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Investigación original

A proposed model for the adoption of green roofs in horizontal property

Un modelo propuesto para la adopción de cubiertas verdes en propiedad horizontal

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Abstract: Green roofs incorporate vegetation into urban environments (specifically buildings), making it possible to replace the plant material that is destroyed during construction processes. **Purpose:** this study aims to identify the factors that drive the adoption of green roofs in horizontal property by means of a technology acceptance model. **Materials and methods:** A qualitative methodology is used, and semi-structured interviews are conducted with the community, construction companies, and employees of the Municipality of Sabaneta (Antioquia, Colombia). **Findings:** According to the results of this study, landscaping, temperature, energy, economic aspects, and quality of life are found to be the factors that determine the adoption of such technology. **Conclusion:** Therefore, green roofs become a multipurpose strategy that, besides helping to reduce the temperatures of buildings and improving air quality and harmony in landscapes, can also be used as gardens, as stated by some of the study's participants.

Keywords: green roofs, technology acceptance models, buildings, environmental education, environment.

Resumen: Los techos verdes incorporan vegetación a la vida urbana en espacios donde hay edificaciones, para reemplazar la huella vegetal destruida en el proceso de construcción. **Objetivo.** Identificar los factores que impulsan la adopción de techos verdes en proyectos de propiedad horizontal, mediante el uso de un Modelo de Aceptación Tecnológica. **Materiales y Métodos.** Se plantea un enfoque cualitativo, aplicando entrevistas semiestructuradas a la comunidad, constructoras y la alcaldía de Sabaneta. **Resultados.** Se identifican el paisajismo, temperatura, energía, economía y calidad de vida como factores determinantes en la adopción de esta tecnología. **Conclusión.** La utilización de los techos verdes es una estrategia multipropósito que permite no sólo la reducción en la temperatura de las construcciones, sino también el mejoramiento en la calidad del aire, la armonía en el paisaje y la posibilidad de emplearlos como huertas.

Palabras clave: techos verdes, modelos de aceptación tecnológica, edificios, educación ambiental, medio ambiente.

Introduction

The expansion of technologies in the market is known as diffusion of innovation. This theory aims to explain the rate at which technological developments spread and are either adopted or rejected depending on the different cultures, the type of users, and their perceptions regarding innovations in a social system (Pérez and Terrón, 2004; Miremadi, Saboohi and Jacobsson, 2018; Chou et al, 2018).

According to Robledo (2017) and León and Palma (2018), the purpose is to understand the structure of decision-making when choosing to use new devices, as well as the overall technology adoption process. For instance, the Technology Acceptance Model (TAM)—one of the most widely used to explain users' behavior in terms of technology adoption—has been successfully applied in research studies (Davis and Venkatesh, 1996; Moreno-Agudelo and Valencia-Arias, 2017).

In this regard, the dynamics of technologies (and the acceptance of new ones) is a valuable tool to predict consumers' intention to use a given technology, as well as their usage and satisfaction with it. Most of these technology acceptance models follow a quantitative approach, in which hypotheses are developed and validated by means of questionnaire-based surveys. In addition, the variables that can be identified via such models focus on the perceived use of a technology and address aspects such as attitude toward use, intention to use, perceived ease of use, and perceived usefulness. This latter is defined as the subjective probability that using a specific system will enhance users' job performance or daily life (Davis et al., 1989; Gómez-Ramírez et al., 2019).

From the above, the TAM's effectiveness to predict individuals' or firms' intention to adopt technologies is clear. However, few studies have examined the factors that drive the acceptance (or rejection) of green roofs, a situation that has led us to conduct this research. The variables proposed in this work provide different aspects regarding the construction of eco-friendly civil works. Said variables were adapted to the Colombian context, considering that they must conform to the country's sociocultural elements—which are determined by its culture, history, territorial context, ecosystems, and responsible planning within the framework of the local development processes and the land-use plans—in order to create sustainable architectural designs (Ojalvo et al., 2018).

The foregoing has led to the current global interest in developing eco-friendly buildings, especially if we recognize that human beings constantly make mistakes when it comes to natural resources. For instance, it is assumed that they will last forever (which is a serious mistake). Hence, a drastic change in the world's environmental management thinking and practice is crucial to correct common errors, such as the implicit assumption that the responses of the ecosystem to human use are linear, predictable, and controllable and that human and natural systems can be addressed independently (Folke et al., 2002; Allam and Newman, 2018; Vargas-Isaza et al., 2015).

Additionally, the rapid urban growth and development has caused a series of problems not only economic and social but also environmental, which is evident in emerging cities, as stated by Zielinski, Collante and Paternina (2012). For this reason, current education should be innovative, train students to have a broader vision and criteria, and offer results and solutions to improve and protect the environment (Vargas and Estupiñán, 2012). Nevertheless, although these criteria help to minimize the chaos, the occurrence of environmental problems (e.g., air pollution, increased temperature, and urban heat islands) in emerging cities should also be envisaged. In these scenarios, technology could help to address such problems through the implementation of relatively simple strategies such as an increased use of solar energy, rainwater reuse, and green covers.

Green roofs (also known as eco-roofs, living roofs, nature roofs, vegetated roofs, and rooftop gardens) are one of these eco-friendly and innovative technologies. This solution incorporates vegetation into urban environments (specifically buildings), making it possible to somehow replace the plant material that is destroyed during construction processes (Saadatian et al., 2013; Oravcová, 2014; Coma et al., 2016; Vacek et al., 2017). According to Cubi et al. (2016), green roofs provide aesthetic value to urban areas. Another aspect to consider (but not less important) is that reported by Bedoya-Ramos and Guzmán-López (2014), who indicate that interdisciplinary approaches and methodologies that serve as a bridge to carry out territorial research, planning, management, and development activities and help raise environmental awareness among citizens must be adopted.

Based on the considerations mentioned above, there are several classifications of green roofs—systems of manufactured layers deliberately placed on structures that support plant life. In particular, Sarté (2010) and Kok et al. (2016) classify them as extensive or intensive. On the one hand, extensive roofs generally have a shallower substrate and can support low-growing, shallow-rooted plant species. Besides their relatively low cost, these roofs are up to 140 millimeters thick, have a low weight (between 50 to 250 kilograms per square meter), require little or no maintenance, and can be installed on sloped surfaces, which makes them more flexible (Ibáñez, 2008; Bianchini and Hewage, 2012; Cubi et al., 2016; Kok et al., 2016; Selník, Nečadová and Mohapl, 2016; Johannessen, Hanslin and Muthanna,, 2017).

On the other hand, intensive roofs make it possible to develop a more complex ecosystem with wider plant diversity (from bushes to small trees). In addition, they are much heavier (around 400 kilograms per square meter) and require higher construction costs and constant irrigation and maintenance by skilled labor due to the drainage and irrigation systems that must be installed and the higher structural loads they have to support. In addition, the thickness of their substrate layer is usually above 150 millimeters because they need a reasonable depth of soil. Also, they are often associated with rooftop gardens (Haggag, 2010;

Cubi et al., 2016; Selník, Nečadová, and Mohapl, 2016; Vacek et al., 2017; Zhou et al., 2018).

Green roofs have advantages and disadvantages. For instance, they may be used as gardens to grow vegetables. Additionally, since they can absorb up to 80% of rainwater, they could offer environmental benefits, contribute to the energy balance of buildings, and change the lives of individuals emotionally and psychologically. Likewise, some of their economic advantages include incentives and sustainable maintenance during the lifespan of greening systems (Perini and Rosasco, 2016; Sánchez, 2016, Valencia et al., 2019).

For the installation of intensive and extensive roofs, an edging made of hardwood, impregnated with insecticides, and coated with protective varnish is essential to reduce moisture, allow for water drainage, prevent the substrate from slipping, and keep insects away. In roofs with slopes of 35%, stripped wooden barriers should be installed at the corners to prevent the entire roof material from moving, at least until an adequate stability is achieved (Barrios, 2018).

In view of the above, this study aims to propose a model for the adoption of green roofs in Sabaneta (Antioquia, Colombia), which is key for the development of this region. Its importance lies in the fact that it could provide insights to help mitigate the problems associated with the loss of local biodiversity and natural wealth, which have been caused by the city's rapid urban growth and lack of adequate land planning. In addition, this work contributes a set of fundamental factors that drive the adoption of green roofs and serve to identify and characterize the variables.

According to Secretaría de Planeación Alcaldía de Sabaneta (2016), Sabaneta is currently facing a problem due to the growing number of condo constructions. For instance, the construction of 8,110 homes was approved in 2015, which currently exceeds 35% of the growth of urban dwellings. Moreover, Sabaneta recorded a population growth of 1.22%, according to data verified and projected by the National Administrative Department of Statistics in Colombia (abbreviated DANE in Spanish) (2018). Regarding its green space, as reported in the Municipal Development Plan 2016–2019, there were 4.51 m^2 of green areas per inhabitant in 2009, which not only includes green areas but also parks, plazas, and squares. This means that there is a deficit of 14.35 m^2/capita, since Colombia's Public Space Policy requires towns to have 15 m^2 of green areas per inhabitant and the World Health Organization (WHO) recommends 10 m^2 per capita. Hence, the goal in Sabaneta's public space plan is to reach 5 m^2/capita, thus increasing the city's green areas per inhabitant (Secretaría de Planeación Alcaldía de Sabaneta, 2016).

Methodology

This research was carried out between 2018 and 2019. Through the identification of the factors that help to examine individuals' intention to use green roofs, it aims to propose a conceptual model—widely employed in the field of environmental sustainability and eco-innovation (Bossle et al., 2016; Roome and Louche, 2016; Shad et al., 2019)—for the adoption of this technology in condos in Sabaneta, Antioquia, Colombia. Its development consisted of five stages: in the first stage, a literature review was conducted; in the second stage, data were collected; in the third stage, the collected data were analyzed and classified; in the fourth stage, reliability was assessed; and in the fifth stage, the proposed model was designed and applied to the collected data.

In **Stage 1 (literature review)**, secondary sources of information that discuss the implications concerning the use of green roofs in other cities around the world were analyzed. For this reason, it was stated that the study follows a qualitative approach.

In **Stage 2 (implementation of data collection instruments)**, 14 semi-structured interviews employed in studies into the adoption of sustainable technologies (Dadzie et al., 2018) and designed based on the duties, knowledge, and decision-making power of each actor involved in the implementation of green roofs were conducted. Such interviews were carried out with the following stakeholders: i) Municipality of Sabaneta: two employees from the Planning Department, with whom the municipality's commitments with the community in terms of social and environmental aspects were discussed; ii) construction companies: two construction companies, whose interest in adopting this technology in their projects was analyzed; and iii) the community: ten inhabitants of Sabaneta, who were selected based on the following inclusion criteria: (1) must have been living in the municipality for at least two years in at least two different properties and (2) must be of legal age, in order to, based on their experience, give their opinions on green roofs and their benefits and how life in the municipality is regarding the environment and the quality of life of its inhabitants.

Furthermore, this study followed a qualitative approach and used convenience sampling based on the criteria mentioned above so that the information obtained from the interviews reflected the reference population. We also made sure that said population was diverse in terms of gender and occupation. Hence, a specific order was not required and statistical representativeness was not applicable because participants would qualitatively represent the perception of individuals with different decision-making roles and knowledge (Martínez-Salgado, 2012).

In **Stage 3 (analysis of the results)**, data interpretation was applied to classify data according to the information provided and following the TAM, as this model helps to define if the technology to be adopted is appropriate. Also, the external variables that have a direct impact on the process (e.g., perceived usefulness and ease of use of green roofs) were analyzed (Davis and Venkatesh, 1996). After data collection, the answers to the questions were transcribed and tabulated. Then, data were analyzed, and the frequency of topics was determined according to the in-depth interviews. Subsequently, the explanations and meanings regarding the object of study were established. In this respect, the answers provided by participants were in line with their priorities. Here, such answers were compared with the factors identified in the literature in order to assertively orient the process.

It should be noted that the frequency of topics was estimated based on the interviews rather than on the literature review. The purpose of this latter was to show the importance of this issue and identify the main authors, countries, journals, and institutions that are currently addressing it. The data were organized and then analyzed, and the explanations, meanings, and trends regarding the object of study were established.

In **Stage 4** (**reliability analysis**), an adequate reliability could be inferred based on the studies conducted by Do Nascimento and Schmid (2008) and Zimmermann et al. (2016) into the current implementation of green roofs in different regions around the world, such as in Europe (Germany, France, Holland, Iceland, United Kingdom, Sweden, and Switzerland), in Asia (Russia), in North America (United States, Canada, and Mexico), and in Latin America (Brazil, Chile, and Argentina), because, in said places, the impacts of such implementation on energy consumption and quality of life have been identified.

Furthermore, in a study conducted by Universidad Pontificia Bolivariana in Bucaramanga in 2016, energy saving strategies were examined, and the following variables were analyzed: air temperature, relative humidity, air velocity, daylight, and energy consumption. In the case of green roofs, the simulation results revealed that heat was reduced by almost 31% and that the energy consumption of air conditioning systems decreased by 5% in some areas (Cárdenas et al., 2016). Moreover, Zhang, Pan and Wang (2017) reported that the following actions could help to reduce energy consumption in future buildings: the design of plan shapes, the geometric shapes of buildings, solar radiation, and winds throughout the year. According to their simulation results, rectangular blocks exhibit the lowest annual energy consumption, followed by Z-shaped and square ones, while L-shaped buildings are the ones with the highest energy consumption. These findings suggest that energy consumption could likely be minimized in condos (Zhang, Pan and Wang, 2017)

Finally, in **Stage 5 (validity of the model)**, the detailed content of the instrument—which, for the purpose of this study, are interviews with some peculiarities, including their attempt to resemble the experiences of the individuals, in which the interviewer proposes and the interviewee tries to produce an answer to each question (Callejo, 2010)—must be in accordance with each question so that a precise indicator leading to the fulfillment of the objectives could be defined. Therefore, employees of the Municipality of Sabaneta, construction companies, and inhabitants of Sabaneta with or without experience in environmental issues and regulations or green roofs were interviewed in order to evaluate the following categories: quality of life, energy, temperature, economic aspects, and landscaping. For this purpose, a series of evaluation and validity criteria (presented in Table 1) were established.

Table 1

Evaluation and validity criteria of the study

Evaluation and validity criteria	Dimensions	Implemented measures
Credibility (internal validity)	Construction of the reality in an adequate and accurate manner.	Combination of data collection materials and databases. Informants Adequate duration of the study.
Transferability (generalization)	Degree to which the developed theories can be used in other contexts.	Maximum understanding of the problem. Minimum generalization of the results.
Dependency (reliability)	Related, permanent, and reliable results.	Definition of the theoretical framework. Random selection of informants. Context of the Municipality of Sabaneta and the construction companies.
Confirmability (objectivity)	Interpretation construction	

Source: adapted from the study by Martínez and March (2015)

Results and Discussion

Searches were made in different scientific databases (Scopus for studies with international impact and Scielo and Redalyc for studies in Latin America) in order to compare some factors and variables that influence the adoption of green roofs and to identify and explore the elements that could have the greatest impact and would enable predicting the acceptance of this technology.

Regarding the community, aspects, such as investment, environmental conditions, economy, landscaping, temperature, and quality of life, were found to be determinants of green roof adoption. This finding was observed in the works of different authors (Vuckovic, Kiesel and Mahdavi, 2017), who identified such factors, and is in line with the answers provided by the interviewees. In this respect, particular mention should be made of Rivera's consideration (2013), which is associated with land aspects, since it suggests the need to regard land planning as an instrument inherent to public responsibility that seeks to preserve quality of life and sustainability.

From the perspective of government entities, the factors that determine the use of green roofs include the environment protection, income from taxes, and municipal development plans. This is consistent with the findings of authors such as Gambi et al. (2011) and can, in turn, be checked against with Sabaneta's development plan

(Secretaría de Planeación Alcaldía de Sabaneta, 2016). Moreover, construction companies were found to be interested in aspects, such as investment, environmental impact, and regulations on incentives for the implementation of this type of technology in buildings, as reported in the works of Lindow and Michener (2007) and Perini and Rosasco (2016).

After the answers to the questions were transcribed, some of the community's priorities were found to be related to the factors identified in the literature—consulted in such a way as to assertively orient the contrast between the TAM and the green roof technology. Such factors, according to the number of times they were mentioned in the interviews (estimated via content analysis), include quality of life, landscape, temperature, investment, economic aspects.

Based on the interviews, the *quality of life* factor was evaluated using three sub-criteria: standards of quality of life, dissemination, and regulations followed by the municipal government and the construction companies on the construction of condos. Also, individuals' opinion regarding the measures implemented to improve the quality of life of the inhabitants of Sabaneta was considered.

One of the questions in the interviews sought to explore if participants were aware of the regulations currently enforced for the benefit of individuals and if they used eco-friendly technologies. Regarding this first question, the answers provided by them revealed a complete unfamiliarity with said regulations, as mentioned by one of the study's informants (see Figure 1):

"*Actually, I'm not familiar with the measures implemented by the municipal government*." (R-01)

This answer indicates that, besides not being familiar with the actions taken by the local government, this individual does not show much interest in getting to know them either. Therefore, the community should feel this motivation and well-being promoted by government entities and construction companies to, thus, improve quality of life.

Figure 1 shows a consolidated report of the interviews conducted with the government entities, the community, and the construction companies in the area under study:

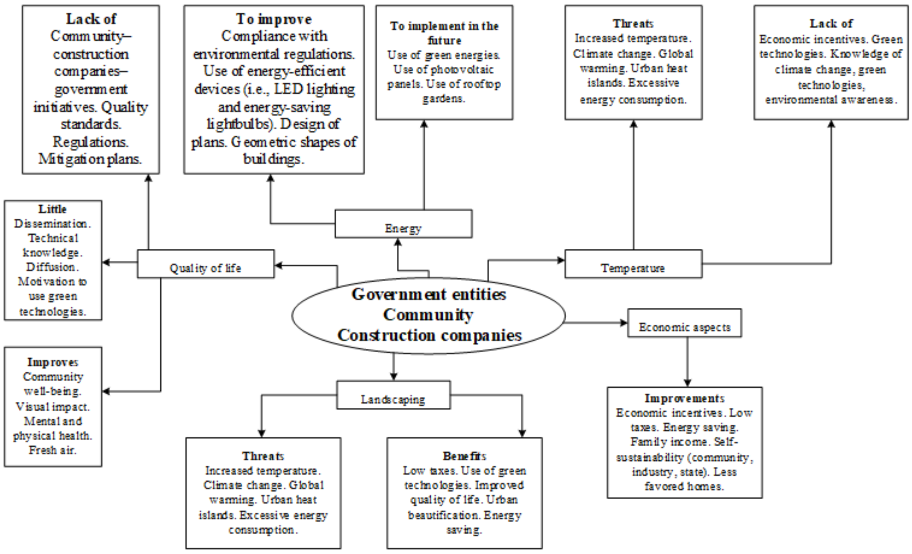

Figure 1

Interviews with government entities the community and construction companies

Source: authors' own work

Figure 1. Interviews with government entities, the community, and construction companies

With respect to the first question, participants (acting as informants) were also asked if they knew what green roofs were, and their answers were found to be close to the semantic definition of the term, which, in our opinion, would indicate that citizens may not be aware of the real implications and usefulness of this technology. Common answers to this question included:

"*I think they are roofs that have [hesitates] plants or crops on top*." (R-02)

With regard to the role of the Municipality of Sabaneta, their understanding of the regulations for the construction of new condos is clear. However, when the representatives of the municipal government were asked if they knew why green roofs have not yet been implemented in the municipality, some of their answers were:

"*The lack of knowledge on this matter and the lack of the necessary materials also makes this difficult*." (R-03)

"*Maybe because the municipal government is not familiar with this, and neither are the construction companies who are the ones who must implement green roofs. Additionally, the state administration and the law does not force construction companies to install green roofs in new buildings*." (R-04)

In view of the above, it could be concluded that the unfamiliarity with this technology, the lack of regulations, and the costs associated with the installation of green roofs discourage their adoption (despite their benefits and contribution to the quality of life in the cities). Therefore, the reasons mentioned above and the answers of the participants suggest the importance to recognize the benefits of green roofs in terms of quality of life, as well as the structural, visual, and emotional improvements and other positive implications they would bring if they were used in condos in Sabaneta. In addition, they indicate the need to plan initiatives to effectively disseminate the significance of this technology.

Furthermore, the opinions of the community, the construction companies, and the employees of the Municipality of Sabaneta on the current energy schemes and their perception regarding the future—in terms of improving, knowing, and implementing management actions or products that may optimize energy consumption—were gathered. The different answers that address these factors are reflected in economic variables. For instance, when asked about the proper use of energy, the community stated the following:

"*I think that people only realize about the importance of this issue when it directly affects their economy or health, but, generally speaking, the community here is still very little aware of environmental problems*." (R-05)

It is thus clear that there is a need to start using other alternatives to save energy and to make individuals aware of the effects caused by an excessive energy consumption and an increased temperature. In the meantime, in order to improve temperature of buildings, the community should be informed about and trained on green roofs and their benefits for current societies through lectures and conferences. Also, the type of vegetation that can be employed in this technology (whether intensive or extensive) must be identified. In this respect, different authors have recommended using sedum plants (better known as succulents). These peculiar species store a large amount of water in their leaves. In addition, their roots do not get buried but spread over the surface because they grow in shallow substrate layers and are resistant to extreme environmental conditions (Aprile et al., 2020). According to Schindler et al. (2019), green roofs with sedum plants also help to reduce temperatures inside houses. Besides this, they provide environmental benefits and financial advantages for societies (Tabatabaee et al., 2019). However, and depending on the needs of the condo and the benefits for the individuals who inhabit it, an improvement plan with an efficient dissemination strategy must be developed.

Another strategy to consider is to hold meetings with the community to inform them about climate change. In these meetings, inhabitants who are directly affected by this problem may express their concerns. Despite all the studies that have been conducted, people living in Sabaneta are not very clear about the city's average temperature because, when interviewed, they gave very different answers:

"*I think the average temperature in Sabaneta is 24 °C*"

"*I think it's 17 °C, but I'm not sure*."

Participant's unfamiliarity with the city's average temperature (as inferred from their answers) could not only be explained by the fact that they are not aware of this type of information but also by the changing climate in the municipality caused by the growing number of constructions and the lack of green areas, which definitely makes the situation worse.

Regarding landscaping, the community and the government entities consider it to be a comfortable factor that generates well-being; hence, their perception of it is basically positive. The results of the interviews show that participants are familiar with landscaping, regard it as part of nature, and recognize its potential and positive visual impact, as well as the fact that it is an eco-friendly alternative. The following is one of the answers provided by participants when asked if they believed that green roofs improve the urban landscape:

"*Definitely! There is no doubt about this, especially if we're talking about vegetation because you'll be able to see a landscape that didn't exist before: you'll go from seeing concrete to seeing a landscape that is really attractive to the eye and the environment. It'll be regarded as a garden to grow hydroponic tomatoes, onions, among other vegetables, rather than as a roof that is retaining more heat and increasing the temperature which is already too high*." (R-06)

This suggests that the community acknowledges the visual transformation and harmony that green roofs would bring. In addition, an added value of this type of technology would be the possibility of growing sustainable crops and having a cooler air around the condo areas. Likewise, participants were asked about the feeling of well-being provided by this type of roofs to the community, to which, for instance, they responded the following:

"*Green brings tranquility to the eye. Also, a green energy source that uses solar panels makes one feel that there exists an eco-friendly future leading to an improved well-being for the community*." (R-07)

In this same vein, from the perspective of the construction companies interviewed, landscaping is also considered to be a pleasing, eco-friendly, and more appealing alternative. For example, when these firms were asked how the architecture of condos would change if green roofs were installed, they gave answers such as:

"*It would clearly change because it [landscaping] offers tools to be more creative. You realize that nature gives you more design options; hence, you get caught in it because you want everything to be coherent: you start with the roof, but then you want the facade to be consistent with the roof , and then the interior to be consistent with the exterior*." (R-08)

According to this opinion, constructions that use green roofs could have a positive impact because they may be used as a reference point to create projects with a greater number of ideas in terms of eco-friendly design. In addition, construction companies could make the most of the different options provided by landscaping (based on green roofs). This means that, through architecture, a construction work can be transformed into a more sustainable project that is, in turn, more visually attractive, eco-friendly, and beneficial for the inhabitants.

Consequently, based on the material collected in this study, a model for the adoption of green roofs in condos in Sabaneta, Antioquia, Colombia (shown in Figure 2) is proposed.

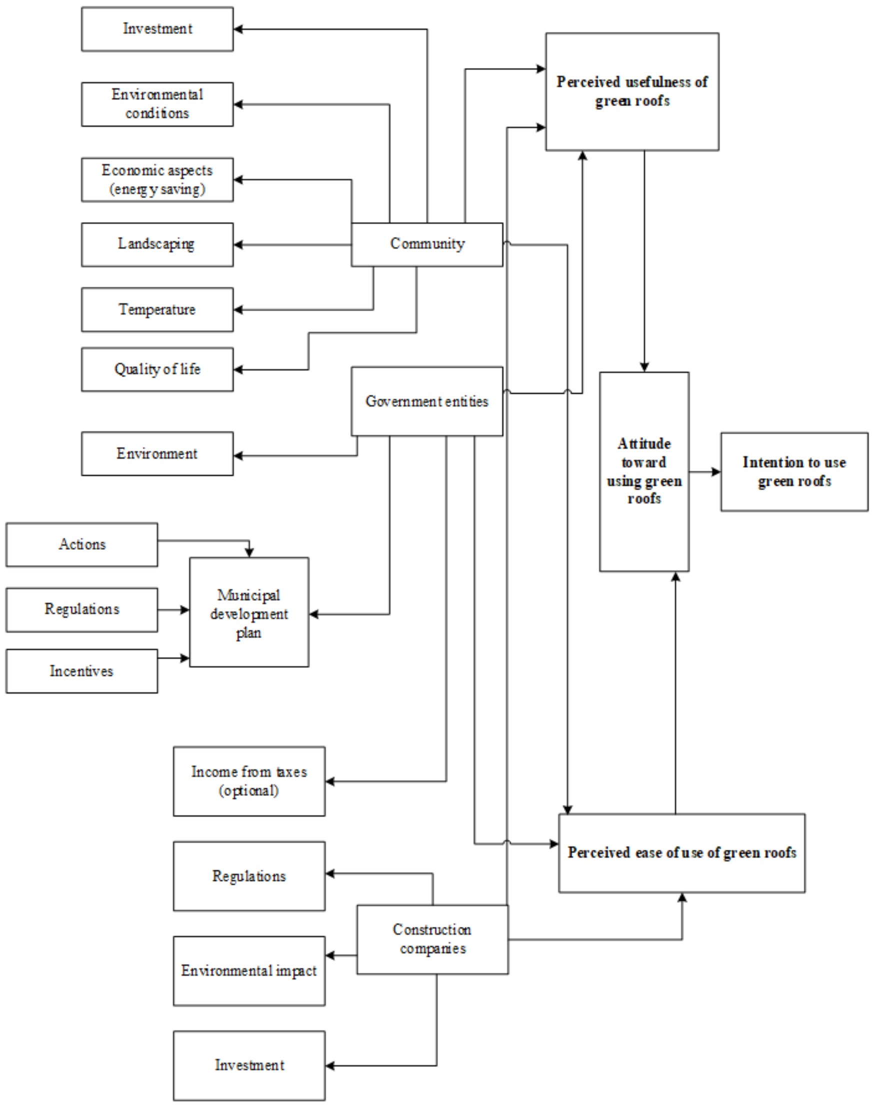

Figure 2
Model for the adoption of green roofs
Source: authors' own work

Finally, a factor that is directly associated with the role of government entities in promoting constructions that incorporate this type of technology through economic incentives was identified. When the employees of the Municipality of Sabaneta's were interviewed, they were asked if the local government would be willing to offer incentives for the implementation of eco-friendly initiatives (e.g., green roofs). The following was one of the answers they provided:

"*The municipality has not yet created incentives to lower taxes or any other types of incentives. As it is not an obligation, this issue has not yet been studied. However, when national and local decrees are issued, the local government will have to consider studying these possibilities*." (R-09)

According to this, future incentives that include discounts on the utility bill and on taxes could be introduced to benefit the community as well as the construction companies. For instance, there may tax reductions for construction-related activities. This would contribute to making buildings sustainable and reducing the deficit of green areas, considering that the municipal government and construction companies should seek the benefit of the territory and its inhabitants by taking concrete actions to improve their quality of life. In this respect, there are regulations in force concerning new urban developments intended for residential use. These regulations require construction companies to leave a 6-meter free space from the border of properties whose current purpose is classified as industrial. In addition, Chapter IV of Agreement 07 of 2019 by the Municipal Council of Sabaneta sets forth the aspects related to sustainable construction based on the provisions of the Sustainable Construction Policy of Valle de Aburrá.

However, there are no clear environmental policies in Colombia on the adoption of green roofs, which are essential to understand individuals' attitudes towards using green infrastructure, as well as the importance of variables, such as aesthetic aspects, economic benefits, energy savings, improved air quality, and lower temperatures in new buildings. If there were clear policies on this matter, adequate and effective strategies could be implemented.

Conclusions

Once the factors that determine the intention to use green roofs in condos in Sabaneta, Antioquia, Colombia were examined, it may be concluded that the TAM—model scientifically used to distinguish the factors that influence the acceptance or rejection of a technology—serves to identify the external variables that directly affect their adoption.

The results of the in-depth interviews conducted in this study and the information found in the scientific literature worldwide coincide in terms of the determinants of green roof adoption, which include landscaping, temperature, energy, economic aspects, and quality of life. Nevertheless, it should be noted that an unfamiliarity with the policies and regulatory guidelines that have been adopted in the territory under study, as well as with the significance and real benefits of this type of technology, was observed. For this reason, government entities should incorporate, into their dynamics, strategies to disseminate such information and raise awareness among present and future generations about the use of eco-friendly alternatives.

In this regard, and based on the information collected, we wonder about the role of governments (especially the executive and legislative powers) in the adoption of this type of technologies, as well as that of public policies as instruments to address the problems that emerge in societies; in this case, the effect of the current economic growth and urban development on people's quality of life, particularly in towns such as Sabaneta, which, in recent years, has experienced an increase in the construction of condos. This requires construction companies and high-impact local authorities to take measures to compensate for ecological impacts and to promote environmental sustainability—currently one of the main concerns on the global agenda (also known as the 2030

Agenda for Sustainable Development) marked by the establishment of the Sustainable Development Goals (SDGs).

Nonetheless, as shown in the results of this study, the implementation of strategies that encourage the use of green technologies is linked to the formulation of policies that offer consumers and construction companies reductions in taxes and, thus, contribute to the development of the region. For such incentives, structured methods should be established in the local development plans. In our opinion, this is one of the challenges faced by pro-environmental technologies, such as green roofs, because tax adjustments are usually a hotly debated issue in the political agendas, especially in Colombia where there are still clientelistic relations that directly impact decision makers.

Despite this, the positive impact of this technology on the lives of the inhabitants of Sabaneta is clear because environmental sustainability is closely related to individuals' quality of life. Green roofs thus become a multipurpose strategy that, besides helping to reduce the temperature of buildings and improving air quality and harmony in landscapes, can also be used as gardens, as stated by some of the study's participants. Therefore, the contributions of this research constitute a valuable input for both decision makers and researchers in the field to explore this issue in greater depth.

Additionally, according to the results of this study, the intention to use green roofs differs among the various stakeholders. For instance, for citizens (or the community in general), this intention is driven by their unfamiliarity with such technology and its potential benefits, while, for the municipal government and construction companies, regulations that stimulate its implementation (particularly in tax matters) are key. This finding is in line with the neoliberal economic model that currently governs firms around the world.

Finally, the local government entities should enhance their current dissemination schemes to strengthen knowledge regarding green roofs and foster the use of this type of technologies. This, in turn, can help raise awareness among the community and improve the quality of life of the inhabitants of Sabaneta.

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