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THE MULTICRETRY SPATIAL ANALYSIS FOR THE MANAGEMENT OF CO-RESEARCH IN COLLABORATIVE SPACES

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Summary. In this paper we present a methodological proposal, based on the fundamental principles of multicriteria analysis that were adapted to the management of co-investigation, to be implemented in collaborative spaces that work with geospatial information. By combining multi-criteria methods with Geographic Information Systems, very powerful spatial analysis methodological guides are obtained, which make possible the integration, analysis, synthesis and dissemination of knowledge. In this case, said conjunction is considered as a support tool for the management of research projects in Higher Education Institutions. To apply and describe this proposal, we worked with two primary sources: 1. Opinions of professors, students and directors of the Universidad Autónoma Metropolitana Unidad Azcapotzalco (UAM-A), -data compiled for the preparation of a thesis for the Doctorate in Projects, UNINI-FUNIBER–. 2. Main challenges faced by urban laboratories, -opinions expressed at the 2021 Seminar, Urban Laboratories in the face of the Pandemic, UAM-A–. As part of the results, the method adapted to the reality of the Urban Form Laboratory of the UAM-A and the description of nine processes, which are based on the Hierarchical Analysis, are presented. From this exercise, a very useful standardized parameter is obtained, so that those responsible for research, teachers, technical teams and collaborators; improve their organizational processes and take advantage of the products derived from collaborative work.

Keywords: Spatial Analysis, Hierarchical Analysis, co-investigation, space and collaborative work.

EL ANÁLISIS ESPACIAL MULTICRETRIO PARA LA GESTIÓN DE LA CO-INVESTIGACIÓN EN ESPACIOS COLABORATIVOS

Resumen. En este trabajo se presenta una propuesta metodológica, basada en los principios fundamentales del análisis multicriterio que fueron adaptados a la gestión de la co-investigación, para instrumentarse en espacios colaborativos que trabajan con información geoespacial. Mediante la combinación de los métodos multicriterio, con los Sistemas de Información Geográfica, se obtienen guías metodológicas de análisis espacial muy poderosas, que hacen posible la integración, análisis, síntesis y difusión de conocimiento. Para este caso, dicha conjunción, es considerada como una herramienta de apoyo para la gestión en proyectos de investigación en Instituciones de Educación Superior. Para aplicar y describir esta propuesta, se trabajó con dos fuentes primarias: 1. Opiniones de profesores, estudiantes y directivos de la Universidad Autónoma Metropolitana Unidad Azcapotzalco (UAM-A),

–datos recopilados para la elaboración de una tesis para el Doctorado en Proyectos, UNINI-FUNIBER–. 2. Principales retos que enfrentan los laboratorios urbanos, –opiniones vertidas en el Seminario 2021, Laboratorios Urbanos ante la Pandemia, UAM-A–. Como parte de los resultados, se presenta el método adaptado a la realidad del Laboratorio de la Forma Urbana de la UAM-A y la descripción de nueve procesos, que están cimentados en el Análisis Jerárquico. De este ejercicio, se obtiene un parámetro estandarizado de gran utilidad, para que los responsables de investigaciones, docentes, equipos técnicos y colaboradores; mejoren sus procesos organizacionales y aprovechen los productos derivados del trabajo colaborativo.

Palabras clave: Análisis Jerárquico, co-investigación, espacio y trabajo colaborativo.

Introduction

In these times characterized by great uncertainty and dynamics derived from the Covid-19 pandemic, it is necessary to rethink the role of socio-urban laboratories installed in Higher Education Institutions (HEI) as information-producing entities, but also as collaborative spaces that today must be considered cross-border –disciplinary– for the generation of knowledge.

In view of this situation, laboratories related to social and urban research activities should provide a transit and openness to realities that lead to collaborative spaces; where "critical thinking, academic development and knowledge management" are developed in terms of achieving an "understanding of the morphological processes of cities in the XXI century" (Avila et al, 2021, p. 4).

To this end, they will have to redefine their lines of action and promote the development of research and educational processes under new forms that will allow them to reorient their objectives and work agendas. Both the forms of research production and teaching have been affected by the pandemic. This situation has accelerated processes in the two aforementioned dimensions, with manifestations that have increased the use of Information and Communication Technologies (ICT), promoted distance education, teleworking, data flows, information, the movement of scientific variables, as well as conceptual redefinitions and technological applications have been incorporated in a forceful and rapid manner in everyday life.

This context makes it possible to approach the reconfiguration of socio-urban laboratories based on the identification of those training and information needs that guarantee success in the quality fulfillment of the guiding ideas and strategic objectives to be considered for the design of a strategy that promotes collaborative work through multi-criteria analysis methodologies based on the principle of co-research (Núñez, 2008). This suggests strengthening the link between research and teaching, both fundamental elements of the work of HEIs. The concept of co-research forces to rethink the teaching-learning processes in an integral logic; however, there is evidence of some factors that slow down the approach of organizations to the approaches of knowledge production and organizational learning, such as: Top management, which is besieged or cornered by constant operability and the short term; the neglect of continuous training, both technical and project management; the working environment of low trust –fear of sharing knowledge due to individual competence–; and the lack of adequate spaces that encourage group or team work (Cuesta, 2001 in Núñez, 2004, p. 5).

To address these and other problems, there are several approaches, among which we identify those that deal with issues related to organizational studies and that have also been dynamic. So far, at least two clearly identified theoretical bodies prevail: the systemic school and the scientific school. The first, according to Rendón and Montaño (2004), is based on organizational theory, which focuses on human relations, while the second is based on management theory. The latter arises from the works of Taylor (1911) and Fayol (1916), which

represent the main theoretical support; although for organizational studies it only represents its material basis (Ibarra and Montaño, 1986 in Ramírez Martínez; Vargas Larios and De la Rosa Alburquerque, 2011). This materiality is permeated by a technological approach, which aims, through ICTs, to provide tools to efficiently carry out management activities and information and knowledge processes.

The vision of organizational studies considers knowledge as the result obtained from co-research processes, through the use of tools and methods in collaborative spaces. In this paper, the discussion focuses on the description of methodological tools that increase capacity, create value, and promote functional and operational organizational innovations considering their pre-existing capabilities. The aim is to comply with the foundational objectives of the IES and to adapt to current dynamics through medium and long-term organizational development strategies. These should focus on the management of the knowledge produced and consider it as a strategic factor for the solution of specific problems.

Regarding the key elements for developing a model of collaborative spaces, it can be pointed out that not only is it necessary to develop high technology, but it also requires increasing the capabilities of people and institutions in the acquisition, generation, dissemination and use of knowledge, in order to produce significant effects on learning. It is evident that the organization open to the production of knowledge represents a paradigm shift with respect to traditional organizations. We are witnessing the emergence of a new management perspective on how organizations should function and how they should deal with change (Pérez and Cortés, 2007).

This article proposes a methodological strategy based on multi-criteria analysis, to establish a standardized work parameter, aimed at research and teaching units, based on co-research in collaborative spaces.

Teamwork and collaborative work

In the Mexican case, a state policy seeks to promote research, which, due to its intrinsic importance, is a way to have a strong innovation and technological development system. Which suggests having a vigorous science dissemination and communication policy (UNAM, 2018).

To this end, the National Association of Universities and Higher Education Institutions[1] (ANUIES) has set as one of its many objectives the creation of scientific and technological collaboration networks. "This implies carrying out the functions of teaching, research, dissemination of culture, extension of services and institutional management with a vision of change, with a renewed perspective of the future to enhance the social function of IES" (ANUIES, 2018, p.17). The transition must take place towards the construction of knowledge societies and is recognized as a complex, unstable and turbulent process, in which HEIs must adapt to the conditions of the environment based on creativity. Collaborative work is a central axis of his discourse.

Within its lines of action, ANUIES foresees the generation of learning environments, through academic and knowledge networks[2]; promoting the use of ICT in most educational programs and; articulating and providing feedback on training, research, dissemination and university extension (ANUIES, 2018). In order to carry out these actions, the HEIs must

[1] Non-governmental organization that groups the 191 most important public and private higher education institutions in Mexico. These institutions, located in the 32 states, together serve almost 60% of the national enrollment and conduct 90% of scientific research.

[2] According to the Program for the Professional Development of Teachers (PRODEP), and in particular in its Rules of Operation 2020, the Academic Bodies are networks and "groups of full-time professors who share one or more lines of knowledge generation, applied research or technological development and innovation in disciplinary or multidisciplinary topics and a set of academic objectives and goals" (DOF, 2021, p. 4).

generate conditions conducive to collaborative research work and the participation of the academic communities. This is: "purposeful collaboration to create knowledge, that is, to create new ways of doing things, which guides the formation of working groups in knowledge society organizations" (Nonaka et al. 2001, in Santizo, 2016, p. 155).

For its part, the National Council for Science and Technology (CONACyT) in its 2019 General Report, reports a sustained increase in the number of researchers, which went from 18,555 to 30,548 in the period 2012-2019 (CONACyT, 2019). This group is made up of researchers from IES and other educational and research centers that are registered in the National System of Researchers (SNI). In this system, one of the elements to be considered is the generation of research groups and networks. In addition to this, the document Towards the Consolidation and Development of Public Policies in Science, Technology and Innovation, published by UNAM in 2018, states that the growth of Science, Technology and Innovation (STI) has increased the number of research lines and products; however, it specifies that scientific activity has been performed, "promoting development individually, rather than collaborative work that stimulates the formation of solid and interdisciplinary teams". Situation originated in part, because "there has been little stimulus to the application of disruptive approaches, in an innovative sense" (UNAM, 2018, p. 26).

For this reason, the creation of research teams represents a challenge for the national STI policy, as well as for the HEIs themselves. Although the benefits obtained from collaborative work are varied, we must not lose sight of the fact that in "joint work [...] its results, [...] are not integrated by the simple sum of individual contributions; there are additional benefits derived from collaboration" (Santizo, 2016, p. 161).

A fundamental element that influences collaboration is the trust existing among the members of a group (Luhmann, 2000, in Santizo, 2016). Another element to consider in collaborative work is the condition of complementarity. The latter, determines that teamwork is more effective than individual work and can counteract problems derived from the diffuse, which sometimes affects the allocation of tasks and responsibilities among members (Baker, 2002 and Fryer, 2013, in Santizo, 2016). The complementary knowledge and skills of researchers can encourage collaboration among them, as long as similarities, preferences and interests are considered and aligned with group objectives.

Co-research

In practice, collaboration represents an important element in strategies aimed at solving problems that, due to their complexity, are impossible to address individually. In research practice, it is convenient to adopt collaborative work strategies and to consider co-research as an approach that assumes that the members of a research group decide together the possibilities of cognitive self-determination in their various fields of expertise. Co-research, in Hartley and Benington's (2000) view, "establishes a dialectical process of inquiry drawing on complementary perspectives, interests, skills, and knowledge bases of scholars and practitioners" (p. 463). The authors recognize stakeholder perspectives and ways of producing knowledge and identify the academic as an actor who is responsible for and leads the research team. Both authors argue that knowledge is not only transferred between stakeholders, but is created jointly through dialectical research processes.

Co-research does not limit the participation of diverse actors and stakeholders in this productive process; therefore, it can be considered in the context of HEI, that students can and should be actively integrated. But also, co-research can be implemented in the classroom, to study the various objects of study, so that both the production and the transfer of knowledge support the teaching-learning process. Thus, the incorporation of the student sector in research will be vital to counteract the difficulties of students to achieve the curricularly prescribed

objectives and those present in HEIs to assume strong educational projects (Boavida and Da Ponte, 2011).

Collaboration, as an element of co-research, starts from an individual motivation and not from an external demand or imposition. Collaboration suggests that the individuals involved are considered as a member within a system, who, through their actions, manage to influence the structure and/or functioning of the same system (organization, event and/or process). The practical part of research is nourished by the previous definition and positions it as an intellectual process. A process based on a set of activities and methods applied in a systemic manner, with the objective of deepening the understanding and/or solution of a specific topic or problem; in addition, it allows for the expansion and development of knowledge and scientific interest.

However, Wagner 1997, cited by Boavida and Da Ponte, 2011, points out that collaboration constitutes a particular form of cooperation. Wagner uses the concept of cooperation "to designate all educational research that is conducted in schools, and even that in which researchers limit themselves to using teachers and students as data sources"; that is, cooperation is inherent in all research (p. 128).

In short, co-research suggests collaborative ways of working where roles are discussed and agreed upon within the team. It does not depend only on the existence of a common objective; it must be accompanied by much more horizontal forms of work and relationships, in order to trigger communication processes in all directions and scales, without losing sight of the responsibilities and commitments acquired as a group. "Co-research is a type of co-production methodology" (Hartley and Benington, 2000, p. 464).

Collaborative spaces

The ways of working, teaching and research influenced by the current dynamics and from the emerging perspective of HEIs, has triggered increasingly strong initiatives on the design of spaces that allow more stable interconnections, both face-to-face and at a distance. Professional training should direct its efforts to the promotion of teaching and research based on collaborative learning -networked, accelerated by the pandemic-. To this end, it is necessary to move towards spaces of collective construction between teachers-researchers-students, grouped on the basis of a common interest. This type of space allows the exchange of different points of view, experiences, problems, ideas and resources associated with research and teaching in the educational sector (Ollarves and Chivico, 2008).

In the task of HEIs to achieve a fusion or balance between teaching and research, the role of the researcher-teacher is of utmost importance. The latter is considered an agent of change and socio-educational transformations. This requires a dynamic role that manages to interconnect the knowledge of scientific knowledge through interactivity between peers –teachers, researchers and students–. The aim is to involve students in the research process and furthermore, to motivate collective interest through the transmission of the main findings obtained from the research activity and clear methods of collaboration.

Physical space is important, as it allows the creation of mechanisms that promote group interactions and interconnected ways of working; but it represents only the material basis. In this paper, the mechanisms and tools are discussed in depth, and only some recommendations of the minimum elements that this type of spaces should have are mentioned in a general way (these are indicative and not limiting). Collaborative spaces according to Duart and Sangrà, 2000 cited by Rodríguez, D., Bertone, R. and García-Martínez, R., 2009 are spaces which, given their physical characteristics, should have a specialized newspaper library and library, as well as well-equipped classrooms where workshops or seminars can be held.

Although this contribution lays the groundwork for defining the minimum operating requirements for this type of space, it is also necessary to clarify some elements. First, the newspaper library today can be part of the repository, where you have a collection of digital publications organized in: 1. Scientific production documents -regularly refers to internal production derived from research and teaching-; 2. Papers from other research groups related to the lines of research; and 3. Publication of journals, memoirs, proceedings and periodicals. To make its management possible, the generation of metadata[3] should be considered in order to implement digital consultation platforms or a basic Spatial Data Infrastructure (SDI)[4]. These conditions do not suggest that a collaborative space -considered in this analysis as equivalent to a laboratory- should become a documentary center; rather, it is a matter of consolidating a data and information bank that responds to the requirements of internal users (including research and teaching groups).

These recommendations should be considered as a starting point. The equipment and technological tools to be implemented will depend on the topics, disciplines and activities of the working groups. In addition, computational capacity, connectivity and space distribution, both physical and virtual, must be taken into account, as well as their relationship with organizational objectives.

The classroom space, according to Duart and Sangrà, 2000 in Rodríguez, et al. 2009 has evolved, thanks to technological advances in terms of communication infrastructure and computer equipment. This requires the provision of terminals, with intranet and internet connections, as well as adequate *software* to enable access, analysis, production, exchange and dissemination of value-added information. Any strengthening strategy must consider the use of available technological means and increase them in a sustained manner to generate material conditions that support the training of students and researchers. The aim is to support the researcher in training in his or her learning process, as well as the trained researcher, so that he or she can become a true facilitator of learning and transmitter of research skills (Rodríguez, et al. 2009). The above approach, contrasts with the opinion of Gamboa, Rodriguez F. (2016) who points out, that "Several authors note how little the educational environment has changed" (p. 202). State explained in part, because the educational relationship remains in the verticality and academic unidirectionality reduced to three units: time, place and action; that is, "all in the same place, at the same time, performing the same learning activities" (Moreno, 2007 cited by Gamboa, 2016, p. 202).

Moving from a static state to a dynamic educational environment suggests recognizing that communication mechanisms and methods become relevant over infrastructure and technological equipment. These mechanisms make possible the functioning and give life to the relationships established in the research and teaching-learning processes. This is why rethinking this type of spaces requires putting people (researchers, professors and students) at the center, so that they can be self-managers of their training process.

Methodological tools

As we have seen, collaborative work involves intentional participation to create knowledge through the formation of groups based on novel forms of interdisciplinary

[3] A metadata describes the attributes of a bibliographic, archival, geospatial, etc. resource, whose main purpose is to describe, identify and define a resource in order to retrieve, filter, report on conditions of use, authentication and evaluation, preservation and interoperability. See Ercegovac (1999), in Senso, José A. and De la Rosa, Piñero A. (2003).

[4] Spatial Data Infrastructure (SDI) is a relevant core collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data. This includes geographic data and attributes, metadata, catalogs and web mapping, and some method of providing access to geographic data.

grouping[5]. This makes it possible to design and implement clear and flexible ways of working, based on the principle of complementarity, which serve as a means to achieve the collective objectives. It suggests that working groups and collaborative spaces implement methods and use technological tools to guarantee the necessary conditions for the production of knowledge and collective learning. what methodological mechanisms can working groups use to trigger productive processes based on the principles of co-research in collaborative spaces of HEIs?

As a first approach to this question, we propose the application of a multi-criteria model, which is compatible and contributes methodological elements to co-research and supports the teaching-learning processes, from a collaborative work approach. Multi-criteria analyses are methodological tools that facilitate the understanding of the complexity of a problem, or the uncertainty of a situation or decision, where there are a variety of actors and interests. They operate by contrasting the different valuations assigned by the parties involved in decision making, problem solving or research processes.

There are several multicriteria models (see Rendón, Escamilla, Montaño, & Navarro, 2018), but for this work, the Hierarchical Analysis method of Saaty, (1980) AHP for its acronym in English (*Analytic Hierarchy Process*) has been selected, considering two criteria: 1. It is a method that is compatible with Geographic Information Systems (GIS) and 2. It allows the development of personal contributions -evaluations- to the collective work throughout the research and/or teaching process.

The AHP consists of formalizing the intuitive understanding of complex problems through the construction of a hierarchical model. The purpose of the method is to allow the decision-maker to structure a multi-criteria problem in a visual form, through the construction of a hierarchical model that basically contains three levels: goal or objective, criteria and alternatives (Avila, 2002).

Among its various benefits are the following: It is mathematically based; it allows the incorporation of qualitative and quantitative criteria, by means of a common scale; it includes the participation of various people or groups and generates consensus; it also allows verification of consistency and corrections; it is easy to use and allows the solution to be expressed in various media (tables, graphs, maps, etc.) (Toskano, 2005).

Toskano (2005), points out three elements to be considered by the team in charge of the AHP application: 1. Identification of participants according to their capabilities, skills, knowledge of the problem and interests. 2. Information required. In this case, the focus is on geographic information, although it also includes scientific, technical and tacit information. 3. Time and resources: resources associated with the process, design of a work plan that defines dates, agenda, logistics and participatory techniques.

AHP is complementary to GIS, through spatial analysis. This type of analysis responds to the need to analyze geographic phenomena in a systemic and efficient manner. It enhances the relationship between computer science, cartography and statistical methods (Siabato, 2018). A fundamental element in this type of method is undoubtedly Geographic Information (GI). It is analyzed in terms of its usefulness for the development of research, teaching and decision-making processes. From its construction to its use, GI is based on basic principles derived from

[5] Conceptually speaking, interdisciplinary grouping can be understood from the following concepts: "The word 'discipline', in the sense used in the word 'interdisciplinarity' [...], means a branch of knowledge, instruction, learning, teaching or education. So, 'discipline' is a set of knowledge or skills that can be taught and learned." Seen as action, it "refers to an activity that exists between existing disciplines or in a reciprocal relationship between them", without denying its independence. It is recognized that the "convergence of two sciences [...] requires an operational material continuity [...], and implies the establishment of common material principles. (such as the principles of mechanics or thermodynamics)"; avoiding as much as possible to fall into "a reductionist monism (of a formal nature)". As a process, "Teaching and learning are moments of scientific activity, but they are not necessarily the moment of constitution of scientific theorems but the moment of their transmission"; that is, this type of grouping can affect both research and teaching in IES, through communicative acts (Alvargonzález, D. 2011, p. 387, 388, 389 and 394).

spatial cognition, which is linked to the way in which we structure space and how we relate to it. Its material expression –digital or printed cartography– is nothing other than spatial or geographic information and is the result of the codification of the consequences of everyday activities (Gutiérrez, 2019). It represents one of the main materials used in spatial analysis.

Finally, Siabato (2018) points out that students, researchers and educators at all levels of education, already have massive access to this type of information, with which, it does not represent an impediment to use it.

Method

The methodological strategy based on spatial analysis serves to establish a structured parameter for collaborative work aimed at research and teaching units within the framework of HEIs. To this end, the schematic proposal incorporates initial aspects of the researcher based on the corpus of knowledge of organizational and technological studies, in addition to the experiences applied in both research and teaching processes.

The methodological approach focuses on the opportunities provided by the AHP model; considered in this vision as a catalyst for collaborative processes and facilitates the planning and definition of stages, actions, relationships, mechanisms and support tools. This is an operational research (descriptive-relational), cross-sectional, in which the methodological process is described and an analysis of the possible interactions between the components of the AHP model and the organizational activities and actions is carried out. It is based on a mixed data analysis method: 1. In the quantitative dimension, information derived from two questionnaires applied to internal users of the Urban Form Laboratory of the UAM-Azcapotzalco was used. This was used to identify, segment and diagnose the internal communication system; analysis expressed by means of contingency tables. 2. In the qualitative part, a documentary analysis was carried out to obtain strengths and opportunities in the institutional environment and the opinions expressed by the participants in the Seminar 2021, Urban Laboratories Facing the Pandemic[6], were analyzed to identify the main challenges. This set of empirical elements was used to identify information and training needs, which are part of the definition of an operational problem -in terms of collaborative work- and to materialize organizational opportunities, by incorporating them into the methodological proposal in a structured manner.

Results

Main needs

The starting point is the identification of internal users based on the analysis of their main activities, which are presented in Table 1. In this process, two major segments of interest were identified: 1. Teachers representing 45% and 2. Students equivalent to 55%. Within the first group, 56% stated that they carry out teaching and thesis advising tasks; while 33% of professors diversify their activities even more (teaching, thesis advising, research and

[6] The Urban Form Laboratory, the Urban Studies Area and the Postgraduate Program in Design and Urban Studies, with the support of the Department of Design Evaluation in Time and the CyAD Division of the Universidad Autónoma Metropolitana Unidad Azcapotzalco, organized the Seminar 2021, Urban Laboratories before the Pandemic".

participation in academic committees), and only 11% are engaged in management and/or coordination tasks.

Table 1
Percentage distribution of teachers and students according to their main activity.

Main activity	General segments	
	Teachers (%)	Students (%)
Coordination	11	--
Teaching and thesis advising	56	--
Teaching, thesis advising, research and academic committees	33	--
Student	--	73
Student involved in a research project	--	27
Total	**45**	**55**

Based on this case study, a need is identified to increase the number of teachers involved in research processes.

To identify the availabilities (capabilities, skills and interests) of the users, we used their membership in groups organized according to their line and area of research (categorical variable of membership, which was crossed with the topics of expertise declared by each participant).

Figure 1
Word map according to specialty topics

Note. Prepared by the authors, with information on the percentage distribution of professors and students by line and area of research in relation to the topics of expertise. Processed with TagCrowd.com

According to Figure 1, the topics of specialization of the segments grouped by lines and areas of research suggest that most users consider that geographic, statistical and documentary information are useful in studies on urban issues, as shown in Figure 2.

Figure 2
Word map of the main types of information used

Note. Prepared by the authors, with information on the most useful type of information by line and area of research. Processed with TagCrowd.com

In relation to Table 2, the use of physical spaces available in the HEI facilities, it is interesting to note that the classroom and the laboratory are most frequently used for teaching activities and thesis advising, according to the opinions of the professors. Most of the students make use of these spaces, in addition to the computer room. It is understandable that these spaces are frequently used by the student sector, since their main activity is academic. It is noteworthy that the teachers who stated that they participate in research projects mostly use their cubicles, classrooms and libraries to carry out their activities. This situation suggests that research is carried out in private places and is possibly caused by the lack of collective spaces and/or consolidated laboratories or by the absence of a collaborative method.

Table 2
Percentage distribution of space occupancy by type of main activity

Physical space	Main activity (%)					
	Coordination	Teaching and thesis advising	Teaching, thesis advising, research and academic committees	Student	Student involved in a research project	Total
Classroom	--	14	14	71	--	35
Classroom, Laboratory	--	50	--	25	25	20
Classroom, Cubicle, Library	25	25	50	--	--	20
Classroom, Laboratory, Computer Room	--	20	--	40	40	25

With regard to the strengths and opportunities currently available to the LFU, the following strengths stand out: It has physical, organizational and institutional support capabilities, as well as intellectual capacities, available institutional mechanisms and tools for aligning objectives through affinity and complementarity with similar organizations.

In parallel, the 2021 Seminar participants expressed the opportunities they identified in their laboratories, which were documented as follows:

1. Horizontality at the time of working, being inclusive, encouraging space to enter into research;
2. Interdisciplinary process, interaction with different stakeholders and credit to the information generator;
3. Research agenda as a collaborative tool, use of scientific networks;
4. Knowledge as a central element of collaborative work with a real impact on the collective;

5. Guarantee stability to the work teams in the laboratories;
6. Use of free *software* and sharing mechanisms;
7. It positions scientific work as open science and citizen science;
8. Intellectual co-ownership as a public good;
9. Laboratories as productive units of knowledge.

The results obtained from this organizational characterization are the inputs that nourish the necessary elements to design and apply the AHP according to Toskano's (2005) approach.

Description of the proposal

In response to the needs detected and the challenges identified, the methodological strategy based on the AHP is described as a model for structuring the research-teaching work in collaborative spaces.

The model proposed and described under the LFU reality -for demonstration purposes-, complies with the three elements necessary for initial planning according to Toskano (2005).

1. Identification of participants (teachers and students). In a second level of segmentation, five subgroups selected according to their main activity within the IES were defined: a) coordination, b) teaching and thesis advising, c) teaching, thesis advising, research and academic committee, d) student, and e) student involved in research. The segmentation can go into more detail, if those areas of specialty and/or interest are considered; if and when required. In other HEIs and entities, the number of groups and subgroups may vary, as well as the variables that define the activities, specialization and interests, among others.
2. Information required. Considered as a fundamental element to evaluate and make decisions. It was found that for the segments identified, cartographic, statistical and documentary information was indicated as the main types of information required and used, according to their activities and defined affinities, based on their lines and areas of research, as shown in Figure 2.
3. Time and resources. It considers those resources associated with the process, in addition to the design of a work plan that defines: dates, agenda, logistics and, very importantly, participatory techniques. In this process, only part of the logistics and some suggestions on participatory techniques are developed, as part of a descriptive exercise and not strictly applied.

To address the issue of participatory techniques, the general diagram of the strategic proposal for collaborative work is presented at[7].

[7] Collaborative work is not exclusively to be implemented in groups focused on research projects; it is worth remembering that during the teaching-learning process, students continuously form teams, investigate and analyze objects of study, topics or even territories and spaces. In this sense, the proposed method shows its goodness, since it allows the teacher-researcher to provide methodological elements to the students, so that they can develop it and participate actively, either to identify problems and/or solutions, or to have sufficient criteria to enable them to make a decision. In this way, the methodological tool contributes positively to teaching.

Figure 3

Process diagram for the application of multi-criteria analysis, in collaborative work groups

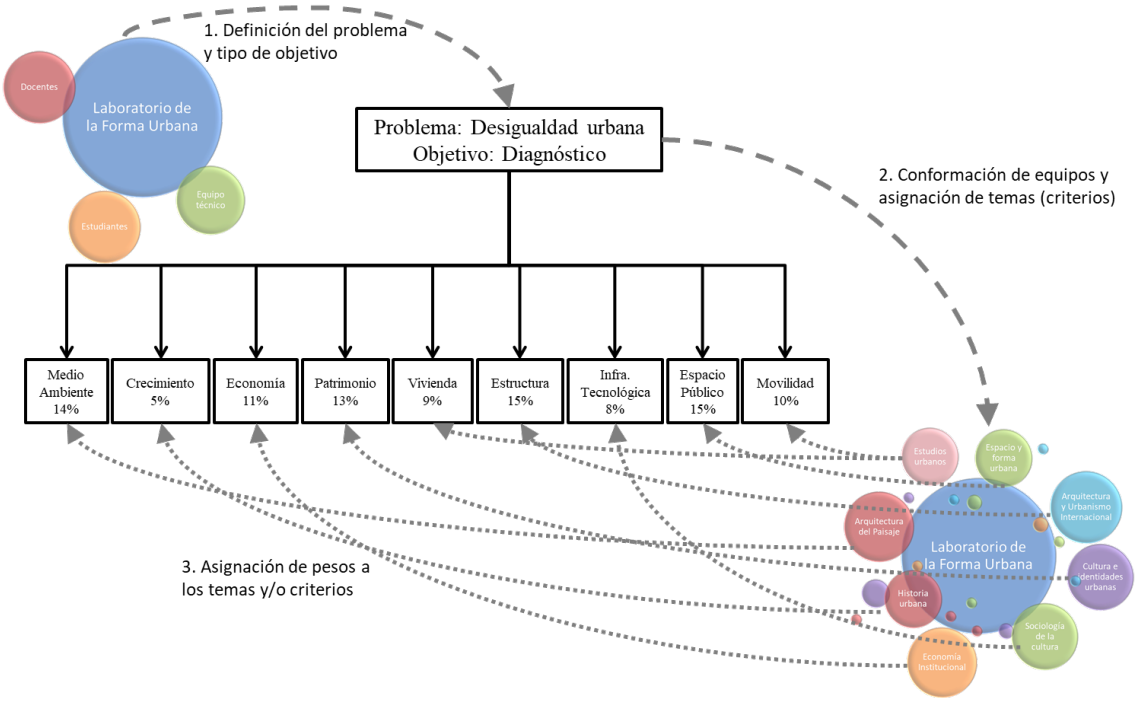
Note. Own elaboration. Between each process, the main activities to be carried out before starting the next one are indicated.

The following processes that can be integrally applied in the research-teaching-learning processes are defined below:

1. Definition of the problem and type of objectives. Based on the register of collaborators and considering their qualities (capabilities, skills and interests), the problem and the objective pursued by the model are defined together. Two types of objectives or goals are usually defined: 1. Diagnostics and 2. Strategic or proposals. In this process, brainstorming is often used based on the analysis of data and information available in print and/or digital media.
2. Formation of teams and assignment of topics (criteria). Based on the definition of the problem, relevant topics are identified and, through their analysis, a better understanding is obtained, allowing the creation or identification of working groups for their analysis and assignment of the topic by group. The register of collaborators from process 1 should be taken up again, considering their respective skills and interests.
3. Assignment of weights to topics and/or criteria. Once the teams have been formed and their topics assigned, weights are assigned. The groups hierarchically order the list of issues identified in the previous process; evaluating their importance or causality, in relation to the objective: to define the problem or design solutions. The weighting or weight assignment techniques may be selected by the thematic teams and defined by them, or they may use the technique in which the technical team has the most experience. It is also possible to use those techniques that adapt to the work methods and the number of participants. The important thing is to collectively define the weight of each topic.

Figure 4

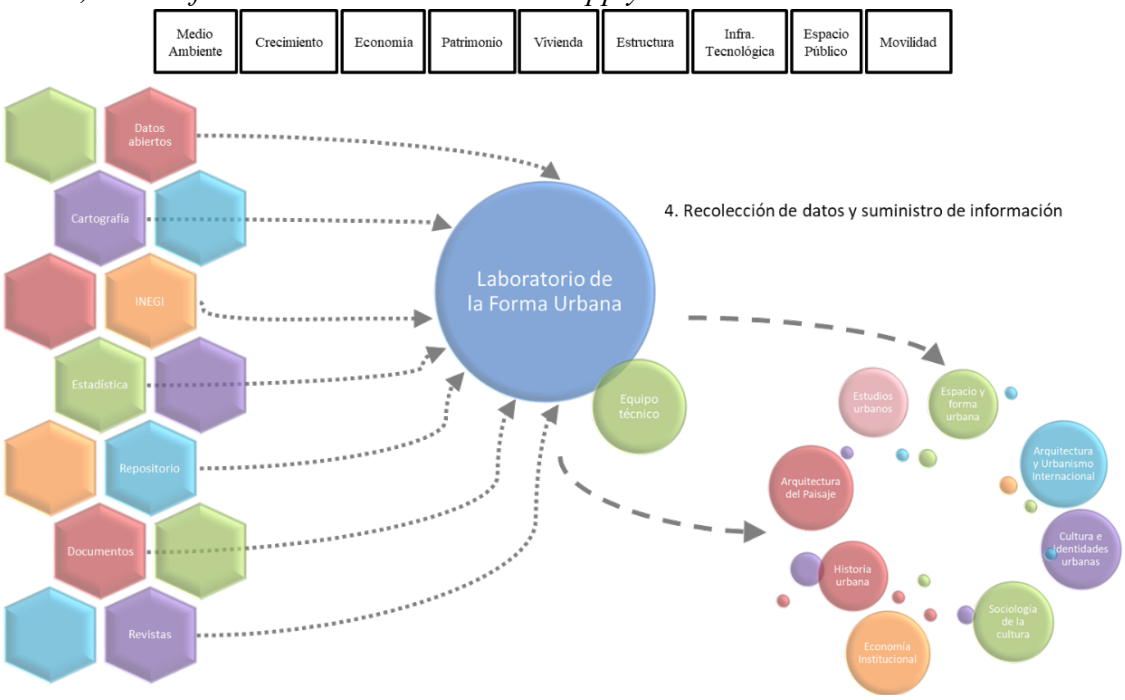
Processes 1, 2 and 3 of the AHP conceptual scheme applied to teamwork in collaborative spaces



4. Data collection and information provision. Data and information (documentary, cartographic and statistical) are collected by the technical team and made available to the thematic teams through shared repositories and data banks. The technical team must guarantee distribution based on criteria of usefulness, timeliness and reliability.

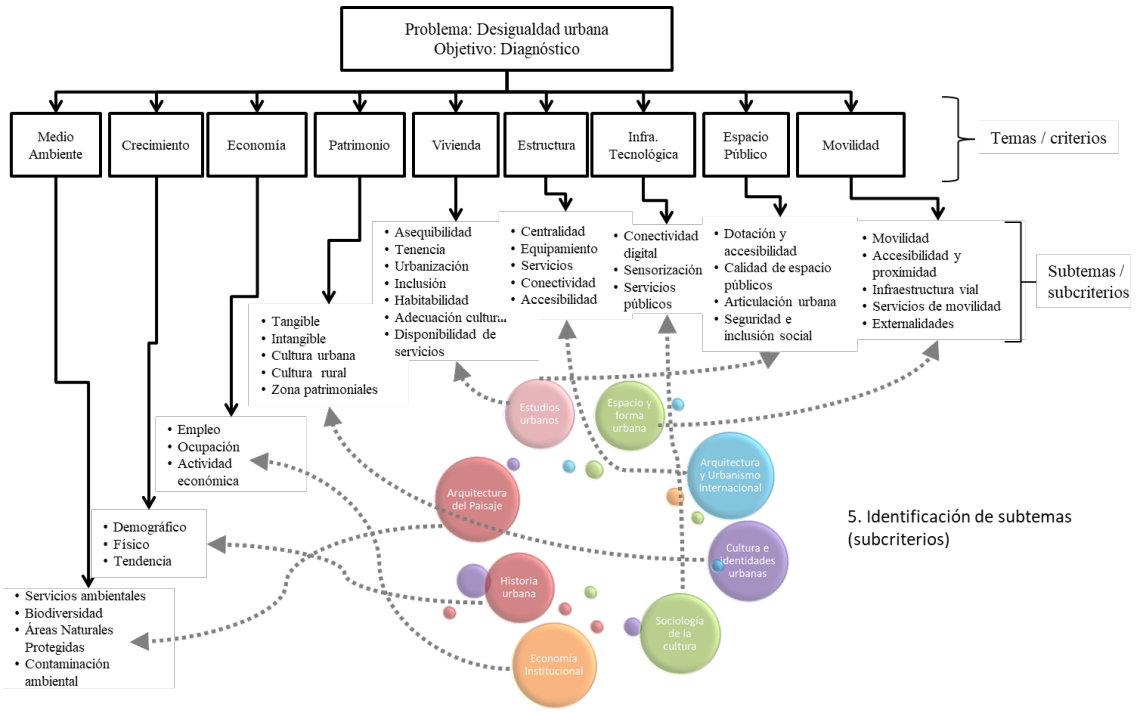
Figure 5

Process 4, outline for data collection and data supply



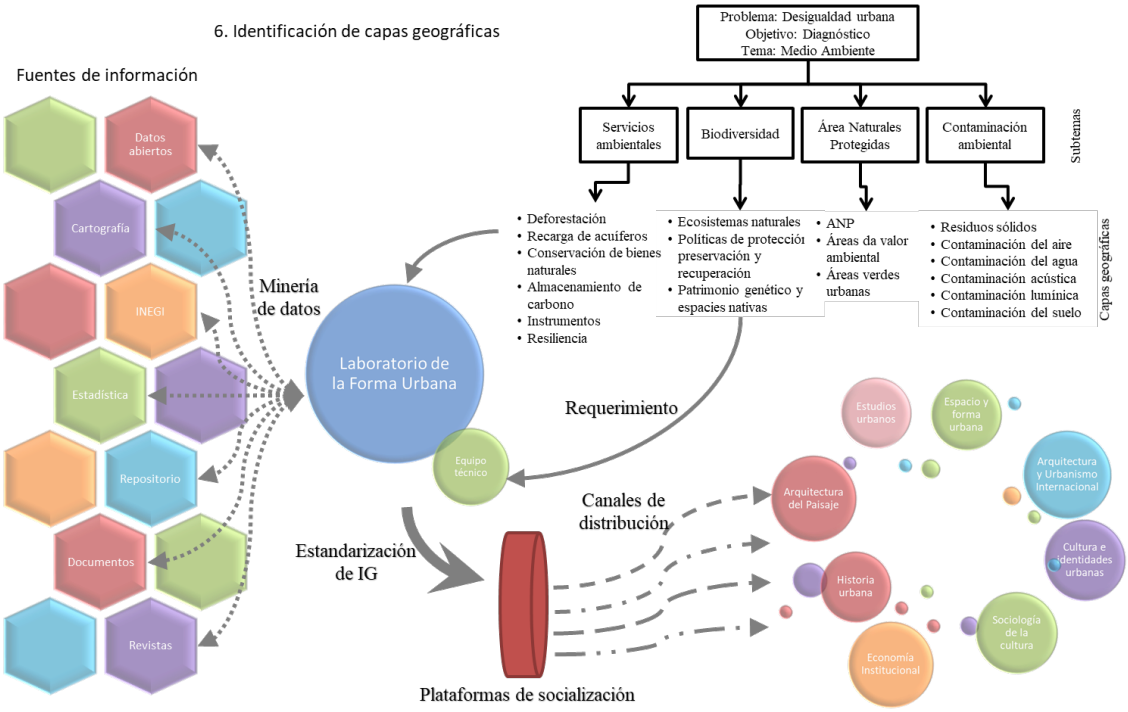
5. Identification of sub-themes (sub-criteria). The work in thematic teams should reanalyze their topic (process 3) to identify relevant subtopics. In other words, it is a matter of disaggregating the problem into topics and the topics into subtopics.

Figure 6
Definition of subtopics



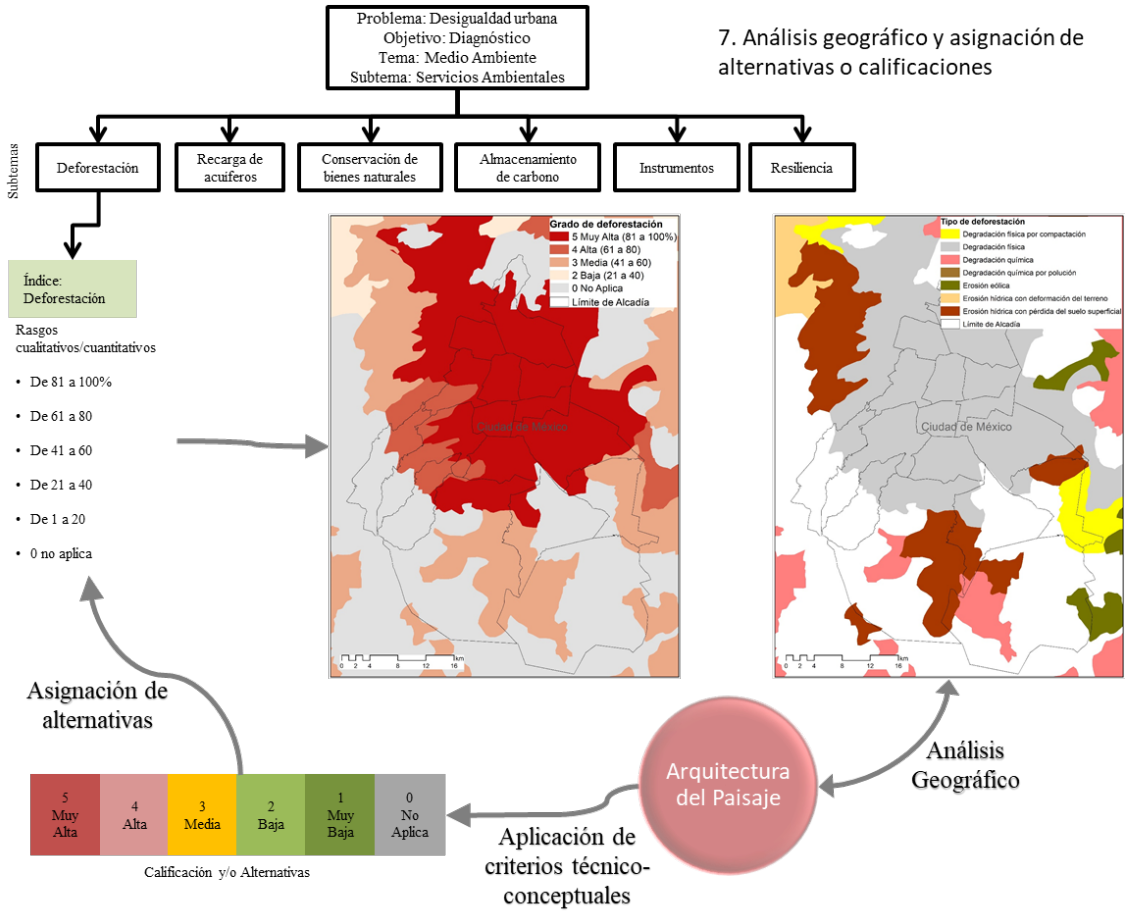
6. Identification of geographic layers. The geographic layers that are relevant to the approach and analysis of each subtopic are identified and selected. The technical team must take care and guarantee that the geographic information is standardized and relevant -updated and interoperable-.

Figure 7
Process for the identification of geographic layers



7. Geographic analysis and assignment of alternatives or ratings. For each subtopic, more than one geographic layer can be identified and used. To this end, each thematic team must have at least one person who can handle cartographic tools. Each geographic layer defines its attributes, understood as categorical or numerical features specific to each geographic element (it is suggested that these be units of analysis in polygons to facilitate the integration of layers). This process consists of assigning alternatives or qualifications to each geographical element, based on its particular features or attributes. The proposed scale ranges from 0 to 5; where 0 does not apply, 1 is very low and 5 is very high. For the assignment, the existing technical criteria that support the decision to assign a differentiated rating must be considered. The valuation of alternatives for each topic or subtopic are assigned, based on the coverage, degree, level and even; existence or not of services or infrastructures. This is to identify each geographic element, through an integer (from 1 to 5), i.e. for a quantitative metric, expressed in percentages of coverage of homes with internet, a value of 5 would be assigned to those geographic units with lower percentages and 1 to those with higher coverage (as long as the objective is the identification of problems or shortages); if the objective is the opposite, it is qualified in an inverse manner. To determine the desired slices and number of classes, GIS *software* has stratification methods (one of the most commonly used in automated mapping is *Jenks*Natural Breaking).

Figure 8
Geographical analysis scheme

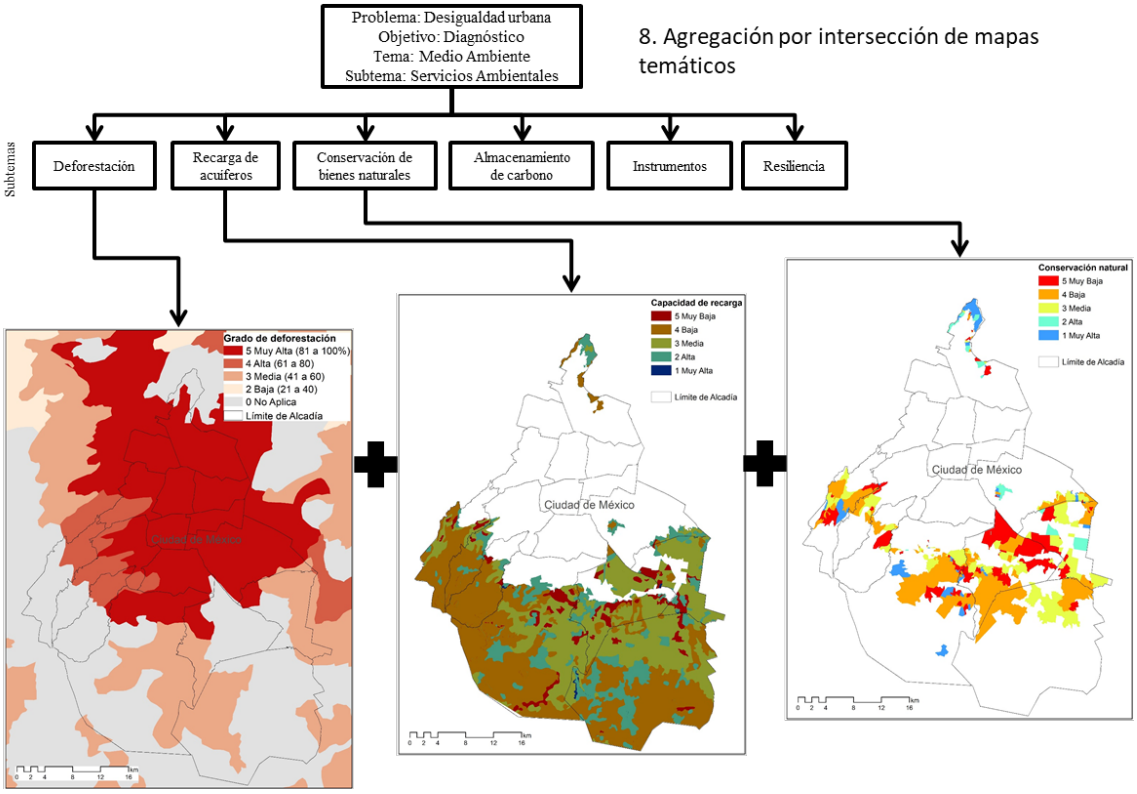


Note. The content of the maps is merely illustrative. Prepared by the authors, based on data from CONABIO: http://geoportal.conabio.gob.mx/metadatos/doc/html/degra250kgw.html

8. Aggregation by intersection of thematic maps. Once the assignment of ratings for each geographic layer has been completed, they are integrated into a map, which summarizes all the thematic maps obtained for each sub-theme. It is a process of aggregation, through the intersection of layers to obtain sets of integrated maps, -with a greater number of geographic units; since some are subdivided, but do not lose their features-. This allows a summation of all the ratings to be applied, so that they can be reclassified again, using the six alternatives mentioned in process 7. Each subtopic will have a synthesis map, which will be added to the general model; in other words, this process of aggregation and synthesis is repeated until the initial level of topic or criterion is reached.

Figure 9

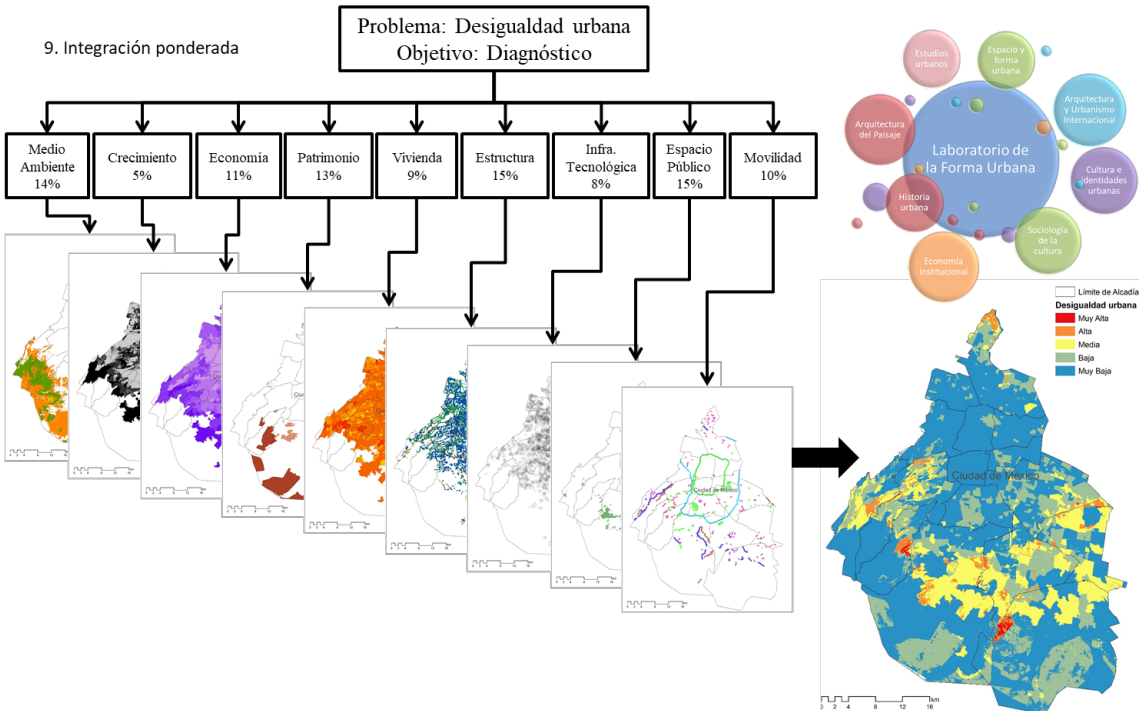
Spatial analysis scheme based on map algebra.



Note. The content of the maps is merely illustrative. Own elaboration, based on data from CONABIO: http://geoportal.conabio.gob.mx/metadatos/doc/html/degra250kgw.html y http://pgot.centrogeo.org.mx/geocontext/viewer/4

9. Weighted integration. In this last step, the integration of all the summary maps of each topic is sought. Each one must be qualified (normalized) on the scale of the alternatives, to be multiplied by the weight or weighting defined collegially in process 3. The intersection between geographic layers is applied and a synthesis map is obtained, which integrates all the cartographic products of the themes and sub-themes.

Figure 10
Scheme for weighted integration of criteria



Note. The content of the maps is merely illustrative. Prepared by the authors, based on data from CONABIO: http://geoportal.conabio.gob.mx/metadatos/doc/html/degra250kgw.html y http://pgot.centrogeo.org.mx/geocontext/viewer/4

The set of maps for each sub-theme, in addition to those that synthesize the results, are extremely important elements, both for the analysis and for the design of intervention proposals. Each represents a relevant input to the understanding of the problem, supports the arguments and identifies causal relationships of expressed problems, and is useful for policy design or decision making. Finally, they provide a methodological structure for teamwork and promote the transition and/or consolidation of collaborative spaces.

Discussion and conclusions

The daily work of teachers, researchers and students has been sharply affected by the effects of the pandemic and the containment policies established by governments around the world. This situation led to the use of technological communication tools that were used as a practical and emergent measure. Many HEIs used educational platforms or developed their own at a fast pace. However, their sudden use forced all sectors to use them without much familiarity. Tools were used without having clear scopes and objectives.

Academic programs became "emergent" but not necessarily innovative. The social distance and the closing of facilities caused a pause in the forms of teamwork. Some academic programs predicted a resounding failure for distance education; however, research and teaching processes were triggered in this modality -which would be pertinent to analyze in other research-. There are other less pessimistic views on the case. These point out that the reduction of travel time to work, school and other places served to increase productivity and reduce

environmental impacts, among others; valid opinions even when there is no clear data on the effects of teleworking and distance education.

In this reality, the ways of working are increasingly provocative and also require new processes for working at a distance, in hybrid or semi-presential formats -the latter referring to the educational context-. Thus, in the midst of the conceptual crisis and social, economic and health uncertainty, the forms of collaborative work and the technological and methodological tools are added to the discussion and reflection. Responding to these new demands suggests taking up existing methodological approaches and adapting them to particular needs.

In relation to this work, the proposed methodological strategy is explained in a structured manner, responding to the needs and availabilities detected in the object of study. This is intended to be motivating, not only for the community analyzed, but also to trigger processes in similar institutions. The methodological exercise takes up different concepts and perspectives, whose categories and descriptions served as a basis for the analysis of primary variables. In this sense, teamwork, collaborative spaces, co-research and spatial analysis were relevant throughout the research. Their presentation gives meaning to the collaborative strategy proposed and described.

Teamwork was considered as the intentional collaboration to actively participate in the generation of knowledge. These collaborative forms should consider the design and implementation of innovative and proactive strategies that encourage collective participation. In HEIs, these collectives should be consolidated through the work of teachers, researchers and students, to enrich and strengthen the teaching-learning processes, in all directions and scales. The aim is for institutions to define and build their organizational culture, based on complementarity, in order to increase their intellectual capital.

In university environments, especially teachers and students have received countless work programs, guides, methods and instructions, as well as training courses for the technical management of ICT and alternative methods on distance, blended or hybrid educational systems. Collaborative environments have mainly referred to virtual environments and have shown their advantages in a short time. Taking up the approaches of methods such as AHP in this environment and adapting it to the work methods characteristic of each type of organization will have positive consequences for its own development and improvement. It also provides an opportunity to publicize its usefulness and benefits to the organization and, above all, to working groups, whether they are social, educational, public or private. The AHP takes advantage of technological skills - by necessity developed in practically all sectors of society - to combine them with technical work tools for the production of information.

It is a proposal that proposes to detonate teamwork, strengthen pre-existing collaborative spaces for the integral development of research and teaching; it is also a methodologically structured strategy that can be adapted to similar cultures, institutions and organizational forms.

The main conclusions derived from this research are as follows:

1. The AHP is a method that can be adjusted to different realities and types of organizations. In IES, it can be implemented by collaborative research groups, by student teams, or mixed -the role of the professor-researcher becomes relevant in his role as facilitator and/or coordinator-.
2. The AHP, when complemented with diagnostics based on the theory of organizational studies, allows the technical and/or managerial group to form balanced teams, strengthened by the capabilities, skills and interests of its elements.

3. Its adaptability allows its use in work teams for the integration of research and teaching, the latter through the active incorporation of students in the former.
4. Its structure is very simple, allowing the problem to be broken down for analysis and understanding at different scales.
5. It allows for group work through participatory techniques without diverting attention from the objective.
6. It does not require for its operation a robust technical team, but it does require technical capabilities in the management of GIS, digital platforms and participatory techniques.
7. It is increasingly common for working groups to use spatial analysis as a tool that allows them to develop procedures for the analysis of geographic data. These make it possible to obtain additional knowledge about the dynamic characteristics and behaviors of the multiple processes occurring in a given space. For this reason, spatial analysis is considered as one of the articulating axes of this proposal.
8. Information management is simple for two reasons: a) Hierarchical schemes give direction to data and information flows and b) They allow control of information based on time, space and action variables.
9. Through its development, it generates organizational learning in two directions: a) In the way work teams react and operate, and b) In terms of the production of information, knowledge and learning.
10. Although it is not a new method, it manages to unleash innovative processes, it tightens links, finds affinities and complementarities; and above all, it enriches the research-teaching-learning process.
11. Both the organizational diagnosis and the AHP put people at the center. The first, by identifying their needs and availabilities; the second, by considering the human factor as the main decision-maker for the allocation of alternatives, which are not based solely on expert knowledge.

Although several advantages are mentioned, it must also be recognized that within the working groups there are divergences and opposing points of view. Most of the complications faced by this proposal for its application in HEIs are caused by a working environment of low trust - derived in part from the competition and individual production of research -; the lack of adequate and unconsolidated spaces that encourage group or team work; the absence of technical teams specialized in multi-criteria spatial analysis, - neglect of continuous training - and weak promotion and application of organizational techniques to encourage collaborative work. To face these challenges, it is suggested that HEIs be receptive to ways of working that prioritize the co-production of knowledge through the work of research groups and consolidate collaborative spaces. The role of teacher-researchers becomes indispensable for the promotion and application of methodological tools for co-research, both in their work spaces and in the classroom. These are just some of the challenges and suggestions; however, it is necessary to further study their weaknesses in practice, in order to identify those factors to be considered in order to solve possible conflicts and respond assertively to current and future challenges. The concepts of democratization of research, open or citizen science would help to continue to deepen in this regard.

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