Integrated urban monitoring framework

A conceptual framework for land dynamics monitoring

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Introduction

Historically public policy on urban development concentrates on responding to land market demand [1]. In recent decades important evolution of public policy is undergoing for a stronger market management to meet the challenges posed by urbanized area rapid expansion. These challenges are the urban development containment for preserving peripheral space not built while allowing controlled growth of the city by densification of housing, commercial and other activities. Public authorities must of course adapt legal tools for these requirements being zonings, urban belts, development areas, land taxes. They could influence the demand by increasing the attractiveness of specific urban areas through the development of public spaces, infrastructures and transportation offer. But, a clear view of the land market is needed to create favorable conditions for the land mobilization for urban densification and preservation projects.

Land monitoring systems for development, use, cover and markets have specifically intended to provide decision makers with indicators. These indicators help decision makers to intervene in the market in a coherent and effective manner. General indicators could be replicate from one region to another, but more specific indicators must be adapted or created based on the development objectives of respective public authorities and development actors. This ideal can only, of course, be implemented if data are gathered, translated, organized for the production of these indicators. At this time this requirement is rarely met. Available data are sparse in time (incomplete, not updated, lack of historical depth) and in space (insufficient resolution or scale, incomplete). Resulting maps from analysis are too complex or not adapted to decision making and partially use the full potential of collected data with innovative methods and tools.

The goal of this paper is to propose an integrated urban monitoring framework (UMF) for land dynamics. This framework is oriented around two domains: land use and land development. This paper identifies and describes existing datasets in the Swiss and Portuguese contexts. These data should be used, updated and maintained for the production of indicators. Innovative approaches for the production of spatio-temporal indicators and their analysis through time are also discussed. These approaches result from empirical studies conducted over the last three years in the geographic information science (GISc) research field.

Literature background

Monitoring of land development using geographic information systems (GIS) is a subject of research since the 1990s [2] in response to concerns about urban sprawl. Accessibility to infrastructures and interdependency of transportation systems and land uses has been the heart of these concerns [3]. The European Environmental Agency (EEA) conducted a research project on the urban expansion of European cities based on remote sensing images [4]. This project analyzes the urban expansion problematic using two approaches: the first uses the CORINE land cover automatic interpolation and the second uses the MOLAND land use. The EEA studies grow scenarios using cellular automata based on the current land uses, accessibility, zonings and socio-economic context.

Geographic information systems (GIS) usage is limited until today. Lack of up-to-date data and integration difficulties at the regional scale have produced this state. Some research within different contexts have collected cartographic and statistic data and produced indicators that could be visualized and explored by stakeholders [2]. The CityCOOP project from the COST Action C9 “Urban Quality Processes” produced a participative evaluation and decision framework [5]. It offers to groups of actors a platform for project information, issues and preferences definition based on cause-effect system. Another project developed the System for Monitoring URban Functionalities (SMURF) software and is also based on participative dimension [6]. SMURF offers methodological foundations for participative monitoring system implementation. Focusing on countries under development, this research uses global and aggregated indicators. These indicators are produced from low resolution data, but are highly coherent within the relational indicatorset method (RIM) [7].

Land change science (LCS) has developed interesting results, mainly in the environmental field [8]. A multi-scale evaluation framework is proposed by Rindfuss et al. [9] and highlights issues around data availability and aggregation process validation to produce trustable results. Impacts of land-use changes could be analyzed using the multi-scale monitoring system that uses the Driver, Pressure, State, Impact and Response indicator framework (DPSIR) [10]. These indicatorsets are needed by decision making process for sustainable development [11].

Proposed urban monitoring framework

During the last years, this project has conceptualized an integrated land dynamics UMF. Land use change and land development is closely linked to transportation development. In urban area, this tight link results in mandatory requirement for monitoring to take into account the network constraints on land development. The framework is built for stakeholders, being urban planners, transportation engineers or public interest groups. It uses dual-iterative cycles based on top-down (decision maker to data) and bottom-up (data to decision maker) approaches. The UMF (see FIG 1) is based on four conceptual layers:

1) Stakeholders: the users that bring the planning questions and/or needs for their respective decision process, and their needs related to this process being visualization systems, geo-atlas, dashboard, etc.;
2) Institutional knowledge: the index, repertory and system of spatio-temporal indicators accessible through web-based decentralized systems. These spatio-temporal indicators are partly based on map comparison methods: fuzzy-set map comparison, adapted landscape metrics, etc.;
3) Information: data-warehouse of information for past to present urban land uses (e.g. aggregated geo-referenced information), modeled information for a specific period of time (e.g. geographic weighted regression, network based kernel density estimation, multiple centrality assessment, localization indicator, accessibility), and projected information/scenarios (e.g. Urbansim, cellular automata, multi-scale and multi-agent system);
4) Data: the raw data from public and private producers (e.g. governments, agencies and infrastructures companies) or volunteered producers (volunteered geographic information – VGI) with particular attention to availability, liability, resolution and update frequency aspects.

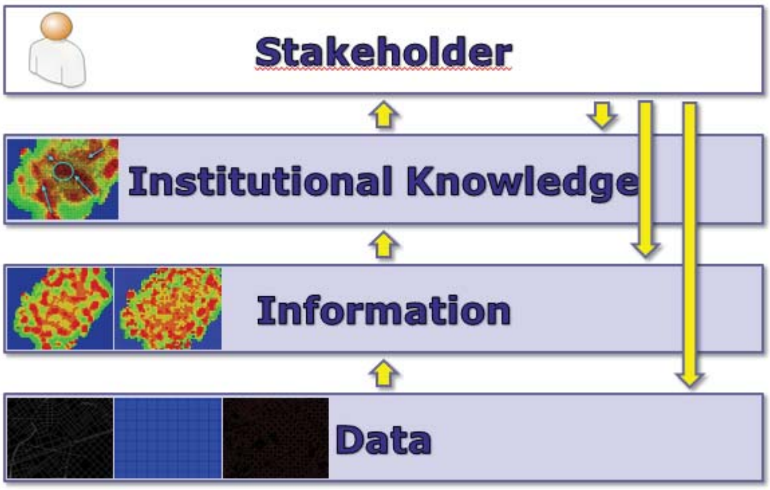

Figure 1: Monitoring framework layers: Stakeholder, Knowledge, Information and Data

Case studies: Geneva (CH) and Coimbra (PT)

This paper identifies and describes existing datasets in the Swiss and Portuguese contexts. This paper suggests how these data could be used, updated and maintained for the production of structured information. Specific illustrations are made about aggregated geo-referenced, modeled and projected information from different case studies. Innovative approaches for spatio-temporal indicators production are presented mainly based on map comparison methods. Finally, a brief overview of tools for decision process based on this integrated UMF is made.

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