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Are People Responsive to a More Sustainable, Decentralized, and User-Driven Management of Urban Metabolism?

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Abstract: Smart, green, and resilient city paradigms have been mainly promoted through top-down and technocratic approaches. However, based on the notion to return to “the right to the city”, emerging community-driven initiatives are providing self-managed infrastructures contributing to urban sustainability transitions. This paper explores the relevance of the behavioral aspects of people-centered approaches in dealing with two different facets of urban metabolism: physical infrastructure (involvement with the management of decentralized infrastructures) and consumption patterns (involvement in proactive reduction of resources used). In the first case we assessed community perceptions about the roles, benefits, and willingness to proactively engage in the management of decentralized green infrastructures in Bogotá City, Colombia. For the second facet, we measured the effectiveness of change agents in re-shaping energy consumption decisions within urban social networks in South Africa and Saudi Arabia. This paper’s results show that pre-determined and standardized strategies do not guarantee positive, nor homogeneous, results in terms of meeting sustainability targets, or promoting community involvement. Hence, a better integration of people-centered and top-down approaches is needed through context-dependent policies, for enhancing both users’ appreciation of and commitment to urban metabolism participative management.

Keywords: people-centered approach; behavioral change; sustainability transition; Bogotá; South Africa; Saudi Arabia; energy saving; change actor; green infrastructure

1. Introduction

We are getting used to hearing that “we live in a world of cities”. How to make city living sustainable is one of the key challenges of our times [1]. The United Nations set a stand-alone goal on cities within the Sustainable Development Goals, stating to “make cities and human settlements inclusive, safe, resilient and sustainable” (Goal 11; [2]). As exemplified by this goal, it is becoming common for concepts such as sustainability and resilience to be used synergistically [3], or interchangeably [4]. However, critical perspectives on these concepts reveal that, for example, resilience *per se* does not

always contribute to systems sustainability [4,5], but implies multiple trade-offs [6] and even social injustices [7,8]. In fact, resilience has sometimes been “manipulated” to reproduce business-as-usual practices and “used as a label to fit conveniently on top of pre-existing agenda” [9]. The normative and imperative position of building resilient cities, by addressing risk reduction, is similar to the normative and positive framing of building sustainable/smart cities, by increasing the well-being of the citizens, while reducing their environmental impacts. New digital technologies can be employed to serve this purpose [10]. The top down, technocratic focus on energy systems, mobility, and resource efficiency led by the ongoing smart city discourse runs the risk of neglecting the human element when addressing urban sustainability [10–12]. Such tensions and contradictions, generated by the principles and practices contributing to urban sustainability, reveal the need for aligning similar, although diverging, concepts (and related practices) and stakeholder involvement in long-term processes commonly conceived as “sustainability transitions” [13–17]. This paper is built around the need for a better understanding of how to enable more people-centered approaches to deal with, and even “anchor”, urban sustainability transitions.

Increasing amounts of attention from different fields have been devoted to urban community-led initiatives, contributing to local transition initiatives [18], recovery and risk reduction in urban [19,20], and peri-urban areas [21]. These efforts provide a rich source of evidence that demonstrates that cities, on one hand, are the key sources of pollution [22] and, on the other hand, they can be seen as hubs for sustainability and social innovations [23,24]. “Spontaneous interventions” is one of the recent global phenomena taking place across United States, in which urban design spontaneously emerges from activities led by individuals, groups, and communities, which contribute to the definitions of their own sense of place, and enhancement of residents’ quality of life. Furthermore, in the last few decades, information and communication technologies (ICTs) have provided the tools necessary to realize an exponential growth of people-centered initiatives [25]. Relevant examples are happening online (like change.org, a petition website for social change, among others, through participatory actions connecting more than 100 million users) or on the ground (such as “Meu Rio”, a local mobilization network enabling participation and community-led initiatives in Rio de Janeiro, Brazil). These participatory platforms have smoothly evolved from the claiming of spaces or city services, to the engendering of people-centered experiences of self-production and management of urban services and decentralized infrastructures. Such an evolution could be seen as a recall of the Lefebvrian concept “the right to the city” [26,27], and consequently, as Jimenez proposed, “right to the infrastructures”, through open-source urbanism [28]. Traditionally framed within a top-down, standardized, and centrally-managed systems, infrastructures have been suffering from “splintering effects”: induced inequality and spatial fragmentation brought about indirectly because of their spatially different level of services [29], dependent on cities’ and districts’ agendas, involvement of powerful actors and funding availability. In this context, arisen as a response from the most neglected parts of the cities or districts and boosted by recent financial crises, “inverse infrastructures” are emerging as a user-driven, self-organizing, and decentralized management phenomenon [30]. Examples range from open wireless systems, shared mobility experiments, or co-production and self-management of distributed networks of solar photovoltaic panels. Such people-driven experiments are reinforcing the call for the right to infrastructures, and even elevating to the notion of “people as infrastructures” [31]. While an increasing volume of literature is beginning to explore these community-driven experiments [21,28,32–34], there is an imperative need for better understanding and addressing a behavioral change that is intrinsic in these efforts, both in the top-down (in which city management entities make key decisions on how cities are to be developed) and bottom-up (in which citizens’ perspectives, about their roles and implications within the city, contribute to urban management) ways. There is, hence, a phenomenon to reverse the top-down, technocratic approach in managing sustainable, smart, and resilient cities.

In order to explore such a phenomenon, this paper aims to answer the following key research question: “to what extent are citizens aware, ready and responsive to a more sustainable, decentralized and yet user-driven management of urban metabolism?”

To address such a broad research question, the paper focuses on two different but complementary aspects of urban metabolism: the first is its built facet (the physical infrastructures supporting it), while the second is related to its intangible facet (the services and resource flows of consumption patterns). People-centered approaches could, indeed, be related to both of these two management facets, through the involvement within decentralized or inverse infrastructures management or contributing to leverage behavioral changes in resources consumption. The paper provides examples and evidence from different study cases. The first part is focused on decentralized green infrastructures, which through a set of urban ecosystem services [35] can be managed by different communities or individuals [36]. In line with the work of Wan *et al.* [37], the paper analyzes the community perception about the role, benefits, and their willingness to enhance their engagement within the management of these decentralized green infrastructures (in the case of Bogotá city, Colombia). A second part of the paper strives to understand the pivotal role of change agents and how these could contribute within an urban social network to boost energy consumption reduction behaviors (with study cases from South Africa and Saudi Arabia).

2. Methods

This study was developed under an international research collaboration entitled “Operationalizing User-driven Resilience for Sustainability in CITIES” (OURS CITIES). The international partnership program’s main goal was to explore actions and community programs that could contribute to enhancing city-level resilience by enabling people-centered approaches in dealing with urban infrastructure decentralization and behavioral changes in managing resources. After considering the situational settings—socio-cultural and political conditions—three different cases were carefully chosen in order to explore the city end-users’ behaviors and potential contributions to selected urban sustainability transition cases. The criteria employed for deciding these cases have been the following:

- Cases should be located in developing countries and emerging economies, which are facing accelerated urbanization and, to some extent, under a framework of unplanned and unregulated urban developments, lack of institutional coordination, conventional fragmented urbanization management approach and lack of planned expenditure on the required infrastructure, thus imposing particular challenges to the conventional top-down urban infrastructure management approach. Interestingly, despite the previously-mentioned restrictions in emerging urban areas, citizens are currently experiencing profound socio-cultural changes with regard to their perception of sustainability issues and their role to address them.
- Cases must involve stakeholders in undertaking certain measures of ecosystem services management or resources conservation.
- Methodologies must delineate the opinion of stakeholders (especially end-users) in undertaking the above-mentioned roles, and/or evaluating the effectiveness of them playing these roles.
- Statistically-rigorous methods must be used to classify or evaluate the above-mentioned information obtained from the studies.

The first part of the paper aims at quantifying socioeconomic disparities regarding green infrastructure in a large urban center (Bogotá, Colombia) resulting from unplanned urbanization (e.g., to what extent social and economic variables are related to green infrastructure availability) and how user-driven initiatives could help to increase accessibility to decentralized urban green infrastructures. We particularly focused on assessing perceived environmental and social benefits of green areas, the perception of proximity to public green spaces (accessibility), the frequency of use and type of activities carried out in these green spaces and willingness of the population to increase green infrastructure at their place of residence. Our target stakeholder group was primarily high school and university students (both ungraduated and postgraduate) from different socioeconomic levels with places of living well distributed within the city. Our belief is that such a population group will be in charge of leading most of the future user-driven initiatives in most urban areas around the world.

The analysis methods included: (i) correlation analysis between the amount of green areas and different social indicators (including population density, socioeconomic classification, and mean household income); (ii) hedonic pricing method, which uses a semi-log regression for analyzing how the housing prices are affected by the distance and the availability of green areas; and (iii) an online survey conducted between February and April 2015 (with a sample size of 1420). The online survey quantified perceived environmental benefits of green infrastructure, such as drainage mitigation, air pollution removal, increased flora and fauna diversity, temperature mitigation and noise reduction, and also social benefits including improved aesthetics and landscaping, better recreation and open sport areas, culture and art development, increase of property values, and social and family integration. From our analyses, interesting conclusions were drawn on the nature of stakeholder involvement that is necessary to enhance user-driven management of such green spaces.

The second part of the paper focused on two cases in Grahamstown (South Africa) and Khobar City (Saudi Arabia). The key objective of this part is to understand how households can be engaged to adopt energy reduction behaviors through a bottom-up stakeholder-initiated community program, in which the amount of energy savings were correlated to different intervention methods.

The study in Khobar City spanned six months in which 88 households volunteered to get involved; there were three groups in this study: one that received intervention in the form of reminder stickers and a video clip on role models performing energy reduction actions, and a control group. On the other hand, the South African study involved a random selection of about 103 households in a low-income community in Grahamstown; the households were divided into three sub-groups, namely the full treatment (FT) group, the partial treatment (PT) group, and the control group. Different types of intervention methods—namely, pamphlets, stickers, and face-to-face discussions and feedback—were used to provide information for promoting electricity conservation in participant households. For the FT group, a combination of pamphlets, reminder stickers, discussions, and feedback on energy saved were used to encourage participants to engage in electricity conservation behavior, while only pamphlets were used for the PT group. Any Hawthorne effect (which is the phenomenon that people modify or improve their behavior in response to their awareness of being observed) was measured and accounted for among all of these groups, so that we can accurately attribute any energy savings to the intervention administered. Both cases followed the analytical framework proposed by He and Kua [38], and Kua and Wong [39].

3. Results and Discussion

3.1. Community Decentralized Green Infrastructure

3.1.1. From “Greening the Grey” to Enhancing Urban Ecosystem Services

Kennedy defines urban metabolism as the flows of energy and materials within cities' socio-economic activities and bio-geochemical processes [40]. Green infrastructure, defined as the set of techniques that uses vegetation, soils, and natural processes to manage the urban environment, has been shown to be one of the principal components of urban metabolism [41]. In cities, green infrastructure generally refers to those areas that provide flood protection, cleaner air, and cleaner water; these include urban tree canopy, green streets and alleys, green lots and sensitive natural areas, such as parks and protected open spaces. However, several authors [42–44] have pointed to the capacity of green infrastructure to increase property values, neighborhood integration, and quality of life. Those benefits within an urban metabolism are part of a new study area introduced by Daily [45] and redefined by the Millennium Ecosystem Assessment (MEA) in 2005 as “ecosystem services”.

Ecosystem services are all the processes through which natural ecosystems sustain and fulfil human life [45]. Cities that are properly managed should be able to take advantage of ecosystem services that could provide a social-ecological change towards sustainability [46]. Recent studies have shown that the appropriate way to achieve sustainability relies not only on recovering the ecology within cities but also the ecology outside cities. According to Jansson [46], most of ecosystem services

consumed in cities are generated outside the cities (including services such as food production and carbon storage) whereas most of the environmental and social ecosystem services interactions occur inside the cities (for example, population well-being and environmental quality), thus forming a complex urban metabolism.

For analyzing ecosystem services in cities, it is important to differentiate “goods” from “services”. Ecosystem goods refers to the most common needs from which humans take advantage (for example, water, air, and soil), while “services” are more complex and less tangible benefits afforded by natural and social processes (for example, runoff mitigation, water treatment, and human well-being) [47]. The role that green infrastructure plays in reducing urban vulnerability, enhancing quality of life, and urban ecology footprint, are all these natural and social processes (redefined by the MEA as “regulating and cultural ecosystem services”) [48]. Providing equally-distributed ecosystem services and guaranteeing positive community perception and involvement in the management of these services is what builds the basis for future sustainable and resilient cities [49].

3.1.2. Bogotá Citizen Perceptions of Urban Ecosystem Services

Bogotá is the capital city of Colombia with a population of nearly 8 million inhabitants, and has an urban area of 400 km², according to the local District Secretary of Planning—SPD. It is, therefore, one of the densest cities in Latin America. It is characterized by irregular land use patterns and marked socio-economic disparities [50] and in the last decades, it has faced the common consequences of unplanned urbanization. Bogotá is considered a representative example of fast growing cities in Latin America and other developing contexts, and so obtained results on ecosystem services can contribute towards a better understanding of the interaction between the urban green landscape structure and socio-economic aspects.

Recent research identified marked inequalities regarding ecosystem service provision by urban trees in Bogotá, thus pointing to the need of more holistic planning efforts to improve population welfare [50]. In order to further assess socioeconomic disparities regarding green infrastructure in Bogotá we carried out a correlation analysis among population density, social stratification, and the amount of available green areas. We used, as our spatial unit of study, the local planning units: Bogotá has 117 planning units called *Unidades de Planeamiento Zonal* (in Spanish), or UPZ. Population density data was obtained from the National Administrative Department of Statistics—DANE (based on population estimates for 2010), while social stratification and household income was obtained from a city-wide survey carried out by the District Secretary of Mobility—SDM in 2011 (based on 16,157 personal interviews). For estimating the amount of green areas in each of the local planning units (UPZs), the iTree software (developed by the USDA Forest Service) was used along with satellite images. Results from our Bogotá case study showed that higher mean household income and socio-economic classification are positively correlated with the amount of green infrastructure which, in turn, are negatively correlated with the population density. In addition to this, by means of the hedonic pricing method, we analyzed how housing prices are affected by the distance and the availability of green areas. Housing prices were obtained from the District Secretary of Mobility—SDM 2011 survey. Other additional variables were also considered to describe housing prices, such as access to public transportation and main roads. We identified that the availability of, and distance to, green areas are explanatory variables of the housing prices ($p < 0.1$).

Previous results confirm the aforementioned social disparities. As described by Dobbs *et al.* [51], establishing these linkages is relevant for correlating environmental and social inequalities, and provide evidence on the disadvantages associated with unequal and centralized management of ecosystem services in cities. As seen in this study, the negative correlation between green areas and population density is a consequence of urban consolidation when planning does not include a sustainable development that maintains the social and environmental benefits in cities [51]. Social inequality and centralized distribution of green infrastructures in Bogotá was also observed from the answers of survey respondents. Results showed that 92% of respondents perceive that Bogotá

does not comply with the minimum green area per inhabitant that is recommended by the World Health Organization (9 m²/inhabitant). However, 47% of the respondents perceive that their places of residences have good amounts of green infrastructure, and 52% of them (out of those that carry any activity in green areas) indicated that they have access to a public park within less than 10 min walking. Furthermore, 89% out of those that carry any activity in green areas perceived that those areas are either in acceptable (37%), good (39%), or excellent (13%) condition. High socio-economic levels ascribed a highest importance level to green infrastructure when choosing their place of residence (which probably makes them believe that Bogotá complies with the minimum recommended area of green infrastructure per inhabitant) compared to those respondents from a lower socioeconomic classification, even though no socio-economic differences were found between these groups in terms of frequency and types of activities. In general terms, Bogotá's citizens that carry any activity in green areas (81% of the respondents) prefer engaging in physical exercises and leisure activities in green areas near home—47% and 32% respectively—not in their study place, which is in line with the results of Krellenberg *et al.* [52] for Santiago de Chile) than other types of activities; for example, cultural or social events (7% and 15% of the respondents, respectively). Also, the majority of respondents believe that environmental services are important (78%), especially in relation to water runoff mitigation (26% of the responses) and air pollutant removal (83% of the responses).

3.1.3. Citizen Involvement Experiences within the Management of Decentralized Green Infrastructures

The Bogotá case study results emphasize that the majority of the households showed very positive attitudes toward increasing green areas (70% if living in apartments and 87% if living in houses), confirming the general trend (explored in other studies) in developed countries [53]. However, even if, generally speaking, “increasing well-being” and “improving environmental quality” were the principal incentives to enhance quantity and quality of green infrastructure (other options included having space for pets and increasing property values), it is remarkable that, in Bogotá, our sample study revealed the high value of green infrastructures perceived related to water run-off mitigation (26% of the responses) and air pollutant removal (83% of the responses). This is in contrast with the results of other studies in developed countries [54], which illustrated that in four different French and Portuguese urban areas, social and cultural benefits of green infrastructure are definitely the most preferred (60%) and more valued ones, rather than other environmental benefits. Driven from such a consciousness background about urban ecosystem services, there are several volunteer activities in Bogotá, including those on urban rainwater harvesting, reforestation, and volunteer tax payments. The “Food and Environmental Plan” from *Un techo para mi país* organization worked in two vulnerable neighborhoods in Bogotá. In 2013 more than 50 volunteers created a communal garden (100 m²) and installed vertical and horizontal gardens for approximately 20 different families. *Al verde vivo* is a tree adoption program for the recovery of Bogotá's river and, as a result of voluntary donations, there have been more than 80,000 native trees planted in the upper basin of the river. The Botanical Garden of Bogotá has collected more than USD \$400,000 in ten years through *Árbol de vida para Bogotá* program, funded by voluntary contributions of vehicle tax payers for planting and maintaining trees in the public spaces of the city. There are many other examples regarding increasing community-led initiatives managing green infrastructure, including those involving neighborhoods protecting trees, parks, and common areas, and recreational and educational activities that involve the use and user-management of green infrastructures. However, while behavioral changes and decentralized green infrastructures management is emerging “from below”, the links between community-led and top-down infrastructures management are still poorly understood and implemented. Protected green areas began to be part of the urban planning framework introduced during the 1990s and primarily aiming at enhancing biological connectivity. Nowadays this technocratic and land use management approach (restricted to protected areas) is recognized as obsolete and inefficient for enhancing sustainability transition [55]. Innovating planning practices and policies through a more collaborative and participatory framework within the communities [50] is a key stepping stone for

urban sustainability and resilience, since it increasingly comes from people who have not been previously considered as stakeholders [56].

3.2. Change Agents-Driven Behavioral Change in Energy Resources Management

In this section two case studies have been selected to explore the role and effectiveness of change agents within urban social networks in re-shaping a more sustainable use of energy resources. The South African case study, in Grahamstown, was compared with a second case in Saudi Arabia, Khobar City. The same data collection methods were used, but with very different results, confirming that pre-determined and standardized strategies in enabling behavioral changes, through change agents, neither guarantee positive nor homogeneous results, in terms of addressing sustainability targets.

3.2.1. Behavioral Change in Grahamstown

In the case of the pilot household energy intervention program in South Africa, we worked with the Makana Municipality through the Environmental Management Department and a total of 103 households, who participated in the study between March and August 2014. Results illustrated the effectiveness of intervention strategies to promote energy savings among low income urban households. When the data were disaggregated by treatment groups, the findings show that the FT group recorded the most reduction in energy consumption ($p < 0.05$), whereas the reductions in the other two groups (PT and control groups) were not statistically significant. Although the PT group recorded savings throughout the five months, these savings were found not to be significant. Energy savings were correlated with actions like “not allowing appliances to be on hibernation mode after 10–15 min” (Pearson $r = -0.46$), “keeping windows and doors closed whenever the heater is switched on” (Pearson $r = 0.45$) and “switching off lights whenever no one is using them” (Pearson $r = 0.42$). A regression analysis of actual energy reduction and demographic variables, such as age, gender, income, and education level, did not yield significant results.

Correlation examinations (for the FT group) between actual reductions and various value factors (defined by 22 quality-of-life factors) showed that actual reductions were most correlated (Pearson $r = 0.32$) with the “liking for different things in daily life”, which suggests that households who could accommodate changes in their lifestyles were likely to engage in energy reduction programs. We also examined the relationship between energy reduction and the feedback given to households in the FT group, and multiple regression analysis showed that only the statement: “Encouragement makes me perform the recommended measures” ($p = 0.001$) was a significant predictor of energy reduction. The majority of participants (in the FT group) said they “read the distributed leaflets and stickers at least once” and “pasted the stickers in their houses”, thus implying that information-sharing has potential for energy reduction. When all of the intervention strategies were aggregated, the results showed that the distribution of leaflets and stickers, combined with monthly feedback on energy saved and discussions was significantly effective in promoting household energy savings. The key aspect in intervention strategies was that a high level of perceived encouragement was provided to the participating households—without which energy reduction was insignificant. Factor analysis shows that individuals who treasured social relations and spirituality/religion were likely to be concerned for environmental quality (this factor accounted for 25.91% of variance).

All in all, the results of this case study show that interventions were more effective in promoting energy conservation and reduction when applied conjointly rather than separately. Further, household energy reduction had significant relationships with participants’ self-reported actions and personal values, but not with demographic characteristics. In order for household energy interventions to be successful, technology alone will not be sufficient. Our case study showed that determinants of success also include the quality of communication between the households—who are considered the agents of change—and the researchers and government officials. Further, for this method of engagement to be sustainable, it needs to be cost effective and produce significant results to justify

the financial investments into the implemented measures. In other words, the triple bottom lines of sustainability—economic, social, and environmental factors—must be addressed for this measure to be successful. Such a community-initiated and driven effort can be viewed as both a sign of (and a way of) cultivating community engagement, due to its educational (learning) and behavioral (changing) aspects. Although this study demonstrated that some degree of behavioral change can be motivated through the use of the outreach instruments employed in this study, we did not study how long this change could last without sustained campaigns or other political and financial actions.

3.2.2. Change Agents Not Changing Others? Results from the Saudi Arabian Case and Cross-Country Insights

The paired sample test between all the months of intervention in Khobar City found that, except for the control group, there was no significant change in electricity consumption in any of the groups in the course of the entire study. This negative result indicates an absence of the Hawthorne effect (people changing their behaviors in response to their awareness of being observed), especially since there was no significant change in the first month of the intervention, which is key, as explained by He and Kua [38].

Looking at the results, a significant change ($p = 0.042$) in the control group occurred between the months of January and February, but it was justified by the transitioning of the season from winter to spring, causing a sufficiently large fluctuation in energy use. This explanation is supported by the fact that no significant change was observed within the control group throughout the study period until the month of February. Similar to this, there was no significant change (leaflet: $p = -0.000533$; role model: $p = -0.0025$) noticed for the treatment groups in any of the two periods. When the test was conducted on the first (September 2014) and last month (February 2015) of the intervention to assess whether the intervention had an overall impact on the electricity consumption, significant changes in electricity consumption was observed in the control and leaflet groups. This was substantiated by their respective p -values (<0.05). The role model, by contrast, did not reveal any statistically significant change. This seems to suggest that the intervention method involving videos was not as effective as the other two methods. On the other hand, the Wilcoxon signed-rank test demonstrated that there was no significant change in behavior of the change agents belonging to leaflet and video groups. Notwithstanding a few positive changes in the response to a few of the questions asked (that were found to be statistically insignificant), the results demonstrated that the intervention was not effective in persuading the households to adopt energy conservation practices. This concurs with the lack of significant change from month to month.

Measures that worked in South Africa did not work in Saudi Arabia. The difference in the results seems obviously to be related to the different socio-cultural and economic contexts. For instance, the highly-subsidized tariff for electricity does not seem to incentivize nor “urge” the Saudi end-users for energy conservation or reduction, even when environmental impact and consequences of energy production and consumption have been clearly explained. Moreover, the state of the “practice” of conservation in these disparate settings is also perceived to be causing this difference. On the contrary, energy-saving programs in which households act as change agents are desirable in the South African case because of its success and they have been relatively cost-effective. This first case study provided key insights that have several cross-scale policy implications. First, there is a need to formalize outreach and energy-saving intervention programs that are initiated and owned by users. Most importantly, the results suggest that change agents’ “encouragement and feedback element” should form the central part of energy-saving programs. These programs should also aim at promoting key energy-saving actions that households are familiar with, and conveyed in an energy conservation message that the households understand. Going forward, although the results suggested that energy reduction intervention programs can yield positive outcomes in a developing country context, there is a need for further examinations of the effect of various personal values, psychological, and contextual factors on energy consumption to give a more conclusive picture.

4. Conclusions

Social practices and networks have been the main vehicle for community learning and problem-solving. While top-down and technocratic approaches failed to meet many sustainability targets [10–12], “the roles of civil society has been not properly recognized in providing urban services (-)” [57]. Recent and increasing literature is exploring the outcomes of community-driven experiments [21,28,32–34] and behavioral aspects of people-centered and user-driven sustainability transitions [23,58]. Recalling the Lefebvrian concept of “the right to the city” [26,27], and its evolution through the more specific concept of “the right to infrastructures” [28], these social experiments can be conceptualized as practices reverting the technocratic, top down and mainstream design and management of urban metabolism, toward the emergent “inverse infrastructures” phenomenon [30]. Framed as user-driven, self-organizing, and with a decentralized management approach, the phenomenon of inverse infrastructures and its evolution deeply depends on the societal values and behaviors, stakeholder involvement and commitment to manage distributed urban services and networks. Wishing to contribute to the emerging literature on urban inverse infrastructures, this paper wondered to what extent are citizens aware, ready, and responsive to a more sustainable, decentralized, and yet user-driven, management of urban metabolism?

In the first part of the paper, results from the study case on the city of Bogotá (Colombia) contribute to a better understanding of the peoples’ perception about urban ecosystem services. The majority of the households involved in the study showed very positive attitudes toward increasing and potentially managing green spaces, confirming the general trend registered in developed countries [53]. Even more relevant for the purpose of enhancing inverse infrastructures approaches is that their willingness to increase and managing green spaces have been related to their awareness about the potential of green infrastructures to contribute to rainwaters run-off mitigation (flooding resilience, somehow) and air depuration (urban sustainability). It is, therefore, worth noticing that increasing in property values due to a greener urban landscape, or the recreational uses of green spaces, have not been (anymore) the main drivers for people’s involvement in fostering green infrastructures. From this positive background (behavioral information), further research is needed to address the still poorly-understood links between community-led and top-down green infrastructure management. Indeed, innovative planning practices and policy frameworks need to increasingly embrace people who have not been previously considered as stakeholders within the management of urban infrastructures.

From the second part of the paper, results come from the application of a pilot household energy intervention program in Grahamstown (South Africa) and Khobar City (Saudi Arabia). Through these case studies the aim was to understand the role and effectiveness of change agents in boosting energy consumption reduction behaviors. The same pilot program performed successful results in the South African case (different indexes registered a change in behaviors and energy consumption patterns), while it did not work in Saudi Arabia (only marginal positive changes, but non-significant). The large socio-economic difference between the two cases explained how the highly-subsidized tariff for electricity in Saudi Arabia did not incentivize any end-users care for energy reduction. However, the success of the Grahamstown case suggests that change agents’ “encouragement and feedback element” should form the central part of localized user-driven energy-saving programs, to be highly supported from local and national governments. Further research is needed, however, to understand the longer-term effectiveness of these pilot programs.

Actively engaging citizens within urban metabolism management is still very far from being the new normal in cities. However, different evidence and experiments are shaping an emerging dimension of people’s awareness about their potential contributions to more decentralized infrastructures, and people-centered approaches in dealing with resources consumptions. Notwithstanding the negative results of the Saudi Arabia case (mainly due to its specific socio-economic features related to energy price policies) this paper provides evidence and examples about the key role played from education and awareness-building in enabling such a people-centered transition in re-shaping the future cities’ metabolism.

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