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Neighborhood Sustainability Assessment Tools: A Conceptual Framework for Their Use in Building Adaptive Capacity to Climate Change

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***Abstract*—**Climate change remains a challenging matter for the human and the built environment in the 21st century, where the need to consider adaptation to climate change in the development process is paramount. However, there remains a lack of information regarding how we should prepare responses to this issue, such as through developing organized and sophisticated tools enabling the adaptation process. This study aims to build a systematic framework approach to investigate the potentials that Neighborhood Sustainability Assessment tools (NSA) might offer in enabling both the analysis of the emerging adaptive capacity to climate change.

The analysis of the framework presented in this paper aims to discuss this issue in three main phases. The first part attempts to link sustainability and climate change, in the context of adaptive capacity. It is argued that in deciding to promote sustainability in the context of climate change, both the resilience and vulnerability processes become central. However, there is still a gap in the current literature regarding how the sustainable development process can respond to climate change. As well as how the resilience of practical strategies might be evaluated. It is suggested that the integration of the sustainability assessment processes with both the resilience thinking process, and vulnerability might provide important components for addressing the adaptive capacity to climate change. A critical review of existing literature is presented illustrating the current lack of work in this field, integrating these three concepts in the context of addressing the adaptive capacity to climate change. The second part aims to identify the most appropriate scale at which to address the built environment for the climate change adaptation. It is suggested that the neighborhood scale can be considered as more suitable than either the building or urban scales. It then presents the example of NSAs, and discusses the need to explore their potential role in promoting the adaptive capacity to climate change. The third part of the framework presents a comparison among three example NSAs, BREEAM Communities, LEED-ND, and CASBEE-UD. These three tools have been selected as the most developed and comprehensive assessment tools that are currently available for the neighborhood scale.

This study concludes that NSAs are likely to present the basis for an organized framework to address the practical process for analyzing and yet promoting Adaptive Capacity to Climate Change. It is further argued that vulnerability (exposure & sensitivity) and resilience (Interdependence & Recovery) form essential aspects to be addressed in the future assessment of NSA's capability to adapt to both short and long term climate change impacts. Finally, it is acknowledged that further work is now required to understand impact assessment in terms of the range of physical sectors (Water, Energy, Transportation, Building, Land Use and Ecosystems), Actor and stakeholder engagement as well as a detailed evaluation of the NSA indicators, together with a barriers diagnosis process.

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I. Introduction

CLIMATE adaptation has become a pressing issue [1] and one of the most complex and far reaching issues humans have ever encountered [2]. Regarding this aspect, Nobel Prize winner Rajendra Pachauri said, "If there's no action before 2012, that's too late. What we do in the next two to three years will determine our future. That's the defining moment" [3]. Adaptive capacity is a significant matter. Indeed it is the pivotal concept in aiding effective adaptation [4]. Despite the increase of the studies that focus on the need to address the adaptive capacity over the last years; we still cannot find methods to enable an understanding of adaptive capacity to climate change in practical terms [5].

This study aims to present a practical framework for addressing the adaptive capacity to climate change, in the context of the sustainable development process. Particularly, in the contexts of evaluating the behavior of and interaction between physical and social indicators simultaneously [6]. Further, there remains a gap lack in understanding of how sustainability can manage climate change impacts in delivering positive net sustainability gains now and into the future [7]. Therefore, this research aims to understand whether sustainability and adaptation to climate change can be simultaneously adopted and promoted in the built environment development process.

In this study, it is argued that an initial review of existing research has identified linkages between climate change, sustainability and other relevant concepts including vulnerability and resilience that will effectively inform the process of constructing a comprehensive and practical climate change adaptation framework. The first two parts of this study have therefore focused on identifying current gaps in literature to extract two important aspects.

The first relates to the integration of practical concepts to enable the conduct of an analysis of adaptive capacity in the sustainable development context. It is established that despite the linear process of identification and extraction of such concepts, in the end, the relationship between these concepts must be considered as complex and intertwined, when

addressing the planning and implementation of the practical framework.

While, the second aspect, that must be addressed is in the selection of the most appropriate scale at which it is most effective to influence both sustainability and the adaptation process. This issue is core to this study, as success in adaptation depends on the scale of implementation and the criteria used to evaluate at each scale. This work argues for the pre-eminence of conducting the analysis at an intermediate scale, neighborhood, in comparison to either the building or urban scale, is more appropriate in the analysis of adaptive capacity process. Finally, in the last part, a conceptual framework for the proposed neighborhood scale sustainability and climate change adaptive capacity tool is developed and presented.

II. Part One Climate Change Impacts and Need to Sustainability

Climate change is widely acknowledged as a complex and changeable issue, where climatic changes can create feedback loops that are able to reinforce each other [8]. We have already begun to experience what we can name the short term, slow impacts related to an increase in temperature and changes in precipitation regimes. However, unfortunately, current responses to climate change tend to focus on response to these short term impacts, while ignoring potentially appropriate and necessary adaptation to the longer term impacts, such as: a rise in expected climate related refugees, expected to exceed 10 million by 2050, [9] and increased vulnerability of many global cities to hazards such as flooding, heavy precipitation and cyclones, extreme temperatures and drought conditions [10]. Further, an increase in frequency and magnitude of extreme climatic events is a key form in which longer term climate change is likely to be manifest [11]. For instance, both the frequency, geographical range and magnitude of extreme events is expected to increase, such as that experienced in central Europe during the summer of 2000, where extremely unusual and long-lived high temperatures, led to the deaths of over 20,000 people [9].

Accordingly, addressing and designing the methods and tools to respond to the risks associated with climate change should be a prioritized issue [12], and needs to be analyzed and discussed regarding both the short term and importantly the likely long term impacts. The existence of methods as practical tools is important in addressing the adaptation of both humans (social networks) and built environment (physical infrastructure) to these climatic events. These tools need to be developed and implemented widely as well as embedded in the decision making process, in both impact terms. In this context, it is proposed here that there is a potential to achieve this through an investigation of how existing, widely adopted sustainability assessment tools can be utilized to address these issues? This potential is argued on the basis that sustainability assessment tools have been effectively and widely adopted to address and deliver more socially, economically, and environmentally appropriate development of the built environment over the last 2 decades, largely responding to mitigation of global warming. Therefore, it is argued that the integration of an assessment framework for adaptation within these tools, responding as this would to the IPCC working group statement that "Managing the risks of climate change involves adaptation and mitigation decisions with implications for future generations, economies, and environments" [13]. Where, this new focus on the investigation of adaptation should both build adaptive capacity in terms of both physical infrastructure as well as actors' capability to adapt, and make adaptation appropriate decisions [14]. The natural analytical unit for sustainable development research is the socio-ecological system [6]. Therefore, it is important to understand how this physical-social interaction has existed in the sustainability thinking process, particularly in the context of decision making, and its potential role in affecting the integration of the adaptation process.

It has already been acknowledged that existing sustainable development approaches cannot be successful without taking into consideration the risks associated with climate change impacts [15]; and there is no doubt that the proposed investigation is full of challenges regarding the dynamic nature of the climate impacts. But, essentially, in sustainability, the approaches of dynamic developments are promoted, as they should be able to change as the context changes [1].

The following review endeavors to investigate and evaluate the relationship between adaptation to climate change and the sustainability development process, to extract the theoretical concepts within the linkage between these two concepts, in order to inform the proposed practical joint sustainability / adaptive capacity framework analysis later.

A. Sustainability in Relation to Building Adaptive Capacity to Climate Change

It is proposed that there is significant potential in explicitly establishing the relationship between sustainable development and the adaptive capacity to climate change in practice; in bonding the analysis of sustainability and Climate change adaptation, through the adoption and adaptation of existing sustainability assessment processes. The significance of the sustainability assessment lies not only in directing the decision-making towards sustainability, within which is embedded climate change mitigation strategies [7]. However, also, it appears to hold the potential to build the adaptive capacity process to Climate Change.

Reference [16] defines sustainability, as the idea that the future ought to be a better than the present. This further supports the concept that such sustainability assessment tools represent an appropriate mechanism through which to drive towards an appropriate adaptation future. However, it can be seen that currently, such tools focus on the present performance of sustainable development rather than the ongoing and future performance of such assets. It can be seen however, that definitions of sustainability should inherently address the continuity of sustainable performance into the future and therefore adaptive capacity. The consideration of resilience and vulnerability to climate change, in the short and long term, should be treated as a significant perspective on the achievement of sustainability in the development process.

Existing sustainability assessment tools, constitute a range of indicators, across a breadth of sectors, which aim to guarantee an appropriate endeavor in the conservation of environment and mitigation of climate change [17]. The adoption of sustainability assessment tools can already provide support in adapting to climate change, through their effect on managing resources [12]. However, it is important that this concept should be analyzed in terms of both the immediate and long-term consequences of Climate Change impacts [18]. It is proposed therefore that each sustainability assessment tool indicator, identified and established within tools as able to address the sustainable outcome, must also be evaluated in relation to its resilience to the impacts of climate change as well as its potential to enable adaptive capacity within the physical and social systems. Here this study positions the sustainability assessment tools at the center of the analysis process, to evaluate its potential to enable adaptation to climate change impacts. The sustainability assessment tools can mediate and bond the decision making (social networks) and resources management (physical infrastructure), to positively influence the adaptation process to climate change impacts, indeed its resilience, both in the short and long term. In this situation, and to ensure the adaptive capacity of both the place and its community, resilience has emerged as long-term sustainable solution [19]. Where resilience can give any system the ability to remain, after its completion and occupation, on a sustainable track [20]. For instance, in order to address sustainability in energy at the urban scale, in terms of the continuity of the supply, transmission, and demands in effective ways, resilience appears here as a pre-condition [21]. Moreover, the main driver for the adoption of resilience thinking here relates to the advantages to the management of the combined social-ecological systems [22]. However, the management of the assessment, in terms of resilience / adaptive capacity and sustainability of both physical and social indicators, should necessarily be verbose, especially in relation to the needed consideration of timing of the assessment, conceptually at three stages: during the development, the intermediate performance and at some theoretical end point. Here, the structure of the framework is constructed to address the bond among these three stages, rather than assess the outcome of every stage. Moreover, resilience should be a part of the sustainability / adaptive capacity assessment process, and not an additional concept, as the measurement of sustainability at various city levels, is a fundamental procedure in building a sustainable future in the urban context [23].

Accordingly, resilience is not a minor concept; on the contrary, it is a major part to be addressed if the sustainable system designed at the inception of any development is to be persistent. In this study, resilience will be investigated because it is a pre-requisite in building the adaptive capacity to any sudden change. So, if we wish to evaluate the sustainable development process in addressing the adaptation principles, is it possible to integrate a practical assessment of resilience into this process? And as such – further support the evaluation of adaptive capacity? Or is there a need to insert another concept to make the analysis process achievable?

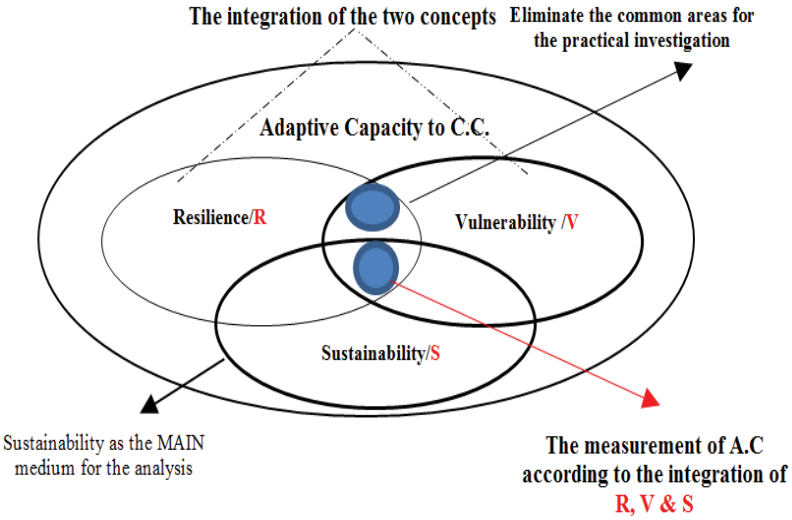

Fig. 1 The main components for the A.C analysis

B.Is Resilience Enough in Addressing the Practical Analysis of Adaptive Capacity to Climate Change?

In resilience studies, the analysis of the adaptive capacity has related to the development of robust strategies for the adaptation in addressing the flexibility of strategies that the system adopts towards the changing condition [2], [20], [25]. Up to now, resilience characteristics have been considered fungible, where current literature has not fully addressed whether there is a minimum level for each to assure resilience [26]. This is not to say that resilience characteristics are weak or unreliable, rather that most of the current studies have related adaptive capacity and resilience characteristics in a theoretical way. For example, [27] demonstrated that urban resilience characteristics are different in regard to the systems, agents and

institutional scenarios, arguing that for each one, the resilience analysis should be different. For example, for the physical systems, resilience characteristics are related to flexibility, redundancy, and safe failure. Such resilience characteristics are clearly integral to the sustainability context and yet remain theoretical concepts, requiring expansion into concepts that are able to be practically applied within deeper, more pragmatic scientific methods. Further, the analysis of these characteristics remains relatively vague, especially in consideration of the trades-offs required between the long term and short term adaption process. The role of resilience has been established in the development of sustainability assessment tools to address climate change impact. In particular, in enabling systems to resist stresses efficiently, to absorb the change [28], [29] and finally to recover [28] as these are the three phases that can be considered the main characteristics of resilience. However, approaches to their analysis and implementation have been demonstrated in more practical characteristics such as: adaptability [20], [24], [25], diversity [20], [24], [25], [30], [31] and interdependence [24], [25]. However, such characteristics have not physically addressed how the system can face the sudden change, especially in relation to sustainability.

TABLE I
RESILIENCE, VULNERABILITY AND SUSTAINABILITY IN THE CONTEXT OF CLIMATE CHANGE LITERATURE STUDIES

	Sustainability & Adaptive capacity to C.C	Resilience & Adaptive capacity to C.C	Vulnerability& Adaptive capacity to C.C
Group One	[34] Cohen et al.,1998 [44] Smit and Pilifosova, 2001 [13] Swart et al.,2003 [41] Ikeme, 2003 [38] Wall and Smit, 2005 [5] Fussel,2007 [45] Damtoft et al.,2008 [46] Kundzewicz et al.,2009 [47] Matthew and Hammill,2009 [36] MacDonald,2010 [40] Melville,2010 [39] Lockwood, 2013 [42] Shaw et al. [43] Scott et al.	[22] Walker et al., 2002 [50] Hughes, et al.,2003 [11] Tompkins and Adger,2004 [53] Keim,2008 [54] Chen et al., 2009 [55] Engle and Lemos, 2010 [48] Bahadur and Tanner,2010 [51] Davoudi et al. 2012 [49] Pelling, 2011 [56] Vella et al. 2012 [52] Graugaard, 2012 [27] Tyler and Moench, 2012	[60] Kelly and Adger,2000 [61] Adger et al.,2003 [62] Adger et al.,2004 [63] Brooks et al.,2005 [64] Vincent, 2006 [65] McLeman and Smit,2006 [66] Füssel and Klein,2006 [58] Hinkel, 2011 [59] Brown et al.,2012 [67] IPCC,2014 [57] Eriksen and Kelly,2007

Despite the identification of comprehensive resilience characteristics that address the important issues relating to adaptive capacity; a gap remains in relation to how the socio-environmental system might face climate exposure. In other words, resilience does not address exposure analysis [6] in order to practically and accurately deal with the range of changes in magnitudes and frequency of climate impacts. In this study, exposure analysis is also important, because it enables appropriate focus of resilience assessment according to relevant characteristics, for example identifying the sensitive community or places, enabling focus of adaptive responses. Moreover, the connection between exposure and sensitivity is also significant, and is rooted in the concept of where vulnerability assessment in the context of climate change mainly combines the natural and social science perspectives [33], in the combination of physical and social factors. The analysis of the relationship between climate exposure and system sensitivity in both the physical and social context, is therefore the framework for the evaluation of vulnerability to climate change to be applied here.

It should be said that sensitivity as a characteristic of vulnerability, like resilience, is not an urgent concept. It is also an inherited property of the social and ecological system [6]. To sum up, in the context of analyzing the adaptive capacity within sustainability assessment tools, it might be appropriate to begin with an assessment of exposure and sensitivity, (Vulnerability), and then to adopt resilience thinking characteristics. The integration between resilience and vulnerability as shown in Fig. 1 provides the combined analytical method for the Adaptive Capacity in sustainability assessment tools. It is not the intention here to include the whole components of the two concepts, but, more likely to extract the common aspects between the two. This is not a part of this study as it needs to discuss the relation between each character of resilience with the main analysis of the two parts of vulnerability, to realize where they can meet and separate, in the context of the adaptive capacity building process.

Group 1: In a comparison of the studies that have focused on the analysis of adaptive capacity to climate change, with the three concepts of resilience, vulnerability and sustainability the following has been found (Table I):

Sustainability: Climate change and sustainability have been pursued as largely separate discourses [34]. But Sustainability has addressed the linkage to adaptation to climate change in different scenarios, such as scale [30], [35], sector [36], management [37] and policy [13] whether governmental and decision-making [38], [39] and information [40] to protect climate resources [41] and business and industry [42]. But, research is still required to include methodological developments, monitoring and indicator studies, testing and evaluation of adaptation measures, and stakeholder participation [5] and to focus on the mitigation and sustainability in regarding the governance and decision making process [43]. In comparison to resilience and vulnerability, this can be considered as developed literature however, there are still gaps in relation to developing sophisticated assessment tools that combine the adaptation to climate change, and in particular in adapting to the longer term specifically. The linkage between sustainability at the neighborhood scale and building adaptive capacity is also not sufficiently addressed at this point. Moreover, the focus on the physical aspects is much more than on the social and social-ecological issues. These gaps

existed in the relation to both concepts with the adaptation to climate change.

Resilience: Mostly, resilience studies have linked the adaptive capacity with ideas such as governance, management, and institutions. It has also been evaluated in relation to the physical asset and disaster context such as [48], [49] but less than in the social focus. In resilience studies, the community scale has the most focus [50]-[52] in comparison with other scales as neighborhood nor individual scale. Notwithstanding, the analysis of resilience characteristics in practical terms is still primitive.

Vulnerability: In research regarding the linkage between vulnerability and adaptive capacity, significant knowledge as regards practical indicators for vulnerability have been established [26], [57]-[59]. However, continuing challenges for vulnerability research remain in developing robust and credible measures [14].

Importantly for this work, the sustainability / climate change studies were different to those studies associated with either resilience or vulnerability. Both resilience and vulnerability were found to have stronger links with characteristics of system adaptation. While sustainability, is more like a creating system that is itself able to adapt and continue.

Group 2: (Table II) Both resilience and vulnerability deal with the adaptive management as core issues in their thinking process [68]. Nevertheless, there are very few studies that combine the two aspects in an integrated analysis for Adaptive Capacity, in practical terms. Even in the studies that have combined these two issues such as [69], [70], it is still not clear where they interact and where they separate, when it comes to the analysis to adapt to Climate Change. However, it can be seen that the focus on the two ideas is important and has begun to increase lately.

TABLE II
RESILIENCE AND VULNERABILITY THE CONTEXT OF CLIMATE CHANGE LITERATURE STUDIES

	Resilience & Vulnerability & Adaptive capacity to C.C	
Group Two	[71] O'Brien et al., 2003 [72] Chapin III et al., 2004 [14] Adger et al., 2005 [69] Brenkert and Malone, 2005 [32] Chapin III et al., 2006 [73] Janssen et al., 2006 [6] Gallopı´n, 2006 [70] Vogel et al., 2007 [74] Williams et al.,2008 [75] Jordan, 2009	[76] Cannon and Müller-Mahn,2010 [77] Johnstone et al.,2010 [68] Miller et al.,2010 [78] Vugrin et al.,2011

Group 3: Regarding the studies that have focused on addressing a combination of the three concepts, as Table III shows, the number of studies which integrate the three concepts are fewer than those that either adopt resilience or vulnerability. In relation between sustainability and resilience or vulnerability, the studies are more developed in addressing the practical strategies for building the adaptive capacity. Where the majority of these studies in the table have focused on the physical-social interaction analysis, but they are still as theoretical studies such as [21], [31] and [88], [90] in resilience and vulnerability literature respectively. The link between sustainable community scale with these two ideas [1], [2] are still emerging in the context of community participation, decision making and management.

TABLE III
SUSTAINABILITY AS COMMON ASPECT IN THE RESILIENCE AND VULNERABILITY LITERATURES

	Sustainability & Resilience & Adaptive capacity to C.C	Sustainability & Vulnerability & Adaptive capacity to C.C	Sustainability, Resilience, Vulnerability &Adaptive capacity to C.C
Group Three	[79] Perrings and Stern, 2000 [30] Folke et al., 2002 [80] Fiksel , 2006 [81] Mayunga,2007 [31] Leichenko, 2011 [82] Derissen et al., 2011 [24] Sharifi and Yamagata, 2014 [83] Childers et al.,2015 [21] Sharifi and Yamagata,2015	[84] Vörösmarty et al.,2000 [85] Turner et al.,2003 [86] Cannon et al., 2003 [87] Lindsay,2003 [88] Adger et al. [89] Hay and Mimura [90] Goklany,2007 [91] Larson et al.,2013	[92] Turner et al.,2003 [70] Vogel et al.,2007 [18] Turner et al. [2] Engle,2011 [1] Eriksen et al., 2011

Finally, the least number of the studies are those related to the integration of the three in one organized assessment process. None of these studies has linked the idea of adopting sustainability assessment tools at any scale, nor to be evaluated, as potential climate change adaptation tools. The literature that combines the three, have questioned the relation among the three. Therefore, there remains definite scope to analyze whether the three can integrate to enable comprehensive addressing of the Adaptive Capacity assessment.

III.PART TWO: WHY THE NEIGHBORHOOD SCALE?

A.Neighborhood Sustainability

The discussion about sustainability assessment tools, at any scale is associated with the most important sectors that affect the interaction between humans and the built environment. Where, sustainability tools available to date have covered such sectors as energy, transportation, buildings and water, and the "sustainability coverage", can be considered as the broadness and profundity of the sustainability topics that are addressed in

the framework [23]. Understanding the coverage of these sectors in the existing tools relates to an analysis of the contents/ indicators as well as their approach to measurement and weighting. It should be noted however, that the explanation of the measurement processes in the context of the integral scoring mechanisms within assessment tools is not a part of this study framework.

The focus here is to demonstrate why neighborhood scale assessment tools are the most appropriate for consideration than other available tools at the building or urban scale. In addition, this analysis will identify the importance of this scale to the physical and social-ecological system. It is noted that despite the focus in the sustainability literature context, being largely on the urban and building scale, due to the greater longevity of assessment tools at such scales, this study finds that the selection of the neighborhood scale presents an opportunity to influence their development in their formative stages. Later, the sustainability assessment tools at this scale will be examined to assess their current and potential ability to enable adaptation to Climate Change.

The neighborhood scale, is regarded as the most effective scale at which to take account of linkages between the different parts of the urban system, such as population, buildings, land uses, transportation, water, energy, biodiversity, air, geology, topography [93], where the concept of neighborhood can be seen to incorporate both place and people. So, this scale should be considered as central and be prioritized in order to develop efficient, sustainable neighborhood systems. Indeed, addressing sustainability at the neighborhood scale is important because many of the problems encountered at the city scale are in fact cumulative consequences of poor planning at the neighborhood level [94]. Although urban sustainability has been discussed in many studies [95], nevertheless, there is a complexity in focusing on this scale to achieve the sustainable target for urban development in the long term.

While at the building scale, this is not the same situation, here, it doesn't formulate a pressure on the natural resources. But, nevertheless, building sustainability tools fail to provide a complete assessment of the cumulative impacts [95] and adequately depict sustainable development [95], [96] due to their necessary lack of focus on the context of the construction. Perhaps due to this, there is now a move towards neighborhood scale assessments in the real world, and the interest about them has increased and spread [96] among both authorities, and especially global investors.

The application of neighborhood sustainability assessment tools has therefore just begun to spread [97]. For instance, regarding LEED-ND, a total of 238 neighborhood development projects, including 205 from 39 U.S. states and 33 from another 5 countries, were registered as pilot projects for LEED-ND certification [98]. Further, many tools such as LEED-ND, BREEAM Communities, CASBEE-UD, Earth Craft Communities, DGNB for Urban Development, Green Star Communities, Star Community Index, GSAS/QSAS Neighborhoods and Green Mark for Districts, have been developed to facilitate sustainability assessment beyond the level of a single building [93].

Regarding the scope of neighborhood sustainability assessment tool /NSA, it can be considered as a tool that evaluates the performance of a given neighborhood against a set of criteria [93], [97]. Where, in a similar vein to building and urban scale assessment frameworks, it is argued that indicators provide essential information as to the viability of a system and its rate of change, and on how these contribute to the sustainable development of the overall system. They should connect environmental and social dimensions, and also offer a social learning capability, particularly learning from policy initiatives.

To sum up, the scale of neighborhood can be essential in addressing the sustainability in the physical neighborhood and community asset and the interaction between them. Yet, this understanding of the community scale is important in moving towards sustainable cities [23]. The neighborhood sustainability assessment tools are larger than physical indicators. That, presenting their components and analyze them in the context of adaptation to climate change, can be useful approach in arguing about building the adaptive capacity in practical methods.

IV. Part Three: The Investigation of the Adaptive Capacity in *NSAS*

A. The Application of the Practical Framework

The proposed framework, developed in Fig. 2 is intended to present a practical range of categories for analysis of the physical-social context, as well as an outline methodology for measuring sustainability, vulnerability, and resilience in the tools structure over time. Further, the framework intends to convert contextual divisions of the three components Sustainability, Vulnerability, and Resilience into scores that can be compared across projects and be aggregated at the Neighborhood level to assess adaptive capacity to Climate Change. The framework provides an approach that can be adapted to the measurement of resilience-vulnerability in combination with the sustainability performance analysis. This approach is important to reveal how the three components interact and where they conflict in the analysis of Adaptive Capacity.

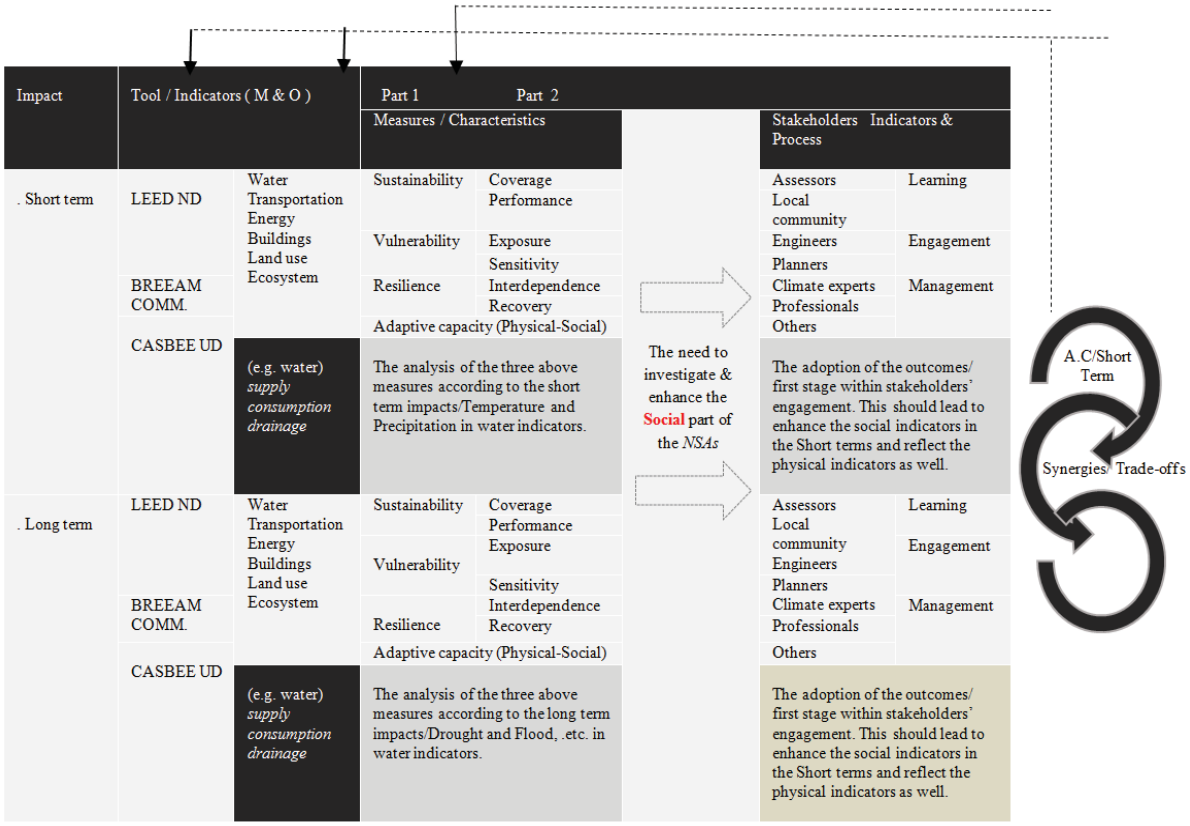

Fig. 2 The practical framework for the A.C analysis in NSAs

In this framework, the analysis of the adaptive capacity currently enabled with existing NSAs is broken into two main divisions, based on the adaptation to climate change literature above in terms of short term and long term impacts. In each division, the three selected tools which are LEED-ND, BREEAM COMMUNITIES & CASBEE UD are compared, due to their status as the most developed currently applied NSAs [93], that consider all three pillars of sustainability. A further consideration for selection was the accessibility of their manuals [98]. The comparison among the three tools, is associated with the analysis of relevant sector indicators in relation to Water, Transportation, Energy, Buildings, Land use and Ecosystems. For each sector, the analysis of the methods index constitutes the interaction of the three measures, Sustainability, vulnerability, and resilience (S, V &R). Tools contents/Indicators will be analyzed in accordance to the integration among the three measures (S, V&R). Further the method index is built, the indicators are distributed into Mandatory/M and Optional/O indicators. First, the exposure of the tools is identified in relation to the Climate Change impacts to analyze how sensitive they are to these. Meanwhile, the sustainable performance of the tools contents as well as their resilient characteristics are analyzed. It should be said that the identification of resilience is to focus on Interdependence and Recovery in particular, in spite of the variety factors identified in the literature, as the study has found that these areas are in particular not addressed in either sustainability or vulnerability assessment. For example, recovery is connected with the restoration capacity of the tools, which requires the system to be dynamic [78] , diverse and efficient at any condition. The ability of the tools to save resources can affect the risk time and decision process, to introduce the availability of options for the reparation process. So, recovery is one characteristic, but its assessment constitutes more than one aspect. This is why this research adopts both recovery and interdependence as evaluation factors. It is expected to have some trade-offs among the three main measures, whereby, some indicators can for example be both sustainable and vulnerable at the same time. To explain more in detail, in the water sector, for example, the short term stressors are related to Temperature & Precipitation with resultant long term impacts including Flood and Drought. They are the most pressing challenges, and directly affect the water sector system in terms of Supply, Consumption, and Drainage issues. Therefore, indicators such as *Wetland & water body conservation*, which it is a mandatory indicator in LEED-ND, will be analyzed in accordance to how it affects the three measures (S, V & R), in both the short and long term. It should be mentioned here that the short term will focus on the seasonal analysis in both summer and winter. This indicator is analyzed as a result of the interaction between physical and social aspects. The integration of the sustainability, resilience and vulnerability analysis should clarify in which part of these two

aspects for addressing the adaptive capacity the weakness was found to be located? However, in general and in the other sectors, not only, in water, the tools have focused on the physical asset more than the social one. That for instance, we find indicators related to *Rain water utilization* in the three tools, but, we cannot clearly see who are the stakeholders / actors relevant to this factor? How it can be linked with the community responsibility to conserve the water? To what areas/people this issue should be prioritized in the decision making process? Moreover, how the tools have presented the other social issues such as health and safety in linkage with the adaptation to climate change? So, as the social asset is seen as essential in addressing the adaptive capacity to C.C., however, it is found to be insufficiently addressed, currently in the NSAs [95], [97]. Here and as can be seen in the figure that in the identification and development of the social indicators, the analysis of the social characteristics, namely Learning, engagement and management, can be seen as common aspects in the adaptive capacity. The second stage will be in investigating these gaps among the various stakeholders. This discussion will be analyzed according to the methods that can be applied in the real world, which, as a result, can help in extracting and developing the social indicators of the NSAs. Nevertheless, it is the intention of this work that the social indicators are not discussed in the context of sustainability separately, but are fully integrated with the evaluation of the other two measures (vulnerability and resilience) in order to combine to influence the resulting adaptive capacity.

V. Conclusion

Since it is widely acknowledged that there will be ongoing implications of climate change impacts over the lifetime of current sustainable developments, we have argued here for the need to construct comprehensive tools for positively addressing the adaptation process over time. Further, we have proposed here that the neighborhood scale is the most appropriate scale at which to first adopt the plans and strategies for that purpose. Despite the relatively few existing studies regarding sustainability neighborhoods and their associated assessment processes, this study argued that the scale is suited to enabling enhanced flexibility to sustainability strategies and enhancing the assessment process. Moreover, the application of neighborhood sustainability assessment tools has increased recently, internationally, despite the literature in the field remaining weak. There is therefore scope and timeliness in pursuing an investigation as to these tools potential performance as strategies to address and enable appropriate climate change adaptation, especially as there remains a difficulty in finding clear frameworks to analyze and promote the adaptive capacity process. In this regard, the establishment and analysis of relevant physical and social indicators can be a helpful approach to consolidate both community asset and the physical built environment, and their preparedness for climatic change impacts. Addressing the linkage between sustainability science assessment process and climate change impacts and adaptive capacity are identified as prominent aspects to enhance both issues. In addition, it is argued that bonding this linkage with understanding and analyses of vulnerability and resilience can be essential in examining NSA tools potential capability to both enable adaptation and mitigation. The examination of the tools ability to enable adaptation to both short term and long term impacts, are found to provide foci in building a practical framework for the analysis.

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