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RETROFITTING AND THE EPISTEMOLOGICAL PROBLEM OF URBAN SUSTAINABILITY

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HIGHLIGHTS

- There is neither academic nor political consensus about whether demolishing and redeveloping buildings is more or less sustainable than maintaining and refurbishing them.
- The lack of consensus on the relative sustainable value of building retrofitting, is parallel to the diverging views of sustainability casted by Ecomodernism and the Environmental Justice movement.
- The non-quantifiable qualities of the social system motivate practitioners to disregard this component of sustainability.
- A resolution to this conflict requires addressing the epistemological biases embedded within the three pillars of sustainability (environment, economy and society).

ABSTRACT

The growing use of green building certificates within the construction industry reflects a societal shift towards environmentally sensitive practices. However, role of technology in providing sustainable commodities can be considered contradictory: while green building certificates neither incentivize, nor disincentivize new construction building in favor of refurbishing, they pose an implicit claim that new construction buildings can be, at the least, as sustainable as retrofitting ones. This paper adds to the rhetorical analysis of sustainability's discourse by analyzing the gap existing among knowledge and discourse, in public policy arguments made regarding to the choice between building refurbishing and demolition. In the light of the analysis of main indicators of the "three pillars of sustainability" and follows a current policy debate at Bajos de Mena (Chile) where the discussion between opting for refurbishing and new building construction of social housing takes place. In doing so, the paper addresses the quantitative-bias leveraging a developmentalist approach towards urbanization, and highlights the underlying epistemological conflict eroding the notion of sustainability.

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1. GREEN BUILDING CERTIFICATES: AN ARCHETYPE OF ECOMODERNIST SUSTAINABILITY

Since the 1990s, the concern for producing sustainable buildings within the construction sector has grown due to the internalization of new environmental-rating agencies. The green certificates arising from these agencies measure the environmental impact of buildings and evaluate their performance in categories such as land or material use, pollution, and health and well-being. Examples of this increased global environmental awareness are the creation of the British *Building Research Establishment Environmental Assessment Method* (BREEAM) in 1990, the American *Leadership in Energy and Environmental Design certificate* (LEED) in 1994, the Japanese *Comprehensive Assessment System for Building Environment Efficiency* (CASBEE) in 2001, the French *Haute Qualité Environnementale* (HQE) in 2004, the German *Sustainable Building Council* (DGNB) in 2007, and the independent *SBToo*l in the 1990s, to cite a few. While scholars have called out some limitations of green building certificates—like the underestimated influence of project end-users (Abdalla, Maas & Huyghe, 2011) or the actual energy overconsumption of some certified buildings (Newsham, Mancini & Birt, 2009)—their progressive institutionalization shows a transition towards a more sustainable building industry.

This increased awareness in new sustainable construction, however, has hindered a deeper debate about alternative patterns of urbanization that may not rely on new construction but on the reuse of constructed space. Since green building certificates neither incentivize, nor disincentivize new construction building in favor of refurbishing, they pose an implicit claim that new construction building can be, at the least, as sustainable as retrofitting ones. The assumption that sustainable urbanization can happen regardless of whether buildings are newly constructed or retrofitted, eliminates an alternative premise: that the demolition of buildings and their redevelopment is not as sustainable as the maintenance of buildings and their refurbishment. This line of enquiry has not been much developed, at least in the form of technical assessments. Within the stream of voices supporting this argument, Anne Power (2008) states that buildings' refurbishment introduces major environmental, social and economic benefits compared to new constructions, among them "a reduction in transport costs, reduced landfill disposal, greater use of materials, reuse of infill sites and existing infrastructure (…) local economic development, retention of community infrastructure, neighborhood renewal and management." In contrast, demolition and rebuilding is associated with "much higher capital costs, higher material wastage, greater embodied carbon inputs (...) greater use of aggregates, and more noise and disruption." The University College of London, otherwise, has recently published a full analysis of the economic benefits and energy efficiency of building retrofitting, titled "Demolition or Refurbishment of Social Housing? A review of the evidence" (2014). The report indicates not only environmental but also social benefits of retrofitting; however, its authors acknowledge that there is weak evidence "linking the impacts of demolition and refurbishment to resident well-being" (UCL, 2014). Even in this case, the alternative premise—refurbishing is more sustainable practice than new construction—is not refuted, but it is unclear whether refurbishment leads to greater overall sustainability.

In this paper, we grapple with why not much research has been done, and how this lack of research affects the practice. Other than in Engineering-aligned analyses, the divergent prioritization of building demolition versus maintenance is implicit in two conflictive ideologies of sustainability. The major supporting evidence to new building construction stems from the cultural belief in modern technology's environmental benefits. This view can be identified with Ecomodernist's agenda, a newly created movement established among a large group of leading scientists, policy advocates, and industry leaders, that responds to the social critiques made against the risks of technology (i.e. nuclear disasters or chemical pollution). Ecomodernists see the role of technology as helping to "decouple" society and the environment, and thus, state that the only way out of modern environmental and social problems is technological development, and not its rejection (Asafu-Adjaye et al., 2015). This sociological view would, in the context of construction sector, prioritize the production of technologically efficient buildings to progressively curb inefficient pre-technological systems. While ecomodernism cannot be taken as a form of developmentalism, its logic finds its natural opposite at the Environmental Justice movement, broadly understood as the equitable distribution of environmental ills and benefits. This movement, addressing the fair distribution of environmental burdens and benefits, acknowledges that technological and urban development do not occur regardless of race and color (Skelton & Miller, 2016).

2. MATTER AND DISCOURSE OF SUSTAINABILITY: METHODOLOGICAL CONSIDERATIONS

This paper adds to the rhetorical analysis of sustainability's discourse carried by several scholars (Myers & Macnaghten, 1998; Gunder, 2006) by analyzing the gap between knowledge-production and ideological representations of sustainability in the case of building retrofitting. In particular it demonstrates that the dilemma existing between new construction and refurbishing, as sustainable building alternatives, cannot be resolved on a quantitative basis. In operational terms, the paper contrasts how technical terminology used to address sustainable urbanization is used in a policy case that highlights the aforementioned dilemma. It is worth noting that in the context of this paper, the analysis of "sustainable terminology" refers to indicators reflecting the "three pillars of sustainability" (environment, economy and society, also called "the 3 Es of sustainability"). This triad, explicit and implicit in virtually every text addressing sustainability, has de facto been used since the 1960s to represent the disciplinary fields defining sustainable development. The 3 Es are commonly represented through a Venn Diagram where the intersection of economic, social, and environmental systems situates a sustainable development scenario (Gibson, 2002). Many scholars have questioned its oversimplification (Giddings, Hopwood, & O'Brien, 2002), its capacity to capture the interaction between all categories (Carter & Moir, 2012) and its ability to represent an 'institutional' system (Lozano, 2008; Meadowcroft, 2000; Spangenberg, 2003); nevertheless, the 3 Es allows to find falsifiable terminology belonging to evidence-based disciplines, with which to assess discourses of sustainability. Thus, this paper looks at the explicit mention of economic, environmental and social capital costs and benefits of demolition and building retrofitting, and their quantification.

In a first phase of analysis, this paper carries exploratory research on state-of-the-art literature addressing sustainable urbanization —and framed according to the 3 Es of sustainability— to identify a toolset of variables (and values) that qualify the benefits of demolition and refurbishing urbanization alternatives. In light of this survey, the paper analyzes a current policy debate at Bajos de Mena (Chile) where the discussion between demolishing or refurbishing the decaying housing complex is taking place. As a case study, Bajos de Mena currently belongs to the broad family of high-density public housing projects created to rebuild an "open and clean city" (Ramroth, 2007) through the production of more technologically efficient buildings; at the same time, it shares many characteristics of the infamous typological heritage that modern architecture left to demolished buildings like the Pruitt-Igoe project (1954-56), the Robert Taylor Homes (1959-62), and the Cabrini-Green Homes (1942-62) in the United States, or the Robin Hood Gardens (1972) in the United Kingdom—to name some cases that fueled the pervasiveness of the ecomodernist approach. Although Bajos de Mena shares the typological problems of modernist housing, it was built only 15 years ago, and not six decades ago as the majority of the other cases; this makes Bajos de Mena worth analyzing since its demolition cannot be solely explained by 'technological deficiencies,' precisely because it is not part of this pre-technological generation. The paper does not neglect the relevance of building typologies and urban form as important variables in this debate; however, the broad range of modernist buildings still standing and successfully retrofitted —as it is the case of Pedregulho Housing (Brazil, 1948-1960), Park Hill Estate (England, 1957-1961), Bois-le-Prête (France, 1959), or Grand Parc (France, 1960)— work as living proof that the performance of the buildings outweighs any typological consideration. This way, Bajos de Mena may render possible to ask why ecomodernist views of sustainability have a primacy over its retrofitting alternative.

3. RETROFITTING VERSUS REDEVELOPMENT WITHIN THE 3 ES OF SUSTAINABILITY

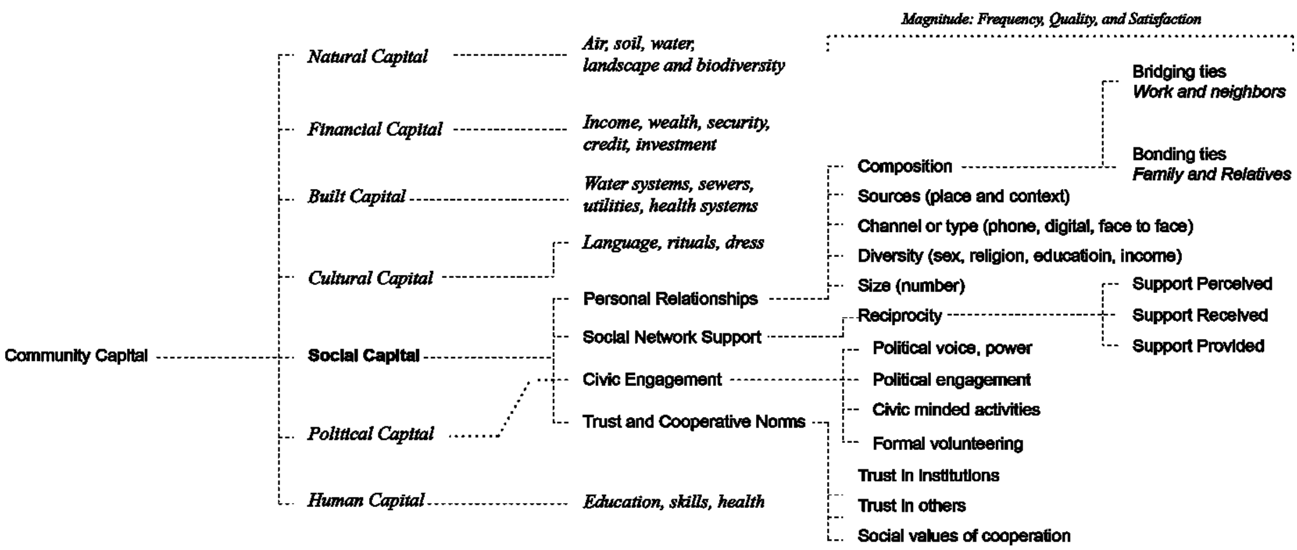
This chapter presents the major findings of a literature review whose main goal was to unpack and weigh each one of the 3 Es in a set of relevant, independent and comparable measures and values. All the technical variables surveyed are indicated at Table 1, as well as the rationale for their selection. As the table shows, the economic sphere plays a fundamental role at evaluating the performance of refurbishing versus demolition and redevelopment. Since all economic indicators are inherently quantifiable, they make it easy for practitioners to rely on cost-benefit analyses to evaluate the relative performance of both premises. Consequently, the tendency to rely on measures of economic capital further advances the ecomodernist view of sustainability. In this process, they usually include the analysis of the investment costs (like Capital Expenditure -CAPEX or Operational Expenditure -OPEX), and the value of a building in the form of capital investment appraisals (which common methods include Discounted Cash Flow-DCF and Net Present Value-NPV). Actual measures of economic capital vary significantly project to project, but they attempt to measure the value of the building and of the site.
Similarly, environmental indicators can also be expressed in numerical values. Indicators like embodied energy and operational energy shed the most insight into the differences between retrofitting and demolition. Besides energy use, other environmental indicators consider physical waste and air quality; waste indicators differentiate hazardous waste, inert waste, and construction dust, and air quality measurements separate stream of meanings, either measuring pollution (like the air quality index) or overall sustainability (carbon footprint, greenhouse gases). However, few existing figures help clarify which type of urban development has a smaller environmental impact. While new building construction is often associated to lower operational energy costs, retrofitting carries less embodied energy costs, and generates less construction waste. Complementary, demolishing and redeveloping sites creates more construction waste (41-53 lb./SF new building versus 3-24 lb./SF for retrofitting) (USEPA, 2003), and the carbon footprint for redevelopment is greater than that for urban retrofitting (Empty Homes Agency, 2008). Furthermore, the energy required to demolish a building (its embodied energy), is a considerable portion of its net energy use (Jackson, 2005). Scholars and first-hand reports demonstrate that although it is possible to measure environmental capital, it is not common practice.
In contrast to economic and environmental capital, the social capital gains (and costs) obtained from urbanization processes can be identified differently depending on the definitions we take. According to the World Bank, social capital "represents around 60% to 80% of true wealth in most developing countries" (World Bank, 2006) and public policies must consider it in order to "leave enough resources, of all kinds, to provide [future generations] with the opportunities at least as large as the ones we have had ourselves" (UN, 2012). However, its incorporation in policy evaluation is still problematic; since the concept of social capital is associated with values such as tolerance, solidarity or trust, the quantitative evaluation of social capital is a complex task. Scholars have not, indeed, agreed on one single definition for social capital, although all definitions surveyed underline the capital benefits obtained by a specific community through the use or possession of a durable network. In a more refined analysis of this problem, Cornelia and Flora's overarching hierarchy for community capital (2004) pays attention to seven types of capital: natural, cultural, human, social, political, financial and built capital; this classification is systematic yet focuses on the interaction among these seven capitals, conflating the independence of economic and environmental capitals within social capital. Cornelia and Flora's community capitals framework, however, paved the way for Veronique Siegler's (2014) most operational definition of social capital; within Siegler's definition, social capital is broken down into four components: social support network, personal relationships, civic engagement, and trust and cooperation (Siegler, 2014), all values being measured according to its frequency, quality, and satisfaction (Figure 1). Although Siegler helps us identify indicators and values for social capital, these indicators are hard to measure. Consequently, generating a positive or negative connotation associated with the two types of development proves difficult without a costly, complex and technical analysis.

Table 1: Survey of indicators assessing capital gains that can be related to building construction

Economic Indicators	**Environmental Indicators**	**Social Indicators**
Capital expenditure (CAPEX) Cost that affects fixed assets of a building. It concerns the acquisition, construction, significant enhancement, or demolition of a fixed asset, and it is typically associated with the beginning or the end of a building's life cycle where large investments in fixed assets are incurred (Maverick, 2017). Operational Expenditure (OPEX) The day-to-day operations, such as wages, utilities, maintenance and repairs, rent, sales, general and administrative expenses, and they are associated with the middle stages of a building's life cycle, once the acquisition and construction are completed and the building is handed over to the client (Maverick, 2017). Discounted Cash Flow (DCF) Evaluation of large investments in capital expenditures by discounting the future cash flows back to the present value (Folger, 2017) Net Present Value (NPV) Present value of the future cash inflows minus the present value of the future cash outflows to determine the profitability of the investment (Kurt, 2016).	Embodied energy Energy consumed by all of the processes associated with the production of a building, from the mining and processing of natural resources to manufacturing, transport and product delivery (Milne, Readon, 2013). Operational energy Day-to-day energy used by residents in a building.	Social capital Aggregate of the actual or potential resources which are linked to the possession of a durable network of more or less institutionalized relationships of mutual acquaintance or recognition. (Bourdieu, 1985: 248) A variety of entities with two elements in common: they all consist of some aspect of social structures, and they facilitate certain action of actors—whether persons or corporate actors—within the structure. (Coleman, 1990: 302) A resource that actors derive from specific social structures and then use to pursue their interests. (Baker, 1990: 619) A set of elements of a social structure that affects relations among people and are inputs or arguments of the production and/or utility function. (Schiff, 1992: 161). The ability of actors to secure benefits by virtue of membership in social networks or other social structures. (Portes, 1998: 6) Social connections and all the benefits they generate. The benefits for people having these social connections can occur either at an individual level or at a wider collective level. Social capital is also associated with values such as tolerance, solidarity or trust. (Siegler, 2014: 2)

Source: Own elaboration

Figure 1: Diagram representing the components Cornelia and Flora's "Community Capital."



Source: Own elaboration, based on Cornelia and Flora (2004) and Siegler (2014).

4. REFURBISHING VERSUS REDEVELOPMENT IN THE CASE OF BAJOS DE MENA, CHILE

All definitions presented in the chapter above are put to test in the case of the public housing project of Bajos de Mena (Chile). In this case, economic capital is analyzed using the major capital expenditures incurred by the government through Bajos de Mena's history, obviating the operational expenses or the cost of day-to-day operations affecting the middle stages of the buildings' life cycle (absorbed by each household). The environmental and social analyses were performed based on secondary literature (government reports and news media) concerning the indicators already presented in Table and Figure 1. As stated, the purpose of this exercise is to evaluate how the different policies carried at Bajos de Mena from 1990 to 2015 are result or related to the aforementioned metrics—economic, environmental and social capital costs—when dealing with the question of refurbishing or demolishing and redevelopment. This allows us to analyze how, in practice, the 'quantitative-bias' of social capital indicators affect the conflict between divergent views of sustainability, namely ecomodernism and environmental justice.

Bajos de Mena is a neighborhood located in the extreme south west of Santiago (Chile's capital) in the district of Puente Alto, known for its high poverty rates, critical levels of overcrowding conditions, high concentration of public housing, low quality environment, and lack of urban services. Its construction began in 1990 with the purpose of providing housing for low-income households. Although its first housing units were delivered in 1994, construction continued throughout the next decade; by 2002, a total of 25,466 units were built (Cociña, 2016) to accommodate 122,278 residents (INE, 2002). The infrastructure problems in Bajos de Mena began immediately after the first units were delivered in 1994. The development grew infamous in 1997, when the recently delivered "Copeva houses"—referring to its builder's name—did not withstand the rains. The poor quality of the reparations instigated the gradual depopulation of Bajos de Mena, and led into the general urban decay of the area. Since the structure of the buildings was stable by that time, a first plan considered retrofitting the units, repairing their leaks, and tackling the two main problems contributing to their stigmatization: the small size of the apartments (near to 45 sq.m, or 480 sq.ft) and consequently, their high densities. The plan aimed to relocate a group of residents by merging two to three of the original apartments into larger units. The plan was quickly discarded to promote a pro-development government campaign whose main goal was to reactivate the construction industry after the 2008 international economic collapse. Consequently, a new plan called "Segunda Oportunidad" ("Second Opportunity," in English) promoted in 2009 the demolition and redevelopment of the whole area (Avanza Chile, 2015; Kilometrocero, 2015). Since the plan was voluntary for the residents, its implementation was not homogeneous, leading to partial demolitions and to the illegal occupation of abandoned and semi-demolished buildings. To counteract the devaluation of the territory, the Chilean Ministry of Housing announced a redevelopment plan in 2014 that included the construction of new transportation corridors, new housing units in the demolished sectors "Mi Barrio mi familia" and "Jesús de Nazaret", a new park over a pre-existing landfill, and the increase of public lighting infrastructure. In 2015, following the same pro-development principles employed so far, the government launched a master plan —with an extra capital expenditure of USD $230M—as another urban redevelopment attempt. Once again, instead of reconsidering the retrofitting of the still remaining structures, the plan considered the construction of a new police station and the promise of providing new services such as a Civic Center, six educational facilities, and the construction of 500 new single-family units in the demolished areas of "Francisco Coloane" and "Cerro Morado" (Plan Integral de Bajos de Mena, 2015). Many of these promises still remain unbuilt, and the government has opted for removing roofs, stairs, and windows on many of the vacant buildings still remaining on site in order to prevent their illegal occupation, without any trace of success to date (see Figure 2).

In the analysis of economic terminology found in literature, and under the best scenario—i.e. without considering appraisal methods or values adjusted to inflation—more than USD $150M have been invested in demolitions, relocation, and construction of new units. This constitutes almost 65% of the whole initial construction costs, which have not significantly improved the wellbeing of the residents -as demonstrated by the current vulnerable conditions of the illegal occupation of semi-demolished buildings, and in the precarious conditions of the build environment of their surroundings. The development of Bajos de Mena demonstrates that developmentalist urbanization is also heavily weighted by political process; and that it is necessary to determine which stakeholders assume the economic costs and benefits of redevelopment – given that in this case they did not lead to the most sustainable solution, however marginal impulse it may have given to private construction companies.

Meanwhile, the environmental impact of the policies deployed still remains unclear. It is extremely difficult to isolate the impact of demolitions and new constructions in the air quality of a polluted city like Santiago; there is no evidence that any company or institution has tracked the construction and inner waste produced during the demolition and construction processes; and there is currently no comprehensive assessment of the embodied and operational energy consumed in the projects' construction or their daily operation. Without any quantifiable data, the political debate has transformed into vague slogans where it is nearly impossible to determine exactly whether redevelopment or retrofitting is best from an environmental perspective. The debate has exposed arguments in both directions; while the position in favor of demolition and rebuilding has been associated to right wing politics, the option in favor of retrofitting was associated to the left wing (El Dínamo, 2013). This condition has "shift[ed] the attention from the main concern, the wellbeing of its inhabitants" (Kilometrocero, 2015) to a political debate with no technical support and therefore, no clear conclusion to date.

With regards to the social cost of the policies implemented, the evidence seems categorical. According to Cecilia González (Kilometrocero, 2015) the area is still affected by overcrowding conditions, drug abuse, and an unresolved social conflict aggravated by the political character of the different policies. According to the information gathered by the same local leaders, 50% of young dwellers consume drugs, 70% of women have been mothers before the age of 14 and, on average, each family lives with less than USD $5,400 a year (Kilometrocero, 2015). Moreover, not all neighbors agreed to leave their homes after

Table 2: Capital Expenditures at Bajos de Mena's housing policies (1994-2015)

Phases	**Cost** USD Millions, not adjusted by inflation
I. Construction 1994-2004 Considering UF227 (USD 9,200) the voucher value to acquire each unit, (Sandoval, 2005) for a housing stock of 25,466 units (INE 2002)	234,2
II. Decay and Rehabilitation 1997-2014	151,7
1997: Copeva Scandal	
A. Repairing cost, considering only the investments made between 1997-2000 (Sandoval, 2005)	1,3
B. Compensation cost, paid after a 16 years trial against SERVIU (La Tercera, 2012; Emol, 2013)	1,5
C. Relocation of residents. Considers a UF227 voucher assigned to 60% of the units affected—approx. 2,100 units. (Habiterra, 2008).	18,7
2009-2013: "Second Oportunity" Program	
A. Demolition (Francisco Coloane and Cerro Morado) (Kilometrocero, 2015)	36,0
B. Relocation (Francisco Coloane and Cerro Morado), considering a relocation voucher of 700 UF (Cociña, 2016) issued to approximately to 1,000 households (Kilometrocero, 2015)	29,2
2014: Rehabilitation plan Considering the cost of transportation corridors (USD $33M), new housing units (USD $20M), Juan Pablo II park (USD $11.2M), and public lighting improvements (USD $ 0.8M) (Kilometrocero, 2015).	65,0
III. Master plan 2015- According to the official webpage: www.planintegralbajosdemena.cl (still to be fully executed)	230,0

Source: Own elaboration, based on references cited at figure

Figure 2: Bajos de Mena. Illegal occupation of semi-demolished buildings (August, 2017). *Source: José Lemaître*

the demolition plan, generating even more division in the community and eroding values of trust and cooperative norms (Kilometrocero, 2015). To summarize, Camila Cociña in her UNDP report states that Bajos de Mena has been, rather than abandoned, "mistreated by a society that, as it put its eyes and hands there, mainly aggravated the site's conditions" (Cociña, 2016).

Even though some residents successfully relocated after the "Segunda Oportunidad" program, they did not necessarily receive the desired social benefits associated with relocation, and instead experienced the disassembly of their social network support and loss of community trust (Kilometrocero, 2015). As with our analysis of environmental capital, available data was lacking in all surveyed sources, implying that such factors were not considered relevant in the process of public policy debate. In general, the case of Bajos de Mena illustrates the lack of an actual relationship between sustainability's technical and public discourses.

As can be inferred from this case, the four aspects of social capital as defined by Siegler (2014)—social support network, personal relationships, civic engagement, and trust and cooperation—are hard to measure or associate in comparative terms with economic aspects. At the same time, the case demonstrates that the quantitative form of economic capital has an intrinsic political value which—with the quantitative-bias at their favor—leverages ecomodernist views of sustainability over its environmentally just alternative. This introduces serious difficulties to transfer any conclusion from articles analyzed to technical or numerical variables within the broad concept of sustainability.

5. Social systems and the quantitative bias

This analysis of Bajos de Mena showcases two epistemological conditions present in the hegemonic discourse of sustainable urbanization, namely the reliance on quantitative economic data, and the lack of technical associations between environmental, social and economic actions in space. The economic analysis of capital costs of Bajos de Mena only shows an increasingly expensive project that cannot be deemed optimal in any way; and the scattered measurements of its environmental benefits, and the mention of the project's social benefit cannot be falsified. The lack of quantifiable data on environmental and social magnitudes makes the economic ones stand out; and even in this case the comparison between the economic costs of demolition, new building construction, and refurbishing, is far from clear. The prevalence of economic data shown in the case of Bajos de Mena expresses, at a first glance, the easiness for quantitative data to gather social consensus; for instance, most scholarly research agrees on the indicators used to measure a building's monetary worth, such as discounted cash flow or net present value, but not all authors concur on which indicators accurately reflect social capital, or how they can be quantifiable. As Siegler recognizes, the value of social capital assets cannot be presented as monetary values, "as it is a broad concept which is based largely on relationships. It is therefore difficult to value overall" (Siegler, 2014). This assumes that the lack of "precision" of environmental and social systems is a defect itself, while it is in fact their inherent condition—the same condition that gives the economic system quantitative values. This bias gives non-quantifiable values a lower status of reality, and transforms a holistic apperception of sustainability into a proxy for technological efficiency and economic growth. The interrelationship between the 3 Es' systems faces an epistemological challenge that requires accepting their components as equally important, thus deconstructing the primacy of economic and quantitative valuation.

In what relates to urbanization processes, it is important to recognize the implicit bias existing at the common definition of the 3Es as the intersection of three discrete and equally interdependent systems. This is far from reality: not only social systems defy quantification and compartmentalization, but also our asymmetric condition as humans challenges the presumed equal inter-relationship between systems (Figure 3). The internal asymmetry existing between economic, social and environmental systems cannot be avoided; and rather, the specific magnitudes and indicators that are relevant for each system (see Table 3) have to be acknowledged, and brought to relevance.

Table 3: Survey of magnitudes and indicators measuring environmental, social and economic costs

Currency	Weight	Energy	Ratio	Qualitative Appreciation
Capital Expenditure	Air Quality	Operational Energy	Human Development Index	Social Capital
Operational Expenditure	Construction Dust	Embodied Energy		Cultural Capital
Marginal Benefit	Inert Waste			SOCAP-IQ
Capital Investment	Carbon Footprint			Social Mobility
Appraisal	Carbon Monoxide			Social Networks
Discounted Cash Flow	Greenhouse Gases			Political Capital
Net Present Value	Hazardous Waste			Human Capital
Cost of Minimum Supplies				Built Capital
Devaluation of Investment				Life Cycle Assessment
Building/Land Value				
Cost of Urban Property				
Pareto Optimal				
Affordability				
Environmental Tariff				
Emission Trading				
Economic Social Cost				

Source: Own elaboration

Rating systems like the Life Cycle Assessment (LCA) are attempting to integrate indicators of all three capitals (social, environmental and economic) into a unified system that evaluates the impacts of a product, process, or activity by looking at its entire life-cycle from raw materials extraction through disposal (BCorporation, 2008). Although these efforts are commendable, the epistemological problem embedded into the discourse of sustainability may need to be resolved outside of a techno-scientific context. As long as the sustainability of a place is explained as the occurrence of events in that place, the relationship between space and sustainability will be mistakenly simplistic. Sustainable construction is not tied to a place itself, but is a set of social, environmental and economic actions that travel across spaces and occur across time. While technological urban developmentalism produces efficient commodities, it has serious difficulties in incorporating the social and environmental actions relations that are needed to make urbanization sustainable. Without solving the epistemological challenge that addresses the inherent condition of each one of the three mentioned systems, the concept of sustainability will probably remain beyond the reach of urban designers and planners.

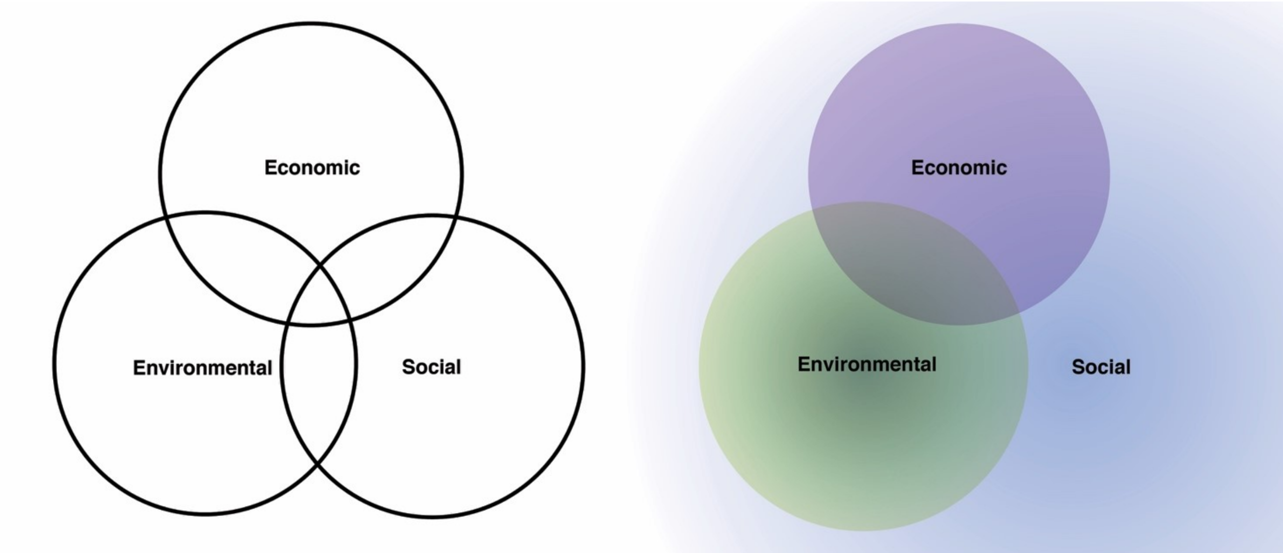


Figure 3: Conventional (left) and proposed (right) representation of systems involved in sustainable development. *Source: Own elaboration.*

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