	1,812,023	4,130,288
2001	1.04	0.94	3,002,970	5,686,844

Note: P_k is the estimate of the population for the city with rank 1 (P_1)

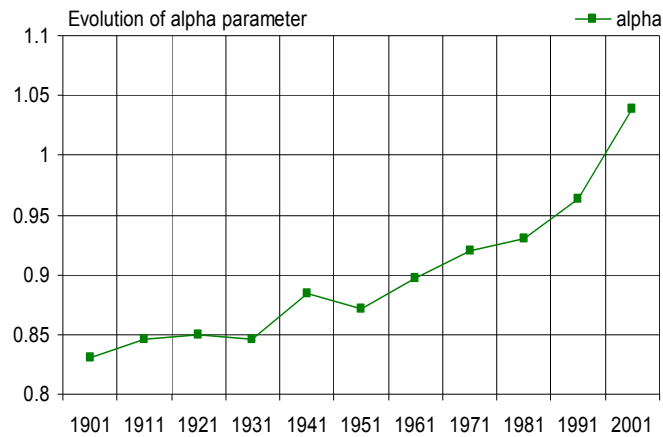
The analysis conforms to Zipf's Law, similar to other empirical studies pertaining to other nations and verifies the prevalence of characteristic scaling behaviour in urban systems population (Gabaix and Ioannides, 2003). Gabaix and Pumain have separately offered explanations for the presence of scaling effects in urban systems, yet, the implications from scaling behaviour with respect to the organisation of human societies in structurally similar patterns as observed in different places irrespective of their geographic boundaries, political boundaries and political economies raises many questions (Gabaix and Ioannides, 2003; Pumain, 2004).

Pumain (2004) asserts that the general structure of urban systems, including scaling effects is the result of social evolutionary processes: as in biological sciences, but in this case the evolution is also partly driven by a cognitive activity of inventing technical and social artefacts. However, the action of this organising principle on the spatial structure of the urban systems is almost always indirect: especially at the level of the system of cities, as there is neither a conscious nor responsible institution for organising and adapting the system to ensure this increasing power of accessibility. The global structure and its more or less continuous adaptation are emerging from the interurban competition.

It is intriguing to note that Bangalore (5,686,844) which emerged as the largest city had taken the lead by almost 8 times from its nearest contenders (Hubli-Dharwad with 786,018 and Mysore with 785,800) (based on 2001 Census estimates). The evolving primacy index (Figure 1) is a cause of concern in the state of Karnataka indicating the increasing urban hierarchy.

The analysis clearly indicates the magnitude of concentrated growth and a strong urban primacy (since $\alpha > 1$), a consequence of accelerated growth of Bangalore alone in the state vis-à-vis other cities of the state. The situation has been evident since the last decade with $\alpha > 1$. We believe that to better distribute economic opportunities, the state should intervene to achieve better spatially distributed growth.

Figure 1 Evolution of the alpha parameter for towns and cities in Karnataka showing concentrated growth and string urban primacy (see online version for colours)



3 The need

There is an urgent need for integration, revitalisation, and renewal of the smaller towns and cities to make urbanisation in India sustainable. With the high rate of urbanisation (current and projected), we must reorganise our regional space so that urbanisation is sustainable. There is a need to upgrade the development of rural areas, smaller towns and cities and integrate them with each other and with the higher level cities. Affordable mobility and creation of a livable habitat (choice of employment, affordable housing, land rights, access to education, medical facilities, etc.) is the key to this integration and revitalisation. Thinking on the regional scale is important, with the creation of interconnected clusters (mixed use development) with first or last mile connectivity² to transit (road and highway for both passenger and freight), along with upgrading of existing infrastructure, basic amenities, and also ensuring land availability. In the case of India, there is an urgent need for revitalisation of smaller cities and towns to make urbanisation sustainable. Larger megacities simply cannot accommodate the quantities of rural migrants expected (in fact, they are struggling to meet the current loads). Thus, we need to think of creating a 'multipolis', drawing lessons from the polycentric multipolises of the Rhine Ruhr area/Randstad, Holland, and other such best practices, adopting and adapting them for Indian reality (Peter and Pain, 2006). Alleviating excessively high urban concentration requires investments in interregional transport and telecommunications to facilitate deflection of economic activities from the mega cities. It also requires fiscal decentralisation, so that smaller cities can reach out to fiscal resources and provide the services needed to compete with the mega cities for industry and population. Redistribution of investment is recommended to develop a strong economic base for neglected small and medium cities so that migration flows are directed to them.

It is therefore urgent that we try to mitigate and adapt to the impacts of the high rate of anticipated urbanisation in India. We need to maintain/increase our high rate of economic growth, but at the same time we need to relook and plan development linking economic planning with, spatial/regional planning, focusing on a comprehensive strategy

at the regional scale. We need to save our cities from an infrastructure gridlock, and at the same time renew and revitalise the small cities and towns and prepare it to absorb the wave of urbanisation. The focus of this planning effort is to make life in urban India sustainable and livable. The principles may include strengthening existing cities and towns, mixed land use development, compact and efficient building design, and range of employment and housing choices, walkable neighbourhoods, variety of transportation choices, authentic sense of place, protection of open space and farmland, citizen participation and development decisions made open, predictable, and fair

There is need to focus development in a regional scale taking into account the political economy of cities and regions. Thus a coordinated and enforceable land use and transportation planning at the state, region, and city levels and this is the key to sustainable urbanisation in India.

4 The approach

It is imperative that economic planning is linked to spatial/regional planning, to come up with a comprehensive strategy on a regional scale that provides form for sustainable emergent systems. Such a task is complex, given the scale, variation in environmental and natural conditions, lack of knowledge of the needs on the ground, and linguistic and social differences within and across communities in India. These problems require a dialogical process that allows iterative framing of the policy problem with data, information, and analysis from multiple perspectives.

A traditional model of planning has been to formulate an optimisation problem to minimise risk or cost. But policy problems rarely have 'best' solutions. Rather, policy problems are 'wicked problems' as leading policy theorists Rittel and Webber (1973) have labelled them, in their paper 'Dilemmas in policy analysis'. This view stresses the reduction of unintended consequences through a dialogical process that allows iterative framing of the policy problem with data, information, and analysis from multiple perspectives. This builds from awareness that infrastructure services and the way in which they are conceived, designed, and governed are inherently embedded in institutional environments consisting of both formal and informal institutions. We draw on both old and new institutional economies to provide insight into processes and structures (Greif, 2006; Aoki, 2001; North, 1990; Moore, 1998; Commons, 1934/1959; Simon, 1975; Mokyr, 1990; Ostrom, 2005; Groenewegen et al., 2010). The Indian context requires us to incorporate discussion of individual capabilities and not merely country but also regional-specific constraints as well (McKinsey Global Institute, 2010; Groenewegen et al., 2010; Basu, 2000, 2003; Kapur and Mehta, 2007). This approach has a dynamic perspective, focusing on process and linkages, not merely a static equilibrium or comparative statics of traditional economic analysis. Design and functioning of key institutions such as markets and governance structures – including elements such as government budgets and fiscal allocation across competing uses, role and functioning of public/stakeholder participation opportunities, and keys issues of standards and development of concepts, data, and evaluation – take centre stage.

An urban region can be regarded as a combination of complex systems, whether economic, social or environment with its sub-systems (containing a large number of variables) that are interconnected to each other by feedback relationships. These inter-linkages and feedback loops of the sub-systems and its variables give rise to the dynamic

behaviour of urban systems. This dynamic behaviour is observed over time and this furthers the complexity of the urban systems. An essential aspect of a realistic simulation therefore must be ability to incorporate time as a variable in the structure of the model, in order to be able to trace the performance or behaviour of the system through time.

Based on the above philosophy, we use system dynamics techniques to understand different aspects of a region (economic, social, infrastructure, political, etc.), simulate, calibrate and validate sustainable development strategies (Forrester, 1969, 1971). The model development framework will constitute several iterative steps that would include identification of stakeholders, value systems that define sustainability, different sectors and its components, study inter-relations and their interactions among the various components that will help in development of a conceptual model. The conceptual model will guide us to development of the computational model, and the system components' rules can be established. The rules being established will enable us to study the system effects of different alternate scenarios in the regional planning context. The rules could be used to develop games to be used as a decision making tool for understanding the impacts of different policies on the regional system and guide in decision-making.

Recent development literature recognises that there is a circular and cumulative relationship between current developments and future development. It emphasises the fact that the spatial distribution of economic activity has a great impact on the persistence of low development levels-low relative income, standard of living, health standards, literacy and longevity (Chakravorty and Lall, 2007). Recently, there has been a renewed interest in analysis of spatial organisation of economic activity, with increasing research on externalities, increasing returns to scale and imperfect spatial competition (Dixit and Stiglitz, 1977; Fujita and Thisse, 1996; Krugman, 1991). New Economic Geography (NEG) models provide for renewed analysis in the support for cumulative causation arguments. These models argue the importance of improved accessibility that reduces geographic barriers to interaction, helping in specialised labour supply, and facilitating into exchange, technology diffusion, and other positive spillovers that reinforce each other. The importance of localisation economies³, dynamic externalities created in specialised and geographically concentrated has also been emphasised (Porter, 1990). The inter-industry linkages have also enhanced and made the localisation processes become more efficient (Marshall, 1890, Venables, 1996).

Urbanisation economies benefit from access to specialised financial and professional services, inter-industry information transfers and availability of infrastructure. A diverse range of input-output linkages also enhances the development process. However it is important to understand that localisation economies, input output linkages and urbanised economies are not mutually exclusive. Different spatial economies interact with each other and it is difficult to separate out the importance of each (Chakravorty and Lall, 2007). It is important to be cognisant about the institutional and social aspects of location theories. These theories suggest that the most decisions are based on perceptions and characterised by imitation, inertia and cumulative causation and these are efficient since cumulative causation reduces the cost of decision making.

This approach has a dynamic perspective, focusing on process and linkages, not merely a static equilibrium or comparative statics of traditional economic analysis. As we use computation extensively, we need to go beyond social science in the traditional sense and see how social scientists' and technologists' views complement, inform, and evolve with each other. Public/stakeholder participation opportunities, take centre stage, in our research methodology. Information design and visualisation, informed by cognitive

sciences, cognitive engineering, and sciences of perception and image processing is an important component in our methodology to communicate to the public and policy makers.

Table 2 Complexities in real world systems

<i>Technical/physical complexity</i>	<i>Social/political complexity</i>
Quantifiable factors	Non-quantifiable factors
Many interdependent variables (system complexity)	Many interdependent, loosely coupled stakeholders (multi-actor complexity; policy networks)
Cognitive uncertainty	Disputed or contested knowledge, values, and norms
Emergent behaviour (e.g., counter-intuitive)	Strategic behaviour to optimise own interests, making use of loop holes in the policy
Design phases (linear or iterative steps of building and using model)	Dynamic rounds and arenas; volatile, erratic policy-making processes, stakeholders entering and leaving at will.

Source: Mayer (2009)

Regional planning encompasses infrastructure problems that exhibit complexity as a result of the interacting physical, technical and economic systems within the larger system and the interactions between the different stakeholders. This 'emergent' behaviour is typical of complex adaptive systems. Characteristics of such systems exhibiting emergent behaviour are listed in Table 2 (Mayer, 2009).

An important aspect of the approach is formulation of the research problem within its overall social context. While seemingly trivial, formulating the problem in an actionable format is often one of the most contentious parts of a research project. This effort would focus on involving representatives from a cross-section of the citizens. The aim would be to have a collaborative effort in formulating the vision(s) and ideas/strategies in designing and understanding the needs of the city/town/region. This would focus on inclusion of multiple perspectives, by participation of a large number of people with diverse backgrounds to ensure identification of stakeholders and their needs/visions. The effort would be to create ideas extracting the wisdom of the teams (diverse team members), identify target concepts by each group; and then collaborate by sharing the target concept(s) across the different groups to generate a set of targets. This would be followed by closure and aggregation that will lead to faster and better solutions. The above two steps of idea creation and closure repeated multiple times will ensure that alternative concepts are explored and their inter-relationships thoroughly examined. This will be difficult, elaborate and a time-consuming process. However, this will be richer because of the interdisciplinary approach and participatory nature of the process of problem formulation.

Modelling and simulation methods have been used successfully to provide a better understanding of the technical aspects of social problems. The game that we intend to build will be inspired by *SimCity*⁴, that will embed the theories of urban planning and acknowledge the influence of System Dynamics (Forrester, 1969, 1971). Gaming methods allow for exploring the solution space with the different stakeholders via a visual medium. The non-confrontational, yet realistic environs of gaming present scenarios that provide for multiple ideas to co-exist and to understand possible effects of

policies (Shubik, 1975). Simulations provide the backbone to set-up multiple scenarios for the games. The use of a visual space for problem solving in games engages the decision makers (and stakeholders) to adapt to unknown variables as they do in reality.

5 Application of approach to case study and future work

The approach developed here combines multiple approaches within a regional planning approach, conscious of the tension between planning and emergence and top down versus bottom up approaches. However, this approach faces challenges like non-availability of data, the dynamism of the Indian economy aggravating this problem. There are substantial improvement needs; however there is a lack of professional skills and competent planners, limited financial resources and an absence in many cities of a knowledgeable institutional framework for planning. Complicating all of this is the urgency for improvements. Current urban infrastructure assets are marginal in many cities and the rapid pace of demand increases requires immediate attention. There is a clear lack of vision and holistic approach towards planning and budgeting. The focus on planning in the regional context is lacking with current planning efforts focused on project feasibility rather than the best solution. The result of the tradition of non-participatory planning in most cities and towns in India have created a major challenge to wisely define visions and needs for their futures.

Given the pressing challenges facing India today, creative and participatory approaches are needed. The challenges to implement such an approach will not be trivial, yet we believe that only through the use of such techniques will the political and social space align with the geography of the challenges/problems.

6 Conclusions

This approach helps us see regional planning as complex and dynamic with many parts interconnected to form an organic whole. Moreover, different stakeholders can participate in the process of decision making. The space for enabling this approach is created using computation. We do not propose computation as the answer to development issues; rather it is the means to enable this integrated approach.

Acknowledgements

This work was supported by the Jamshetji Tata Trust, India and the Next Generation Infrastructure Foundation at TU Delft, Netherlands.

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Notes

- 1 Better connectivity means presence of infrastructure like development of international airport, national highways connecting neighbouring cities.
Lack of fast connectivity refers to less frequency of service and more travel and dwell time to/from the Tier II cities to other parts.
- 2 Refers to connectivity from transit stations/stops to the source or destination of activity centre (home, work, school etc.)
- 3 Refers to the situation in which firms derive the most benefit by being located near similar type firms belonging to the same industry, forming an eco-system of the industry (Examples include Silicon Valley for technology start-ups and Pittsburgh for steel).
- 4 City building simulation game, first released in 1989, and designed by Will Wright.