Articulating Multidisciplinary Knowledge Bundles for Urban Planning

Robert Laurini
LIRIS, University of Lyon, France
email: Robert.Laurini@liris.cnrs.fr

***Abstract*—Conventional urban planning has long relied primarily on data, but contemporary practice increasingly integrates a wide array of knowledge bundles. These bundles originate from diverse disciplines and sources: expert analyses, regulatory frameworks, technical know-how, lessons learned from past projects, local historical in-sights, public participation outcomes, civil engineering, environmental planning, cartographic practices, and even the conventions of cartography and written communication. In addition, lessons learned through the simulation of city digital twin model must also be considered. Given this diversity, it becomes essential not only to identify the knowledge elements relevant to planning but also to articulate a coherent conceptual model capable of integrating them, taking account of both expert knowledge and shallow knowledge. To address this need, the paper proposes a visual model that represents the interactions among these heterogeneous knowledge bundles. Particular attention is given to the potential of generative artificial intelligence to synthesize citizen input and extract meaningful patterns and suggestions from public opinion. The paper concludes by outlining pathways for transitioning from data assisted to knowledge assisted urban planning, aligning this evolution with the broader ambition of fostering urban intelligence.**

Keywords-Urban Planning; Knowledge Management; Visual Modeling; Smart Cities; Urban Intelligence.

I. INTRODUCTION

In urban planning, for decades, the dominant mantra has been “survey before planning” [1] with the connotation of data-assisted activity. So many cities have designed information systems for this purpose [2]. Now, with the advent of artificial intelligence and especially Knowledge Management (KM), a new era is coming under the umbrella of urban intelligence which is defined by the synergy between AI and human collective intelligence (Figure 1).

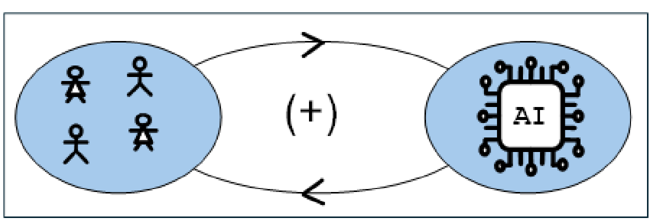

Figure 1. Synergy between artificial intelligence and human collective intelligence.

Since urban planning is a multidisciplinary activity, many different bundles of knowledge must be mobilized, from architecture to economics, from civil engineering to legal issues, from pollution fights to sports and culture. And the goal of this paper is to identify and characterize articulations of those different bundles of knowledge within the scope of operationality.

In computing, knowledge is usually defined as information that can guide action or solve problems [3]. Knowledge bundles can have different origins, i.e. regulations, written documents, reports, satellite images, aerial photos, expert’s know-how, data mining, etc. The major problem is not only compiling them but overall organizing them to help reasoning to find solutions.

However, much of the knowledge acquired by urban planners remains tacit or goes unrecognized as a vital city resource; it should instead be understood and managed as a shared collective wealth.

From a practical point of view, knowledge chunks can be rules (either physical or juridical), best practices, lessons learned, recognized patterns, verified statements, etc. In this category, one can add recommendations and adages. When it is possible, rules can be mathematically written so that they can be formalized in a computer language, i.e. made operational [4], otherwise their use is not so easy for automation.

The idea is not to develop an ontology describing cities or urban planning [5, 6], i.e. designing a formalized vocabulary dedicated to urban planning, but rather to organize existing knowledge chunks and bundles which can be useful to plan a smart city.

Bennet and Bennet [7] distinguish three levels of knowledge, surface, shallow and deep. In the field of urban planning, local authorities may be regarded as project owners, whereas for some aspects, specialized companies typically function as project managers or subcontractors. Put differently, these external actors possess deep knowledge, while planners within local authorities usually have more limited expertise, so shallow knowledge. So, in this study, only expert and shallow knowledge bundles in urban planning will be considered.

Let us make a comparison with car engines: mainstream drivers have some surface knowledge whereas a car vendor has shallow knowledge, and a car designer has an expert knowledge.

This paper is organized as follows: it will begin by a rapid state of review regarding the modeling of urban planning knowledge and then some issues regarding its background. Afterwards, the core of this paper will develop various bundles in the multidisciplinary domain linked to urban planning, together with the modeling for ending the planning process.

II. BUNDLE-ORIENTED MODEL OF KNOWLEDGE

In the state of the art about knowledge modeling, several major families of approaches exist, among other ones based on networks and on rules. Those based on networks allow an interesting model to describe a situation and to reason [8, 9] whereas rules permit to describe the results of a process [10]. Here, we need a model to help design a plan.

In this paper, a top-down approach will be used to present mainstream knowledge bundles for urban planning. Of course, about the context, additional bundles must be considered. In order to model the links between different bundles of knowledge, a visual vocabulary will be defined as in Figure 2 in which a hexagon represents a bundle or sub-bundle of knowledge and a scroll is used for any kind of regulations, existing or generated. A sub-bundle corresponds to a subset of knowledge. For modeling any kind of repository, a cylinder will be used, not only for representing any kind of multimedia databases, but also textual corpora. Two kinds of arrows will be used, the first one for the link between a sub-bundle of knowledge and its corresponding upper bundle, and another for the generation of new kind of knowledge. The process of generating knowledge can be human – for instance by discussing with an expert – or computer-based – for instance by data mining or through generative artificial intelligence.

The two "if-any" arrows (with dots) are introduced essentially because of national contexts which differ from country to country, either due to absence or from being not mandatory.

Colors will be used to denote whether a bundle is the focus (main bundle), a sub-bundle or shallow knowledge

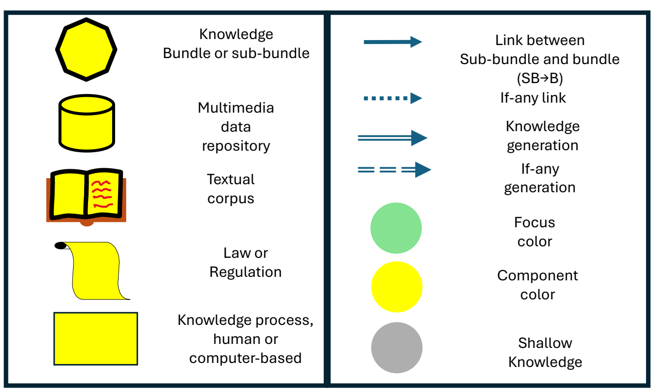

Figure 2. Visual vocabulary for modeling the links between urban knowledge bundles.

We will use this formalism to model the links between knowledge bundles in any organization such as companies, and here in planning.

III. BACKGROUND KNOWLEDGE BUNDLES IN URBAN PLANNING

Before turning to the planning process itself, it is helpful to outline the key elements that underpin it.

A. Juridical Framework

Commonly, urban planning is defined as the coordinated shaping of a city's physical spaces, infrastructure, and policies to support sustainable, functional, and livable communities. It can be seen as a feedforward component of urban governance. For that purpose, most countries have designed laws or more exactly regulations to organize urban planning. Figure 3 shows the national codes (if they exist), urban planning, environmental planning together with regulations concerning buildings and public participation.

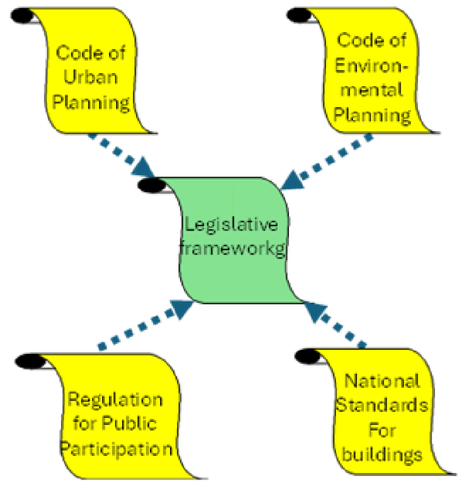

Figure 3. The legislative framework and its main components.

B. Definition of planning objectives

Each stakeholder has his own vision of the future of the city, based on his own knowledge about the city and some interesting experiences gained in other cities.

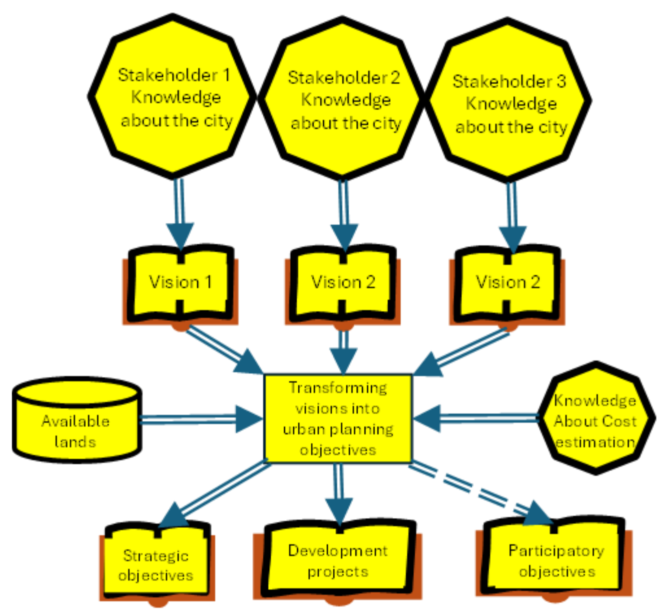

Figure 4. Transforming visions into planning instruments.

Among stakeholders, let us mention various administrative entities, political parties, some activist groups and other protagonists such as the local chamber of commerce. Maybe, some ideological issues can be included in the vision of some of them.

Anyhow, there is a mechanism to select those visions or to make a sort of compromise between them according to land opportunities and some estimation of cost. This mechanism can be some vote made by the local council. Three documents are written, the list of strategic objectives together with their priority, and some structuring projects, those corresponding to planning instruments (Figure 4). Possibly they are complemented by some recommendations regarding citizens' participation.

The case of development projects will not be detailed in this paper. Let us remember that local authorities can act either as a regulator checking whether projects follow all planning rules (e.g. for a gated community), or as a prime contractor (e.g. for a tram newline).

C. Knowledge involved in methodology

Once the strategic objectives are set, the methodology (Figure 5) will begin by studying the previous plans to discover parts currently on-going or not yet implemented, and by stating whether they are still in consideration. Then, it will be a sort of amalgamation of experts' know-how, best practices, conventional methodologies and lessons learned from the past (in the city itself and also elsewhere) If the city has implemented a digital twin (CDT), several simulations can give indications and tips about the potential outcomes.

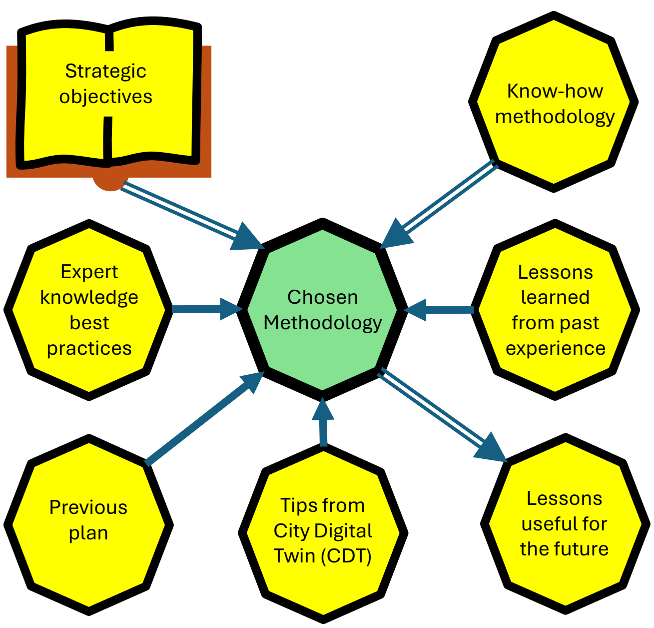

Figure 5. Planning methodology.

D. About internal and external geolocated knowledge

Recall Tobler's Law [11], often regarded as the First Law of Geography: "*Everything is related to everything else, but near things are more related than distant things*". It implies not to limit to the jurisdiction, but also to consider external influences, in other words, external knowledge. For instance:

- The headquarters of a plant – located in my city – are in New York City and its CEO has decided to close it; so, increasing local unemployment.
- A city located in another country has implemented an original biking rental activity. This activity could be deployed in my own city.
- The region has decided to design a new railway system crossing my city, but the main station is not in my city.
- A natural or technological disaster in a neighboring city has consequences for my city.
- Etc.

So, we define external knowledge as information describing external influences that are relevant to a given territory. Several categories of such knowledge can be distinguished (Figure 6):

- Short distance or neighboring knowledge, i.e. knowledge located in the vicinity of the jurisdiction; a solution can be to determine an out-buffer zone around the jurisdiction and consider knowledge inside this buffer zone.
- Long distance knowledge includes the source and contents of external influences coming perhaps from decision made elsewhere. Here, we must consider that local authorities only have shallow knowledge of those influences.
- Technology and sociological watching can be included in external knowledge; however, in some cities, technology and sociological watching must be considered as shallow knowledge.

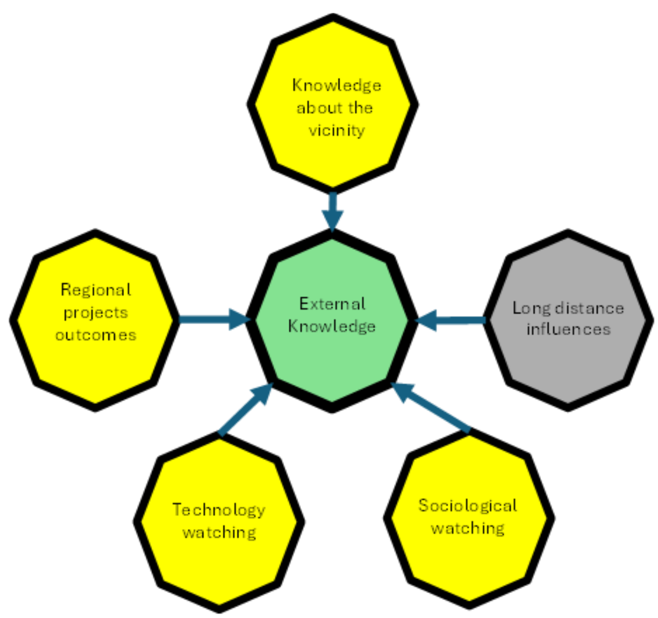

Figure 6. City external knowledge and its major sub-bundles.

IV. DETAILED MULTIDISCIPLINARY MODELS

In this section, several models of knowledge bundles will be presented. It is important to state that they are only for planning purposes, not for design. Indeed, for the design, for instance, of a shopping mall, several consulting companies will be involved with their own knowledge. For planning purposes, only shallow knowledge will be mobilized regarding many activities in the city.

A. General Knowledge about the City

This bundle regroups 6 sub-bundles, namely concerning local peculiarities, local history, city as a system, listed monuments, population needs and risks and disasters (Figure 7). Of course, it is necessary to mention knowledge coming from databases, geographic information systems including 2D and sometimes 3D data, aerial photos and perhaps satellite images.

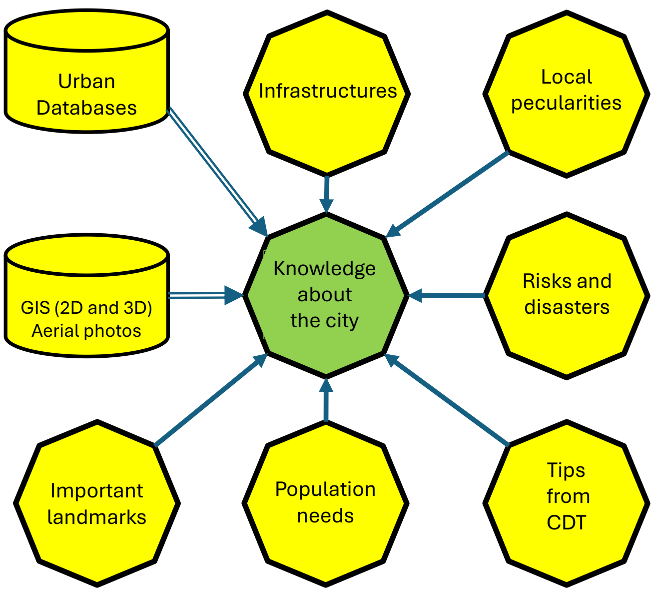

Figure 7. Knowledge about the city and its sub-bundles.

B. Local Peculiarities

Not all cities are similar; each has its local peculiarities due to history and its geographic location (mountain, sea, etc.). For instance, the problems generated by the existence of a harbor or from important touristic landmarks can influence its development, such as skiing resort, or an archaeological site. (Figure 8). Moreover, having an airport or a regional hospital are important assets for economic development.

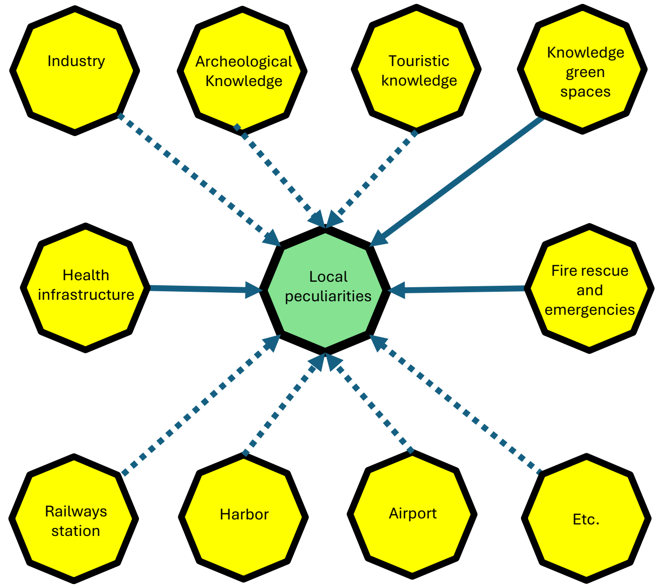

Figure 8. Local peculiarities.

C. Various multidisciplinary models

The wide range of urban activities allows for the design of various bundle models. Figure 9 illustrates a selection of these models; however, many additional variants can also be considered.

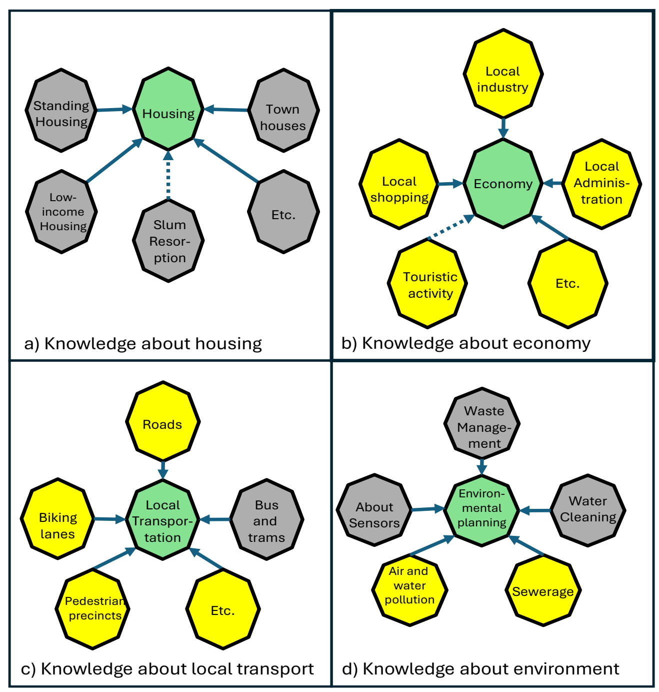

Figure 9. Models of various sub-bundles.

D. Tips Learned from City Digital Twins

Several definitions of the concept of City Digital Twin (CDT) exist [12]. In essence, a digital twin city represents a dynamic, data-driven virtual replica of a physical urban environment. Unlike static 3D models or conventional maps, this technology creates a continuously updated virtual counterpart that reflects real-time behavior, status, and characteristics of the actual city. The system integrates sensor data, satellite imagery, traffic flows, environmental readings, and infrastructure performance metrics to maintain accuracy and relevance.

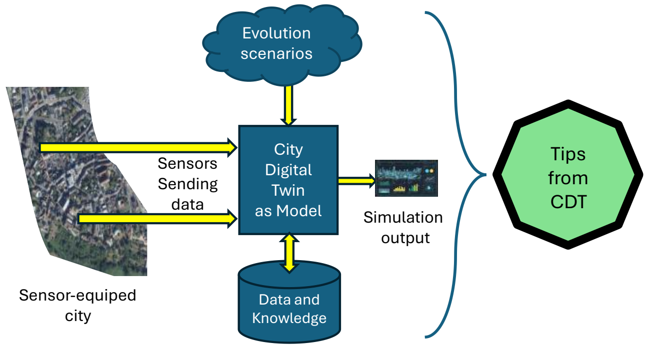

Figure 10. Knowledge (tips) issued from the use of city digital twin system.

The more important thing in our domain is the way that scientists, policymakers and planners interact with real cities with respect to their understanding, prediction and design [13]. The city digital twin system integrates a range of spatial models, from analytical simulations of local neighborhoods to large-scale systems of cities and city systems and briefly describe computational challenges that geospatial applications in cities pose.

Practically, users develop some evolution scenarios which are submitted to the CDT model and generate simulated outputs (Figure 10). Then, those outputs are evaluated through some criteria (efficiency, cost, etc.). At the end of this process, some tips learned are listed as knowledge bundles.

E. Public Participation Knowledge

Two kinds of knowledge must be considered: first, the way to deal with collected citizens' contribution and second, regarding its organizational structure.

In some countries, there are regulations regarding the organization, the documents to be presented to the citizens, the duration, the minutes, etc. However, the more effective the organization is, the more likely citizens are to feel that their opinions are being taken into account. In other words, this is a problem of communication.

Knowledge bundles should be maintained on the most effective ways to present the plan, including maps and explanatory materials, the city's evolution, future development scenarios, key projects, and the organization of public hearings. Some coaches can be trained to explain to people the ins and outs of the plan and to encourage them to give their opinion.

It is important to mention that the presented bundles of knowledge must be considered as shallow knowledge in the countries in which citizen participation is not legally organized (Figure 11).

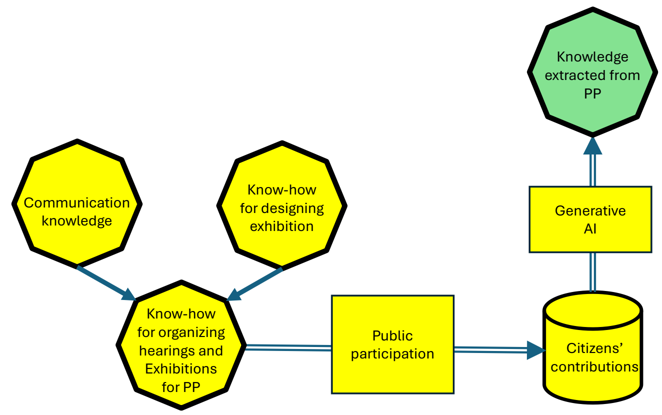

Figure 11. Knowledge bundles necessary to get citizens' contributions through Public Participation (PP).

In urban governance, it is common to organize public surveys, consultations or hearings in which citizens can give their opinions or suggestions on projects proposed in the plans. In other words, those suggestions are positioned through an area and can constitute knowledge chunks coming directly from people. Although there are nuances in the vocabulary, here the word "suggestions" will be used as a general term to describe contributions, opinions, complaints, objections, etc.

It looks like it is possible to use generative AI to extract salient patterns from large volumes of citizen suggestions, to generate summaries and highlight key concerns or good ideas and eventually simulate urban design scenarios based on public preferences.

F. Final Remarks

The model can also be extended to include other knowledge bundles. Examples include infrastructure systems, such as road networks and utilities (electricity, telecommunications, street lighting, traffic management, and district heating), as well as public services related to healthcare, culture, sports, local administration, policing, and recreation. In accordance with the legislative context, such aspects may not be managed by the city, but by other administrations or private companies. Within this model, however, they will often be represented as shallow knowledge for planners.

These shallow bundles are typically entrusted to partners with greater expertise in their respective domains. Two solutions can be mentioned, either to build a file of potential partners and to contact one of them, or to write an open call for tenders.

 ISBN: 978-1-68558-399-6

V. Knowledge Mechanisms Required to Conclude the Planning Process

Once the planners have completed their work, they have to prepare several blueprints out of which two are mainstream: a written report and a map (Figure 12).

The written report will include the objectives of planning and the details for each zone; a substantial part of this report will be the basis for local regulations. For its part, the map must be consistent with the written report and must show visualization of the plan.

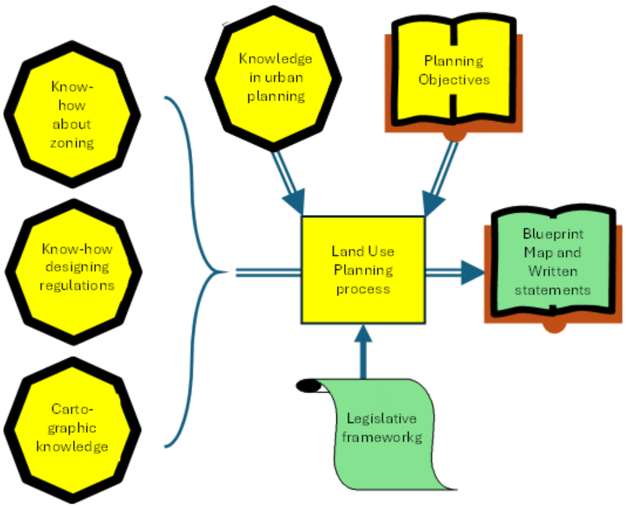

Figure 12. Final blueprint design.

According to the legislation, there is a mechanism for approving the blueprints; for instance, the local council may vote to approve it, thereby giving rise to an enforceable master plan. From the planner point of view, by designing the plan, some lessons have been learned, and a sort of learning feedback loop will be generated, as illustrated in Figure 13. This feedback can affect any kind of knowledge bundles listed in this paper.

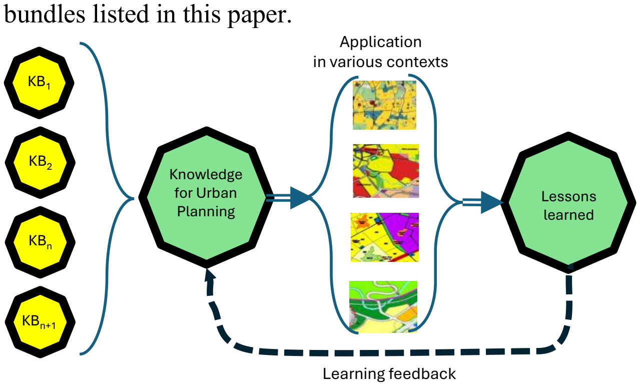

Figure 13. Learning feedback.

VI. Conclusion

In essence, urban planning is a multidisciplinary task [14]. So, the scope of this paper was to examine the articulations of the bundles of knowledge that planners have to master by means of a visual vocabulary. Two levels of knowledge bundles have been identified: expert knowledge and shallow knowledge. Naturally, many other models can also be developed.

The next step is to define appropriate models not only for storing all types of bundles, but also for enabling reasoning over them. By completing and validating this framework, a new form of knowledge-assisted urban planning can be envisioned [10].

References

[1] G. L. Pepler, "Geddes' contribution to town planning," Town Planning Review, vol. 26, no. 1, pp. 19–24, 1955, doi: 10.3828/tpr.26.1.u02775g40240m504.

[2] R.Laurini, Information Systems for Urban Planning: A Hypermedia Cooperative Approach. London, U.K.: Taylor & Francis, Feb. 2001, p. 308.

[3] R. L. Ackoff, "From data to wisdom," Journal of Applied Systems Analysis, vol. 16, pp. 3–9, 1989.

[4] R. Laurini, "A mathematical language for the modeling of geospatial static rules," Journal of Visual Languages and Computing, vol. 51, pp. 1–13, 2019.

[5] J. Teller, K. Keita, C. Roussey, and R. Laurini, "Urban ontologies for an improved communication in urban civil engineering projects: Presentation of the COST Urban Civil Engineering Action C21 TOWNTOLOGY," Cybergeo: European Journal of Geography, no. 386, 2007, doi: 10.4000/cybergeo.8322.

[6] A. De Nicola and M. L. Villani, "Smart city ontologies and their applications: A systematic literature review," Sustainability, vol. 13, no. 10, Art. no. 5578, 2021, doi: 10.3390/su13105578.

[7] A. Bennet and D. Bennet, "The depth of knowledge: Surface, shallow or deep?" VINE Journal of Information and Knowledge Management Systems, vol. 38, no. 4, pp. 405–420, 2008, doi: 10.1108/03055720810917679.

[8] Y. Liu, J. Ding, Y. Fu, and Y. Li, "UrbanKG: An urban knowledge graph system," ACM Transactions on Intelligent Systems and Technology, vol. 14, no. 4, Art. no. 60, pp. 1–25, 2023, doi: 10.1145/3588577.

[9] S. Wang, P. Qiu, Y. Zhu, J. Yang, P. Peng, Y. Bai, and Y. Qi, "Review, framework, and future perspectives of Geographic Knowledge Graph (GeoKG) quality assessment," Geo-Spatial Information Science, pp. 1–21, 2024, doi: 10.1080/10095020.2024.2403785

[10] R. Laurini, "Urban planning knowledge modeling for urban intelligence," in Knowledge Systems and Human Intelligence: How We Organize, Share, and Apply Information, O. Polishchuk, Ed. Hauppauge, NY, USA: Nova Science Publishers, 2026, in press.

[11] W. R. Tobler, "A computer movie simulating urban growth in the Detroit region," Economic Geography, vol. 46, no. 2, pp. 234–240, 1970.

[12] M. Hooli, "Digital twins and urban planning: Designing smarter, more inclusive cities," European Journal of Computer Science and Information Technology, vol. 13, no. 44, pp. 104–112, 2025, doi: 10.37745/ejcsit.2013/vol13n44104112.

[13] M. Batty, "Digital twins in city planning," Nature Computational Science, vol. 4, pp. 192–199, 2024, doi: 10.1038/s43588-024-00606-7.

[14] R. Laurini, "Groupware for urban planning: An introduction," Computers, Environment and Urban Systems, vol. 22, no. 4, pp. 317–333, 1998, doi: 10.1016/S0198-9715(98)00029-5.