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Inter- and transdisciplinary experience in a sustainable housing project in Yucatan, Mexico◊

Experiencia inter- y transdisciplinaria en un proyecto de vivienda sustentable en Yucatán, México

Abstract | Transdiscipline has become a paradigm towards which academic research systems shall evolve, considering that our complex socio-environmental problems require new knowledge production approaches to understand these phenomena and provide clearer and more comprehensive alternative solutions. This paper analyzes both the achievements in the multisectoral configuration of a research group formed for the development of a sustainable housing project in Yucatan, Mexico, and the obstacles and limitations that were encountered in the framework of the new orientations that are being given in the federal scientific and technological policy in Mexico. The paper points out a conceptual review on sustainable housing and inter and transdisciplinary research. The paper also discusses the current shifts in scientific and technological policy; the local context of Merida, where the research was developed and the implications of the new policy frameworks in the development of the project are analyzed, especially in terms of dialogue between participants from different disciplinary fields and social sectors. Finally, the experience of transdisciplinary work through the involvement of community groups in the project is analyzed.
Keywords | inter and transdiscipline | sustainable housing | science and technology policies | Yucatan, Mexico.

Resumen | La transdisciplina se ha convertido en un paradigma al cual deben transitar los sistemas de investigación académicos, considerando que la complejidad de nuestros pro-

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blemas socioambientales requiere establecer nuevas formas de producción del conocimiento que permitan comprender con una mayor claridad e integralidad estos fenómenos. En este artículo se analizan tanto los logros en la configuración multisectorial de un grupo de investigación conformado para el desarrollo de un proyecto de vivienda sustentable en Yucatán, México, como los obstáculos y limitaciones que se tuvieron en el marco de las nuevas orientaciones que se están dando en la política científica y tecnológica federal en México. El trabajo apunta una revisión conceptual sobre la vivienda sustentable y la investigación inter y transdisciplinaria. Se discuten también los giros que se están dando en la política científica y tecnológica; el contexto local de Mérida donde se desarrolló la investigación y se analizan las implicaciones de los nuevos marcos de política en el desarrollo del proyecto, especialmente en cuanto al diálogo entre participantes de diferentes campos disciplinarios y sectores sociales. Finalmente, se analiza la experiencia de trabajo transdisciplinario que se tuvo, a través del involucramiento de grupos comunitarios en el proyecto.
Palabras clave | inter y transdisciplina | vivienda sustentable | políticas científicas y tecnológicas | Yucatán, México.

Introduction

TRANSDISCIPLINE HAS BECOME a paradigm towards which all academic research systems shall evolve, considering that our complex socio-environmental problems require new knowledge production approaches to understand these phenomena and provide clearer and more comprehensive alternative solutions. Today, socio-environmental transformations occur at global scales, albeit with particular characteristics in each territorial context.

This paper analyzes the experience of a research group working in Yucatan, Mexico, seeking the joint production of knowledge about sustainable housing to address precarious households in the outskirts of Merida, the capital city of the state of Yucatan. This city enjoys a positive image at national and international levels, supported by high safety and quality-of-life indices (Bolio 2014). As a result, immigration has increased, leading to accelerated urban growth that has boosted housing construction projects. This phenomenon has influenced in the increase of land, construction, and real estate prices (Combaluzier 2021).

At the same time, Merida also experienced decades of immigration of rural populations into the city in search of better job opportunities and urban services. Some of these groups settled in periurban areas of southern Merida, where communities have faced difficulties buying their own houses, in addition to household overcrowding and self-construction, frequently unfinished. In turn, the city has historically experienced a high socio-spatial segregation where the northern

zone enjoys important privileges while the southern one has been relegated (López 2019).

Within this framework, in December 2020, the research group undertook a project to seek sustainable housing solutions in Merida, Yucatan, through technological innovations, submitting it to the National Council of Science and Technology (Conacyt, in Spanish), the agency of the Mexican federal government in charge of scientific and technological development.[1] It is worth noting that the current federal government has sought to focus the research agenda on environmental sustainability issues, aimed at addressing social needs and national problems. This led to the formation of an inter and transdisciplinary team involving different academic institutions, local government agencies, civil society organizations, citizen groups, and social-based organizations living on the periphery of the city.

The present work analyzes the achievements in the work team multisectoral conformation and the obstacles and limitations faced during this experience. It is important to point out that this is not a research paper, but rather a narrative, critical and reflective process based on the experience of the authors as participants in an inter and transdisciplinary research group, with the purpose of contributing empirically to the analysis of the implications of these methods for the production of new knowledge and the solution of concrete problems, as in the case of sustainable social housing.

The paper begins with a conceptual review of sustainable housing and inter and transdisciplinary research. It then discusses the new orientations that are being given in the federal scientific and technological policy. Subsequently, the local context in which the studied project was carried out is analyzed, as a prelude to the presentation of the experience studied and the analysis of the challenges that arose in the development of the research, in the new policy framework, especially regarding the dialogue between participants from different disciplinary fields and diverse social sectors. Next, the involvement of the communities of the peripheral areas of Merida, Yucatan in the project is addressed, particularly through the development of participatory workshops. Finally, reflections from the analysis of this experience are presented.

1 It is important to point out that, in terms of the timeline, the paper refers to Conacyt until May 7, 2023, given that the project application was submitted in 2020 and the validity in 2022. The most recent changes in science, technology and innovation policy took place with the approval of the General Law on Humanities, Science, Technology and Innovation on May 8, 2023, at which time the organization responsible for science in Mexico adopted the acronym H, changing from Conacyt to Conahcyt (National Council of Humanities, Science, Technology and Innovation) (DOF, 2023), so that the paper will refer to Conahcyt when referring to events occurring after that date.

Volumen 13, número 36, (201-224), mayo–agosto 2025
DOI: https://doi.org/10.22201/ceiich.24485705e.2025.36.91373

About the notion of sustainable housing

Housing is the most intimate space of the humans who inhabit it and although from an administrative perspective it is a habitable material space, it also reflects sensitive spaces of the way of life, cultural identities, family needs and climatic conditions, representing the complexity of social relations that must be satisfied (García 2021). While for some privileged social groups, it is a reflection of aesthetic styles and preferences, for the most vulnerable groups it is a result of their economic possibilities and limitations (Canché *et al.* 2024). Therefore, the issue of housing needs to be approached from different disciplinary approaches, such as architecture, urban planning, engineering, sociology, political science, environmental science and anthropology, to mention a few; which is a reference for the inter and transdisciplinary approach of the team formed for sustainable housing in periurban areas of Merida, which is analyzed in this paper.

Housing is a basic right, as enshrined in Article 4 of the Mexican Constitution, according to which "every family has the right to enjoy decent and dignified housing". However, the housing of vulnerable populations represent different problems such as the insecurity of the materials with which they are made, overcrowding, lack of public water, sanitation or electricity services, and even their settlement in unsafe or at-risk areas (Canché *et al.* 2024). Moreover, in many cases these social groups do not enjoy security or property certainty, having to improvise their homes in precarious conditions, many in rented or other relatives' homes, or in unfinished projects, all of which deteriorate their quality of life (Cruz *et al.* 2024). It is considered that in Latin America these scenarios are faced by popular settlements that constitute 60 to 70% of urban areas (Fidel and Romero 2017).

Thinking about the habitability of housing in contemporary societies also requires considering sustainability. This is an essential factor if we consider that the increased urbanization processes have contributed significantly to aspects such as the fragmentation of ecosystems, changes in land use, reduction of forest areas and many other socio-environmental impacts that entail risks for current and future populations, which increase in vulnerable areas. It is therefore necessary to consider sustainability criteria in low-income housing throughout the entire life cycle of the building, from design, construction and operation to its destruction (Solís, Robles and Rodríguez 2020).

Sustainable housing has been conceived from different perspectives that include the architectural —use of efficient life and long useful life of the building—, and the institutional quality of housing and the environment that favor the responsibility of neighbors with their community (González-Yñigo and Méndez-Ramírez, 2018). Therefore, from this second point of view, in Mexico, sustainable housing, in addition to considering environmentally friendly criteria, links a sustainable ope-

ration in terms of energy and water saving, for which the incorporation of eco-technologies is required (Infonavit [2010] cited in González-Yñigo and Méndez-Ramírez, 2018), such as solar cells or wastewater treatment plants.

Fidel and Romero (2017) specify that the use of ecotechnologies in the design and construction of housing requires a participatory approach, where the knowledge and perspectives of the populations involved are integrated to the specialized technical knowledge. Experience has shown that participatory processes generate more solidarity and commitment among inhabitants, allowing a greater collective appropriation of spaces, as opposed to planned real estate projects, many of which have an industrialized and unsustainable production. In short, the interaction between multiple knowledges can lead to better solutions, overcoming the problems generated by a technocratic vision of housing (Fidel and Romero 2017), a line that was also traced in the call from which the project analyzed in this paper arose.

In this tenor, some factors of sustainable housing referred to in this topic's literature include the materials used for construction, which generate the lowest possible environmental cost, systems for the rational consumption of water and energy, natural ventilation and lighting, optimization of living space and even the reuse of materials at the end of their useful life (Mingüer 2017). Sustainable housing also involves overcoming the anthropocentric vision that governs the idea that humans can take over any territory and adapt it to our needs and tastes, including other criteria related to the reduction of ecological impacts in the transformation of natural spaces (Mingüer 2017).

In line with the above, the call to which this project subscribed stated that "one of the particular objectives of Conacyt in terms of research on sustainable housing and cultural and environmental relevance [...] is to promote the formation of interdisciplinary, inter-institutional and cross-sectoral research and advocacy groups that understand, in their complexity, the fundamental problems of housing and, in general, of habitat" (Conacyt 2020a). To this end, it motivated the enunciation of proposals aligned with SDG 11 that included, among other aspects, approaches to climate change mitigation; buildings resilient to disaster risks and public health; collaborative innovations for the development of technological systems; optimization of the life cycle of housing from a circular perspective; articulation to the regional vision of adequate housing and sustainable cities; and housing as a mechanism for food security and sovereignty (Conacyt 2020b).

In the project analyzed here, particular aspects of sustainability in housing were considered in the context of the subtropical climatic environment of a city like Merida, where high temperatures and humidity conditions remain throughout the year. Therefore, some sustainable strategies contemplated the design of envi-

Volumen 13, número 36, (201-224), mayo–agosto 2025
DOI: https://doi.org/10.22201/ceiich.24485705e.2025.36.91373

ronments with cross ventilation, which allows regulating the high temperatures of the environment, the generation of shadows to prevent overheating, a greater use of vegetation (trees or green walls) and design of roofs and walls that provide shade (Canché *et al*. 2024). Another crucial aspect was the development and use of ecological materials to replace more traditional cement-based materials, and the replacement of natural wood with plastic or composite plastic wood, in order to reduce deforestation, allowing the use of other natural fibers whose residues can be reused (e.g., agave bagasse, sugarcane, rice husks, etc.) (Canché *et al*. 2024).

Semblance of inter and transdiscipline as approaches to socio-environmental research

The inter and transdiscipline concepts are closely related to the sustainability challenges emerging over several decades to preserve life on Earth. These imply understanding highly complex (Morin 1990; García 2006) and dynamic socio-environmental issues, which remain permanently uncertain (Funtowicz and Ravetz 1999). Both inter and transdiscipline stem from new configurations of academic research teams that require expanding their own epistemological conceptions to achieve a greater impact on the transformation of reality (Giraldo and Arancibia 2023).

Various disciplines come into contact in interdisciplinary research, modifying their methodological structures and leading to interdependency, ultimately resulting in the integration and enrichment of knowledge (Torres 2000). It should be noted that work teams include specialists from different fields of knowledge and disciplines, meaning that interdisciplinarity is a characteristic of research processes rather than work teams, which are multidisciplinary.

Transdiscipline is considered a higher stage of interdisciplinarity (Delgado 2019), where it is essential to include various population interests and values (Klein 2008) to influence the transformation of socio-environmental problems. This involves the need to incorporate non-scientific knowledge provided by different social stakeholders, which contribute, from diverse experiences, perspectives, and worldviews, to understanding complex issues within specific territorial scenarios.

The above means that transdiscipline is needed for both theoretical and practical perspectives (Luengo 2012), which implies the impact on the design of better public policies and the collaboration with various social actors to solve a specific issue. Consequently, in transdiscipline, methodological and theoretical boundaries fade away to integrate practical, technical, or traditional knowledge through intercultural dialogue to produce a novel knowledge system about a phenomenon that science itself could not totally explain or solve on its own (Delgado 2019; Luengo 2009).

One approach to undertake transdisciplinary work is through Participatory Action Research (IAP, in Spanish), which contributes to social change as it can potentially increase the influence of participants to promote this transformation. It can also foster the development of the community involved, promote leaders, solve issues according to their priority, stimulate self-help, and strengthen solidarity and collaboration among community members (Balcázar 2003).

In practice, thinking about transdiscipline implies an aspiration rather than an attained goal and entails a paradigmatic revolution. This approach will require a gradual change in the traditional way of organizing academic communities and improving communication or "translation" and mediation processes during the dialogue between multiple languages, values and interests (Luna and Velasco 2021). This aspect is analyzed in the interaction between the heterogeneous actors who were members of the research group discussed in this work.

Orientation of public policy in science and technology in Mexico and strategic national programs

The current Mexican government, known as the Fourth Transformation or 4T (2018–2024), has set out different policy action frameworks that prioritize social welfare and brings an end to the neoliberal period, seeking a regime shift. The science and technology area has not been left aside of these changes. In particular, the sector now called Humanities, Sciences, Technologies and Innovation (HTCI) has evolved toward a paradigm shift, focusing on the human right to science, the social impact of research, support for disadvantaged groups through the exchange of knowledge, and participatory research, seeking universal access to and the democratization of knowledge (Conacyt 2018).

It is worth mentioning that these changes in public policy regarding science, technology and innovation were embodied with the approval of the General Law of Humanities, Science, Technology and Innovation on 8 May 2023; on this date, the government agency responsible for science in Mexico included the H in its acronym, changing from Conacyt to Conahcyt (DOF 2023).

In this reference framework, the National Strategic Programs' (Pronaces, in Spanish) budget program aims to set the basis for the collaboration and convergence of academic communities to promote a more effective and efficient use of public resources to benefit the population and the environment (Conahcyt 2023). This way, Conacyt defined ten Pronaces with a vision of bringing comprehensive attention to strategic issues, considering theoretical-practical knowledge and seeking a continuous dialogue to trigger inter and transdisciplinary research and high social impact (figure 1). These Pronaces include housing, the framework of the experience analyzed in this work.

Volumen 13, número 36, (201-224), mayo–agosto 2025
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Figure 1: The ten Conahcyt's National Strategic Programs.

Source: Conahcyt (2023).

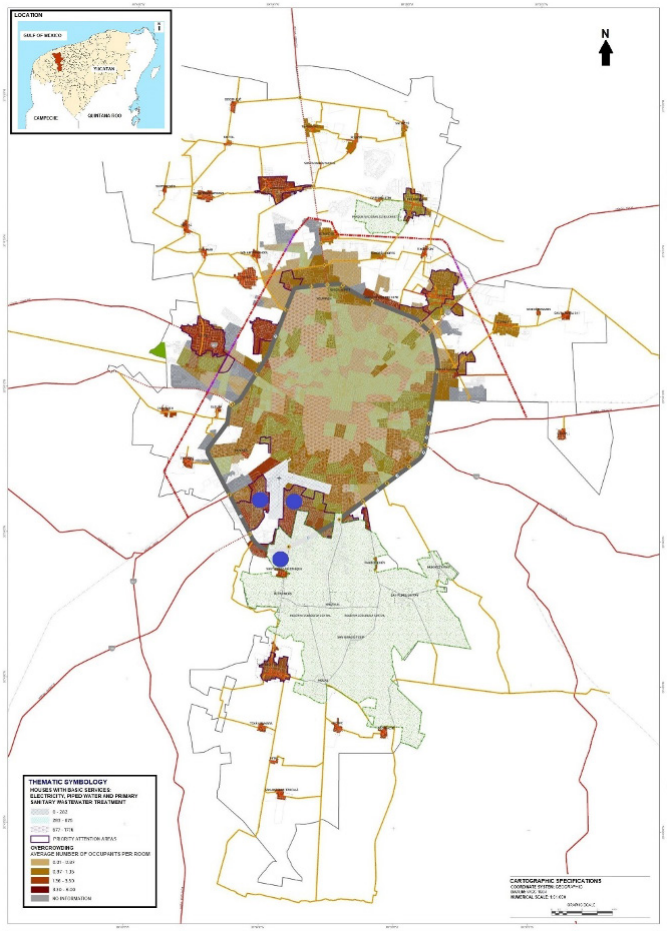
The guidelines established by the government implied submitting a proposal for a pilot project to be conducted over three months; in case of a favorable response, we would propose a more ambitious project of broader scope, called the National Research and Impact Project (Pronai, in Spanish), to be carried out over three years. The pilot project was given a favorable resolution to receive financing for its execution and gave way to the formation of the work team, as described in the following section. However, it did not make it to the next phase, which is suggestive to reflect on the practical implications of projects of this type, in which a good number of sectors of the country's scientific and technological communities have not been involved.

Merida, Yucatan facing the housing problem

The municipality of Merida, capital of the state of Yucatan, located in the southeast of the country, has an area of 854.41 km². It is a hybrid territory with an urban and rural area, which, on one hand, has an urbanized center that starts from the foundational area towards the outside, with a physical limit represented by the peripheral ring road; and after this, there is a large extension to the north and south occupied by 47 rural or urban localities (figure 2). The urban part is made up of neighborhoods and subdivisions, and the rural part is made up of 12 police stations and 35 sub-commissaries.

The purple circles indicate the areas inhabited by the groups of citizens to whom participatory workshops were given (adapted from cartographic map).

Figure 2: Geographic location of Merida's priority attention zones.



The purple circles indicate the areas inhabited by the groups of citizens to whom participatory workshops were given (adapted from cartographic map).
Original source: Instituto Municipal de Planeación de Mérida (2023). Original information in Spanish.

Mass housing construction, industrialized and unfocused on the concept of Decent Housing, became an emerging activity to mitigate the crisis of the henequen industry starting in the 1980s and became the main source of employment, to the extent that the construction sector's share in the state's GDP surpassed the national average. As a consequence, the percentage of urban population coming from rural areas increased notably from that decade onwards, increasing the urban surface and the metropolitan area in the municipality, where an important

Volumen 13, número 36, (201-224), mayo–agosto 2025
DOI: https://doi.org/10.22201/ceiich.24485705e.2025.36.91373

role was given to urban and real estate megaprojects (Iracheta and Bolio 2012, 49-53). On the contrary, in the south, the low value of the land and the low interest of construction entrepreneurs in acquiring and investing in it (in contrast to the land in the north, northeast and northwest of the municipality), have led to a less aggressive change of land use, but still present through some real estate developments.

Merida has been a city in constant dynamism and growth, which has been marked throughout its history by "a dialectic of inclusion/exclusion that accentuates the social inequality and spatial segregation inherited from the previous economic model, although with new characteristics such as the accelerated privatization and fragmentation of the metropolitan space" (Bolio 2014, 31-32). This phenomenon is explained by the neoliberal reforms imposed since the 1990s, in particular, the Agrarian Law of the Salinas regime, which allowed the transfer of large areas of periurban *ejido* land to private hands.

One of the most important problems faced by the low-income rural population is housing. This need has been solved by living in small, affordable houses, generally located in the southern periphery. The low sale or rental prices are one of the main reasons that make the peripheral areas accessible to the low-income population. However, as mentioned above, these homes do not have the minimum quality characteristics, so people live in precarious, overcrowded and unsanitary conditions, as well as in urban insecurity due to the lack of public services. According to the National Council for the Evaluation of Social Development Policy (Coneval 2020), in 2018, 79.6% of the population of Yucatan lived in a situation of poverty or vulnerability due to deprivation and income, which has a direct manifestation in the lack of access to housing, which this Council considers among the factors of poverty due to a lack of patrimony.

Opportunities for poor families to access housing are scarce because they currently have no access to traditional sources of financing, since they do not work in the formal economy and generally have nothing to back them up in order to be considered creditworthy with banks. In fact, their only hope of improving the conditions in which they live is that the government will transfer to them, through social programs, a minimum resource to improve the quality of their housing; for example, through access to land and/or construction materials. However, social housing is one of the areas with the highest rates of backwardness in this region, since the current housing policy, which withdrew subsidies, has reduced the possibilities of access to housing for thousands of families in vulnerable conditions (Montañez 2021).

This social problem is compounded by the environmental impact of the aggressive and vertiginous growth of the city, especially through real estate megaprojects, causing heat islands in the city, which with climate change are gradually

increasing temperatures, which have been intensifying in the peripheral houses of the city (Villanueva-Solís and Torres 2023). Another worrying situation is the lack of drainage in the Yucatan peninsula, which means that dirty water drains directly into the subsoil, contributing to the contamination of the peninsula's aquifer, the only source of fresh water supply in the region (Febles-Patrón and Hoogesteijn 2008). One more aspect to mention is the high-energy expenditure in homes and establishments, especially for the use of air conditioners, which leads to an electricity deficit in the state of Yucatan (Alavez and García 2019).

Due to these problems, the Merida City Council defined the south of the municipality inside the peripheral ring as a priority attention zone (see figure 6), because it is where the populations of lower economic resources are settled and where the backwardness regarding the minimum conditions of habitability and provision of equipment is greater. In accordance with these guidelines, our research group chose this southern zone, in order to contribute with the proposal to improve the living conditions of this sector of the population, with a perspective of environmental sustainability, as will be detailed below.

The sustainable housing research group: challenges facing the complexity of inter and transdisciplinary dialogue

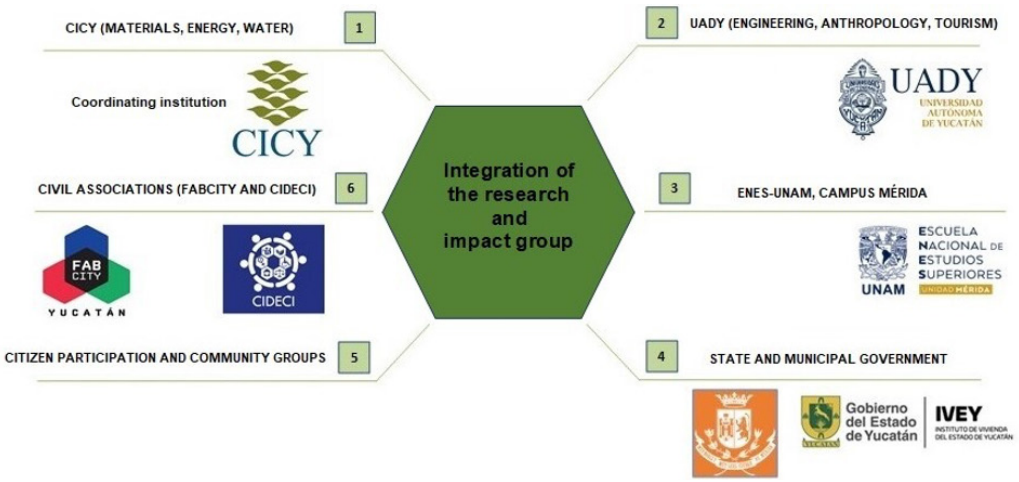
The research-impact group created to address the Housing and Habitat Pronaces brought together different fields of specialty and academic and life experiences. The initial academic core had shared a previous project coordinated by the Center for Scientific Research of Yucatan (CICY inn Spanish) between 2008 and 2012, entitled "Development of a self-sustainable ecological housing" financed by the Conacyt-Government of the State of Yucatan Mixed Fund. In the group of this new project specialists from CICY's materials area were included, with PhDs in chemical engineering sciences and polymeric materials, and a master's degree in communication with experience in science policy and regional development; from the Autonomous University of Yucatan (UADY in Spanish), two PhDs participated, one in engineering and the other in architecture; from the National School of Higher Studies (ENES UNAM Mérida, in Spanish), a researcher in public policy and a master's degree in architecture, with experience in social planning, citizen participation and participatory design of public spaces. From the government side, officials from the Housing Institute of the State of Yucatan (IVEY, in Spanish), specialists in urban development and planning, as well as liaison personnel from the Municipality of Merida for liaison with social organizations and community groups collaborated. From the civil associations, people with experience in community work and work in urban areas were involved.

Volumen 13, número 36, (201-224), mayo–agosto 2025
DOI: https://doi.org/10.22201/ceiich.24485705e.2025.36.91373

The purpose for each member was to contribute to the project development from interdisciplinary and transdisciplinary perspectives while seeking to generate a pilot Participatory Action Research (PAR) that emphasized in the exchange knowledge methodology with the population involved in the problems addressed. The participants included academic organizations, municipal and state government agencies, grassroots social organizations and communities in the study area.

From an institutional perspective, the group was composed by specialists from the following institutions: Centro de Investigación Científica de Yucatán, A. C. (Center for Scientific Research of Yucatan; CICY in Spanish, the project applicant and coordinator) through several research units: Materials, Renewable Energy, Water Sciences and Research Directorate; Faculty of Engineering and Faculty of Anthropological Sciences, Universidad Autónoma de Yucatán (Autonomous University of Yucatan, UADY in Spanish); Escuela Nacional de Estudios Superiores (National School of Higher Studies), Campus Mérida (ENES-UNAM Mérida, in Spanish); Instituto de Vivienda del Estado de Yucatán (Housing Institute of the State of Yucatan; IVEY); City of Merida (Directorate of Social Development); social organizations such as Fab City Yucatán A.C. and CIDECI, A.C.; as well as the following Citizen Participation Councils and Community Groups in Merida, Yucatan: two groups from Colonia Emiliano Zapata Sur 3, a group from Emiliano Zapata Sur 1 and 2; a group from Colonia San Antonio Xluch; and the Community Groups of San Luis Sur Dzununcán and San Juan Bautista. Figure 3 outlines the integration of the research and impact group.

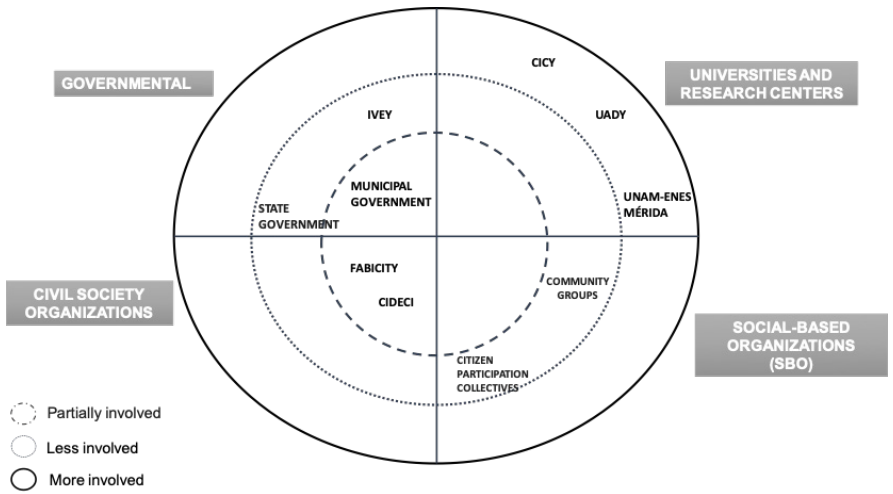
Figure 3: PRONAI Research and Advocacy Group.



Source: Cruz *et al*. (2022). Original information in Spanish.

It is important to mention, according to the map of actors (figure 4), that the degrees of participation and collaboration in the research collective were different for each sector, which we classified into four groups, namely: 1) governmental, 2) universities and research centers, 3) civil society organizations and 4) social-based organizations. As can be seen in figure 4, academic institutions had a higher degree of involvement, secondly, the state government, through IVEY, as well as social-based organizations and to a lesser extent civil organizations. This reflects the difficulties of maintaining the commitment and collaboration in research projects by non-academic actors, since they do not constitute a priority for them, implying other types of motivations that sometimes is not possible to attend to in the expected times, given that scientific and technological processes have other time horizons. Even these transdisciplinary processes achieve better results when they arise from the initiative of social and productive actors.

Figure 4: Map of actors. Pronai Advocacy Research Collective.



Source: Own elaboration.

In this experience, and according to the Conahcyt guidelines, the multidisciplinary group was integrated to tackle the problems of interest through a comprehensive approach. The group was made up of 11 members of the advocacy project and 50 participants from the community groups. However, it is worth mentioning the project development constraints that emerged from the shift in government policy since neither training nor all the tools were available to address several aspects required to articulate the project. This is because this approach transitions from a scheme of basic research proposals to one of applied research, emphasizing

Volumen 13, número 36, (201-224), mayo–agosto 2025
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the social "impact"; however, several terminologies remained undefined from the calls. The following are some controversial aspects at the time of Pronai project submissions:

- General research and impact strategy (pilot experiences).
- Active dissemination strategy.
- Methods for the inclusion and integration of knowledge and practices by stages.
- Proposal of internal mechanisms for reflection, recovery, development of practices, and progressive coordination improvement of all work-group members.
- Team performance assessment criteria and indicators.
- General guidelines for the national propagation strategy (active dissemination).
- Research-impact group performance.

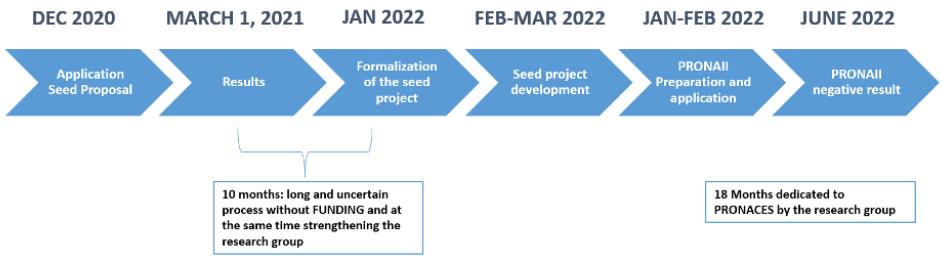
This undoubtedly reveals a complexity from the postulation of the proposal and the possibilities of fulfilling these expectations embodied in the scientific policy instruments. However, the integration of the group itself also presented complexities, such as the lack of a common understanding of different notions, for example, the concept of social vulnerability, PPI or industry 4.0 and circular economy. The latter terms, for example, were suggested by the proposal evaluation group to be included as an important part of the overall project formulation. Another problematic situation was the different interests and values of each of the stakeholder groups that interacted in the project and the implications of this (in relation to time availability, resources, differentiated objectives and degrees of commitment). The integration of theoretical and methodological notions was addressed with seminars to establish an integrated framework around the topics listed above, such as social vulnerability, public policies and governance. We also worked on topics such as circular economy and industry 4.0, as well as action research methodologies based on PRA.

Another problematic situation was the different interests and values of each of the groups of actors that interacted in the project and the implications of this (in relation to the availability of time, resources, differentiated objectives and degrees of commitment). Integrating diverse actors, in order to comply with a requirement of the call, such as social actors or civil association-type groups, implies an enormous challenge of involvement in the project so that their involvement is not only on paper, but so that they can really join the dynamics of the working group in an active participation. This represented a complexity factor to achieve the same level of cooperation among the different actors. Given that the scientific dynamic has traditionally been to form work teams between

academic peers, opening these spaces to other non-scientific actors represent important changes in the way work, scope and responsibilities are shared.

It should be noted that the time allocated for the development of the first phase of the project (seed project) was only two months. However, the total time from the formation of the team and the application to this first stage until the PRONAII result was obtained, was a year and a half, as shown in figure 5. Esta- blishing an inter and transdisciplinary framework in the time allocated for this first phase entailed an important effort of openness among the members, to establish a dialogue between the basic sciences and technologies, and the social sciences. In addition, the long time between the application of the first phase of the project (seed project), which took almost a year, generated great uncertainty. Nevertheless, the integrated collective decided to continue working even without certainty given the commitment established with the communities and neighborhood groups.

Figure 5: Timeline in the development of the project.



Source: Own elaboration.

However, the most significant and challenging aspect of transdisciplinary work was the interaction with the communities of marginal urban zones since many academic researchers usually work in experimental laboratories following a monodisciplinary approach. Moving to the social laboratory and applying social methodologies as PAR, implies training and expertise in other methodologies, as well as a social sensitivity not commonly experienced in hard disciplines. This involved engaging and bonding with new team members (academics and fellows) who were better acquainted with these inter and transdisciplinary work fields. Another constraint was the time available for community group members, since most were women and mothers who alternated between housework, childcare and participation in these collective activities.

A final complexity was the excessively long time taken for Conahcyt to provide us with information on the correct and timely execution of the pilot project. Almost one year passed between the initial pilot project approval date and the

Volumen 13, número 36, (201-224), mayo–agosto 2025
DOI: https://doi.org/10.22201/ceiich.24485705e.2025.36.91373

Pronai project submission, during which, the group had minimal feedback from Conahcyt and, to add more complications, there were no financial resources provided by the government. Under these circumstances, keeping a united research group focused on participating in the project was difficult. However, the project leader and the group members showed their commitment despite the lack of funding certainty. During those months, internal seminars were held and progress was made in the participatory analysis of the housing conditions by interacting with community groups. All this led to greater integration of the research group and to acquiring new learnings as a team.

Experience from the interaction between academic and community groups

Within the Participatory Action Research (PAR) methodological framework applied in the project, participatory workshops took place with community groups in southern Merida, where these groups live in priority attention areas as defined by the *Instituto Municipal de Planeación de Mérida* (2023) (Municipal Planning Institute of Merida) and as we indicated above, where housing is most precarious, including overcrowding and limited access to basic services. The location of the areas to carry out the pilot experiences was made based on the review and analysis of the information contained in plans of the city of Merida such as the one in figure 2, showing the priority attention zones defined by the Municipal Planning Institute (Implan). These areas are those surrounding the city's airport (the areas of Los Robles, San Marcos Nocoh, San Antonio Xluch I, II and III, and the neighborhoods of Dzununcan). It was decided to also work in areas located outside the peripheral ring (figure 2), given that they also present a significant number of actions requested to address/support housing needs, information that was provided by IVEY.

Workshops were delivered following the IAP methodology mentioned above. The aim was to motivate householders to get involved and contribute, sharing to proposed solutions, the issues related to their houses from their own needs, wishes and experiences with the support of specialists from various fields.

The first contact with the selected communities consisted of an introductory workshop held with representatives of citizen councils in the study areas, supported by the Department of Citizen Participation of the Directorate of Social Development, Municipality of Merida, who allowed us to use their facilities in Integral Development Centers located near the selected communities during the workshops (figure 3). To this end, its promoters assisted us in inviting the leaders of each neighborhood and other interested people to participate. Citizen Councils are composed of neighborhood citizens who meet regularly (weekly or monthly) to

discuss community issues and manage improvements with the authorities. Promoters act as liaisons between Citizen Councils and the City of Merida.

Subsequently, participatory workshops were held to gather data on the urban environment and housing needs. Table 1 summarizes the activities carried out in each workshop. The aim was that the results of these workshops would contribute, both to the design of sustainable housing as well as to the decision making process regarding the training of these communities for the possible self-production of housing in case the Pronai project was approved, focusing on their areas of opportunity, on an analysis of their activities and the real characteristics of the houses. As of the writing of this document, this phase has not started, as the full proposal was not considered by Conahcyt and is dependent on external funding sources for its continuation.

Table 1: Summary of the participatory workshops delivered.

Workshop	Date and place	Addressed to	Description	Target
1. Workshop for approaching and presenting the work project to representatives of citizens' councils.	CDI Emiliano Zapata Sur, February 17, 2022. CDI Crescencio Rejón, March 16, 2022.	Members of Citizen Councils of the southern zone of the city of Merida.	1. Application of a survey regarding their homes. 2. Presentation of the Project and the work team. 3. Recommendations of the councils, for the application of the following workshops.	Workshop, presentation to the community and planning of future workshops.
2. Participatory workshop to diagnose the urban environment	CDI Emiliano Zapata Sur, May 9, 2022.	Members of Citizen Councils in the southern area of the city of Merida.	1. Application of a survey regarding their homes. 2. Mapping of transportation routes and opportunity zones in your community. Analysis of existing infrastructure and equipment. 3. Writing about the historical line of your community and housing. 4. Drawing by children about their housing and environment.	Gather updated information from the perspective of the residents regarding the urban environment and the background of their community.

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Volumen 13, número 36, (201-224), mayo–agosto 2025
DOI: https://doi.org/10.22201/ceiich.24485705e.2025.36.91373

Table 1: Summary of the participatory workshops delivered (continuation).

Workshop	Date and place	Addressed to	Description	Target
3. Participatory workshop to diagnose housing needs	CDI Emiliano Zapata Sur, May 13, 2022.	Members of Citizen Councils of the southern zone of the city of Merida.	1. Drawing up a floor plan of your home and analyzing your activities. 2. Analysis of strengths and weaknesses of your home. 3. Description of your desired home.	Collect information regarding their housing needs, for subsequent design and implementation of training and participatory workshops on self-construction.

Source: Own elaboration.

Between the three workshops held, about 67 people participated and, particularly in the third workshop, there was an important presence of children. During the participatory workshops, surveys were applied to citizen representatives about the characteristics of their homes and various activities were implemented, based on participatory methodologies for habitat design, such as the mapping of community needs, the history of the community, "judging your home" or "drawing my ideal home", which, adapted to the case, were based on the Livingstone methodology for participatory housing design (UN Habitat 1996).

It is worth mentioning that 99% of the representatives who attended the workshops were women, between 30 and 60 years of age, and more than 70% were housewives and mothers, who expressed their gender perspective in their list of needs. At their request, a space was created for children, who, through drawing activities, also considered their vision of the place where they live. A very relevant aspect that stands out in the observations of the workshops is that they are very well organized and perceive their neighborhoods or their blocks as safe, but not the place across the street. There is an expression of belonging and self-care.

The set of experiences, in which methodologies with diverse characteristics were applied and developed, made it possible to generate an improved version of the advocacy model, which, in principle, can be adapted in a differentiated manner to the particular conditions of different communities in which social problems associated with habitat and housing, particularly overcrowding, are present.

It was noted as an important aspect, to give continuity to the activities that include the training of the community about productive processes of materials and housing construction processes, as well as to follow up on the workshops and evaluate the results in greater depth. The type of activities to be carried out will depend on the results of the analysis of the workshops conducted in this

project, regarding the social reality of the selected community. A series of coordinated actions should be implemented to further involve the different sectors involved in the housing and habitat problem through public dissemination and communication activities that promote the positioning of the topic, which will facilitate the processes of social appropriation to contribute to universal access to knowledge.

The dynamics with the communities showed their full willingness to participate, which shows a potential to be explored in future projects of this nature. It is worth mentioning that, as a result of this initiative and not obtaining Pronai funding, CICY promoted its own project to continue the advocacy work with social groups called "Elaboration of a diagnosis to increase the habitability and durability of housing for the vulnerable population of Merida, Yucatan" (Rivas *et al.* 2023), in order to encourage more participation of the target population in the development of designs that would take advantage of the large spaces that usually have the houses, to use them for more vegetation, as well as for their learning in the elaboration of fibro-reinforced concrete and evaluation of different alternative materials in their housing. The approach with the neighborhood groups, in short, made it possible to initiate this process of exchange among the social group in order to establish a dialogue of knowledge and initiate the actions of social retribution of knowledge that will make it possible to build true transdisciplinary work in the future.

Conclusions

The transition from monodiscipline to inter and transdiscipline, coupled with the construction of common analytical frameworks, has become a central challenge for academic research to advance in solving complex social and environmental problems. To this end, it is necessary to be open to other frameworks and approaches to reality, as well as to interact with other types of relevant and, at the same time, socially robust knowledge. On the one hand, interactions shall promote dialogue between different areas of knowledge, both academic and non-academic; on the other, it shall encourage the articulation of knowledge with society to face the current socio-environmental crisis.

An important factor, undoubtedly, was the effort to integrate the project in its entirety. However, the fact that it was not approved by the funding agency meant that the collective and the communities invested some time in an unfinished process, approximately two years of work from the beginning of the process. This could lead to the creation of false expectations due to the gap between academic times and the times of other social actors, although it also led to the construction of lessons learned in the advocacy collective.

Volumen 13, número 36, (201-224), mayo–agosto 2025
DOI: https://doi.org/10.22201/ceiich.24485705e.2025.36.91373

The difficulty of assuming the challenges that this project implied for a research center that by its nature only has researchers in the area of basic and natural sciences, can be seen as a difficulty, but also as an opportunity to open up to participate with other institutions with training in social sciences, and even the possibility of integrating students from different degrees and participate through experience in the formation of human resources.

The transformation in the current Mexican government regarding scientific and technological policy has led to significant challenges in academic communities since it forces a reconfiguration in the roles and characteristics of research groups, as well as in the methodologies adopted and the objectives pursued, which are to be reoriented towards social impact. Although this is a beneficial scope, it should not be the only framework promoted to generate new knowledge. Moreover, in practice, it involves major challenges in the organization of science that cannot be established overnight; instead, it is a mid to long-term process that requires a formative evolution to achieve greater openness to dialogue between specialists from different disciplines and with bearers of non-scientific knowledge; the latter implies that researchers and scientific institutions should generate new strategies for linking with social groups. These new scientific forms and dynamics therefore imply a gradual learning process, but in this case it was carried out under urgent conditions to meet the requirements set by the federal government.

The experience discussed in this paper highlighted the need to improve methodologies to interact with communities facing social and environmental issues associated with habitat and housing, particularly under overcrowded and social marginalization conditions. One of the lessons learned is that replicating these processes in other experiences is unfeasible if they are not first customized to the particular conditions of each community so that they are effective in the joint production of knowledge and, above all, in the implementation of solutions to problems identified collectively. Considering the cultural context and the timing, needs and degrees of commitment in these initiatives led by academic communities is essential to place the gender perspective and children, key actors in the participatory processes, at the center of the interactions.

On the scientific sector, working with community groups and governmental and civil actors also imply greater effort and commitment. In particular, the Sustainable Housing research group should continue carrying out activities such as training the community about material production and housing construction processes, as well as follow-up and evaluation of results. Finally, improving the planning and execution of coordinated work strategies is essential to further engage the different sectors involved in housing and habitat issues. ID

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