NEIGHBORHOOD SUSTAINABILITY ASSESSMENT TOOLS AND WATER SYSTEM ADAPTATION: A FRAMEWORK TO ANALYSE THE ADAPTIVE CAPACITY IN THE PHYSICAL–SOCIAL CONTEXT

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ABSTRACT

The relationship between climate change and sustainable development has rarely been studied, particularly in the context of the built environment development assessment tools and adaptation to both short- and long-term climate change impacts. This research attempts to present a framework to investigate the capacity of three neighborhood sustainability assessment (NSA) tools to enable adaptation to climate change impacts, which are defined here in relation to both physical and social contexts. There are two sets of components that create the structure for the systematic framework. First, the need to address both short-term and long-term impact scenarios, in particular, temperature and precipitation, when analyzing the water sector. It is argued that the adaptive capacity should consider the supply, consumption, and disposal as physical characteristics, and governance and management as social characteristics. To operate this analysis framework the analysis, we argue secondly that both resilience and vulnerability are valuable in analysis of the adaptive capacity in order to identify points of adaptation and exposure. Finally, the resulting analytical framework is applied to three example NSAs, BREEAM COMMUNITIES, LEED-ND, and CASBEE-UD and compares their capacity to enable adaptive capacity. The paper concludes that the three tools have a higher capacity in adapting the physical components to the climate change impacts, than the social, where the latter have shown a noticeable vulnerability in covering issues such as stakeholders' governance, local community participation, and community management, despite the importance of such factors in addressing adaptive capacity to climate change, resulting from both short- and long-term risk scenarios.
Keywords: adaptive capacity, climate change, framework, NSAs, physical-social.

1 INTRODUCTION

Climate change is one of the key issues in recent environmental research [1] as it is likely to have unavoidable impacts on both urban and rural systems and populations [2]. It is, therefore, critical to address adaptation to the impacts of climate change in the current development process as well as to analyze both the immediate and long-term consequences [3]. Further, in order to adapt to these impacts, development systems should be able to remain on a sustainable track after its completion and implementation [4]. In other words, they should be resilient, potentially leading to a reduction in the vulnerability to climate change impacts. However, despite the importance of both resilience and vulnerability in the adaptation process [5], there are still very few studies that link these two aspects in an integrated, yet practical, analysis of adaptive capacity. This paper attempts to analyze the relation between sustainability and adaptation to climate change through the investigation of neighborhood sustainability assessment (NSA) tools as potential strategies to promote the capacity to adapt to climate change.

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These assessment tools are comprised of *indicators* that are practical components designed to track the various changes over time [6], are likely to be used widely even into the future [7], and have a vital role in the creation of sustainable communities [8]. We present three of the most developed NSA tools, LEED-ND, BREEAM-COMMUNITIES & CASBEE-UD, for the analysis and comparison process. As, the greatest climate change impacts are likely to be felt in the water sector [9], this has been prioritized here to evaluate the adaptive capacity, as a dynamic and continuous process in terms of both physical and social characteristics. It is hoped that a similar strategy will be applied in the future to other sectors such as energy, transportation, land use, and buildings. After undertaking the practical analysis of the adaptive capacity enabled by the existing NSAs, sustainability assessment may play an important role in advancing the adaptive capacity in practice, particularly in the physical part.

2 WATER SECTOR ADAPTATION TO CLIMATE CHANGE IMPACTS

2.1 Climate change impacts in the water sector

The water sector is likely to be directly impacted by climate change [9], particularly when it comes to the effects of temperature and precipitation [10, 11]. The impacts can be seen in different scenarios as higher temperatures, reduction of snow cover, rise in sea level, more tropical storms and heavy rains, and frequent summer heat waves and droughts. The reduction of rains causes decrease in fresh water reserves with consequences to agriculture and water resources for the population [12]. These two factors, temperature and precipitation, are therefore found to be the most significant, and it is now important to assess how the changes in their intensity and extremes [10] can influence the water sector. For example, water use in New York City increases by 11 liters per degree centigrade once temperatures go above 25°C [13]. Apart from consumption issues, more frequent drought conditions and increase in the incidence of floods also have harmful effects on the water availability and aquatic ecosystems [14]. Furthermore, these impacts have to be analyzed considering both short-term and long-term effects as climate change can affect both the long-term availability and the short-term variability of water resources in many regions [15]. In the water sector, a focus on short-term outcomes in the decision making process is considered climate susceptible [16]. Accordingly, short-term and long-term risk scenarios are all to be considered to formulate the basis for the analysis of the adaptive capacity.

2.2 Review: the scope for adaptation in the water sector

Many studies have focused on the potential impacts of climate change on the water system and their related appliances and users. Such studies have considered the relation between water availability and predictions of climate impacts and consider water supply as the primary issue [17, 18]. Further such studies suggest that supply-side measures by the water companies can be more reliable than demand side measures [7]. However, other research has attempted to link this issue with water demand [19]. For instance, Döll, [12] shows the importance of considering both water availability and demand scenarios in water management and how the decision affects the balance between these two scenarios. Other studies have focused on the impacts of climate change and how they influence the relation between water-supply and recharge aspects [20]. That groundwater is an important resource for human water supply, and is indeed likely to become even more important in future, in view of the depletion by humans and climatic stresses. Globally, it has been found that 50% of domestic water supply, 40% of water withdrawals for self-supplied industries, and 20% of irrigation water supply is from groundwater [20]. However, there are as yet no studies that explore development of adaptive capacity to allow planning and robust decision-making to be integrated into groundwater management regimes [21]. Much like water supply, the integrity and functionality of the wastewater treatment infrastructure will also be affected by climate change, with sewerage utilities, therefore, becoming significant in terms of adaptation to climate change. In particular, the fact that reclamation and reuse can provide additional water resources in water-stressed areas [22], considerably influences water management in both quantity and quality issues. Accordingly, the physical assets of the water sector and its technologies are significant to the adaptation of the water system to the various climatic impacts [23]. The existence and adoption of sustainable technology is key to not posing a threat to the quantity and quality of water resources [24] and enabling change and reliability, over time and scale [24, 25]. Nevertheless, such technological innovation cannot be the only sustainable scenario to build adaptive capacity. In particular, overcoming issues regarding lack of socio-technical planning [22] and ineffective governance support for sustaining these technologies depends on adapting the human role and behavior to climatic concerns. These social factors are strongly connected to effective physical water infrastructure and technologies. It is acknowledged that water management must be an ongoing process that stakeholders and managers will redefine over time according to climatic changes [25] delivering sustainable management of natural and societal resources [1], by addressing the administration, implementation, and operation of the infrastructure [26] and by creating a dialogue between people with expertise in various domains [25]. While, it is true that water resource management is a broad process, offering the connection between actors and water services, it is also a part of a bigger process where planning or regulation of the management belongs to the governance process, where water governance points towards coordination of the water management process [27] and refers to the multi-actor processes [26] of political, social, and economic organizations and institutions. For example, when existing tools for storm/waste water management are incapable of addressing adaptation over time it reflects defects in governance of adaptive capacity [28]. Accordingly, the role of stakeholders is central in both management and governance processes where all stakeholders should, therefore, be involved in analyzing and operating the process and the outcomes [29], to enable collaboration, learning, and trust. To sum up, it is proposed here that the adaptive capacity in the water sector should be built/treated as an integrated system that combines adaptation of both the water resources and the actors involved. Three issues—supply, consumption, and disposal,—have been found to be essential in adapting the water sector to climate change in the physical context; while management and governance are identified as 'social components' that should be developed in parallel, to build adaptive capacity for both short-term and long-term climate change impacts.

3 BUILDING ADAPTIVE CAPACITY TO CLIMATE CHANGE IN PRACTICE

3.1 Theory of adaptive capacity

In this section, both resilience and vulnerability are identified as two essential measures/strategies in managing the issue of building adaptive capacity. They are both found to deal with adaptation and adaptive management as core issues in their thinking process [5]. So far as resilience isconcerned, it is essential basic concept in adapting to climate change, because it explores the system's versatility and flexibility, in particular, in times of change [30]. It is argued that to ensure the adaptive capacity of both place and community, resilience has emerged as a long-term sustainable solution [31]. Resilience is therefore identified as key to building adaptive capacity both in terms of physical resources and the social context and to evaluate the desired properties of sustainable management of resources. There is also confidence that adaptation can reduce vulnerability [10], through its inherent ability to indicate features of a system (such as exposure, sensitivity, and adaptive capacity) [32–34]. Both exposure and sensitivity are found to be rooted within vulnerability, as substantial factors when dealing with climate change. Therefore it is argued here that vulnerability and resilience offer differing, complementary, and equally valuable input to this emerging, analysis framework.

3.2 Evaluation of adaptive capacity

To evaluate adaptive capacity to climate change, it is important to evaluate the both resilience and vulnerability measures. If a system can resist and continue positively under various climatic impacts, it implies that the system is resilient, as it has comprehensive and flexible strategies with which to resist the impacts. Nevertheless, the evaluation of how sensitive the system components are when exposed to these impacts in different timescales is also important, where sensitivity addresses how the system is adversely affected by these impacts. Accordingly, low vulnerability indicates that either the system has a low sensitivity or that there is a low level of exposure for the system components. For instance, in water management in developing countries, despite the fact that widespread use of low-water usage "pit" latrines can be interpreted as resilient to current high temperature and low precipitation, this same technology can be vulnerable to potential increase in precipitation and flood scenarios [34]. It is, therefore, argued here that a framework to evaluate adaptive capacity should combine analytical and integrated approaches that evaluate performance in terms of both resilience and vulnerability.

4 THE APPLICATION OF THE PRACTICAL FRAMEWORK

In the context of NSA tools, as systems that combine physical and social indicators, both divisions will be analyzed/evaluated to explore their resilience and vulnerability. This evaluation is carried out under short-term and long-term impact scenarios, first for the physical indicators and then for the social. The three selected NSA tools for this analytical process are LEED-ND, BREEAM COMMUNITIES and CASBEE-UD as they are the latest generation of impact assessment tools, and are considered to be more appropriate to promote climate change adaptive capacity than the assessment tools available at building or urban scales [8].

4.1 Physical short-term scenario

The short term analysis is designed to assess how the NSA tools have addressed the existence of comprehensive indicators/strategies of physical characteristics that can, under the exposure of short term climate events, overcome the vulnerability rate and achieve a high level of resilience. This is undertaken by each NSA tool, and after identifying the indicators, the resilient strategies for each of the three physical water characteristics, namely, supply, consumption, and disposal are examined. Finally, the vulnerability section will assess the potential sensitivity of these indicators in adapting to the climatic impacts.

4.1.1 Physical long-term scenario

The long-term analysis is concerned with understanding and analyzing the physical indicators in relation to the long-term impacts of climate change, to assess issues such as the maintenance of water facilities, long-term management, and risk analysis and management within the NSA indicators. So, it is expected that each tool will consider the short-term and long-term impacts within their structure, whether for specific indicators, or in combination.

- **Discussion**

When exposed to short-term impacts whether increased/decreased temperature or increased/decreased precipitation scenarios, it is found that the ecological and natural resource indicators are significant in conserving water supply. For example, the exploitation of rainfall, a major issue in the recharge of groundwater resources, can reach the 95th percentile in LEED-ND.

The adoption of residential/commercial fixtures and efficient landscaping strategies can also direct the resilience when it comes to water consumption indicators. Nevertheless, there

Table 1: The A.C. evaluation of the physical indicators of water/ LEED-N.

LEED-ND Resilience–Vulnerability analysis in short and long term	
Indicators	**Resilience:**
- Wetland & water body conservation, - Site Design for Habitat or Wetland and Water Body Conservation - Restoration of Habitat or Wetlands and Water Bodies, - Long-Term Conservation Management of Habitat or Wetlands, - Minimum Building Water Efficiency, - Waste water management , - Steep Slope Protection, - Minimum Building Water Efficiency, - Water-Efficient Landscaping, - Agricultural Land Conservation, Storm water management, - Floodplain Avoidance	**Supply:** Preservation of wetland/water bodies whether natural or man-made, helps conserve native plants and wildlife habitat, minimize erosion to protect the habitat, and reduce stress on natural water systems by preserving steep slopes, commit to implementing a long-term (at least ten-year) management plan for new or existing on-site native habitats, water bodies, and/or wetlands, retain on-site at least 25% of the average annual wastewater, and reuse that wastewater to replace used potable water. **Consumption:** Reduce the burden on water use through adoption of criteria for baseline water usage in both commercial and residential buildings through fixtures, fittings, and appliances, using irrigation strategies such as appropriate plant species, plant density, and microclimate factors, irrigation efficiency, use of captured rainwater, use of recycled wastewater. **Disposal:** Implement a comprehensive storm water management plan for the project that retains on-site, through infiltration, evapotranspiration, and/or reuse the rainfall volumes, permeation equipment such as permeable pavement. **Vulnerability:** Address the short- and long-term climate change impacts in specific and clear sections, indicators and restrictions on treatment issues, monitoring water quality and quantity in the long term, and treatment and management of grey water. Long-term water storage units and measurements, relation between the water quantity and long-term usage, clear plan for long-term maintenance issue, bonding with flood risks prevention and storm management, protection of sewerage units, reliable data on existing local coastal processes and associated impacts, no requirement for information for the present uncertainties in climate science.

is still a need to explicitly illustrate the direct link between indicators and short-term climate change impacts of geographical areas as well as to focus more on other treatment strategies such as grey water treatment. Regarding the long-term analysis, the Long-Term Conservation Management of Habitat or Wetlands in LEED-ND is an example of the natural long-term water resilient strategies. However, this plan is set for only ten years, and with the current level of climate change uncertainty, these climatic projections should be considered [10] for longer terms. Finally, LEED-ND provides credit points in its rating system for building outside the 100-year floodplain but does not require it. As table 1 shows This still may not be enough to assure resilience; due to the unpredictable nature of floodplains, land classified as belonging to the 500-year floodplain today may turn out to be within the 100-year floodplain due to sea level rise, erosion, subsidence, and other geomorphic processes [35].

For the ecological and natural resources in BREEAM COM., the exploitation of rainfall is important and linked with the rating issue, where it is awarded with three credits when there is more than 50% of the total hard surface for the site, to ensure that surface water run-off space is used effectively to minimize water demand. Other indicators, such as water efficiency, water

Table 2: The A.C. evaluation of the physical indicators of water/ BREEAM COMMUNITIES.

BREEAM COMM. Resilience–Vulnerability analysis in short & long term	
Indicators: - Ecology strategy, - Water strategy - Water pollution, - Adapting to climate change, - Flood risk assessment, - Flood risk management, - Enhancement of ecological value, - Utilities, - Rainwater harvesting, accessibility and maintenance	**Resilience:** **Supply:** Protection, enhancement, and creation of local ecological habitats and processes that sustain them (including supply and quality of water, and accessibility and minimal disruption in water/sewage services, impacts on water resources) ensure that surface water run-off space is used effectively to minimize water demand. **Consumption:** Minimize water demand through efficiency and appropriate supply-side options, taking full account of current and predicted future availability of water in the area, reduce the water demand in landscaping in residential, and non-domestic buildings, and allowance must be made for impacts. **Disposal:** Calculations confirming all rainwater collection systems have been designed, comprehensive drainage plan of the site made available to the authority responsible for maintaining the drainage infrastructure and future development users, shut-off valves are fitted to prevent the escape of chemicals to natural watercourses. **Vulnerability:** The need to address the climate change impacts in specific and clear sections, an ecology strategy covering the construction and operation phases, ecological impact assessmentusually required for planning applications for large scale developments, ecological protection mechanisms, clear plans for water/sewerage utilities maintenance, a general lack of locally reliable quantitative data or information on specific impacts related to adapting to climate change, the need to research more rainwater harvesting equipment and their usage.

pollution, and water treatment, as Table 2 illustrates can be resilient man-made strategies to prepare against climate change impacts, as conducted by the other two tools as well. For flood and risk management, BREEAM COM doesn't avoid the hazard areas, but includes criteria for reducing flood damage risk to developments within flood hazard areas and also considers how the facility must be designed and built to be protected and operable during a 500-year event.

Finally, in CASBEE-UD, and in comparison with the other two tools, the rainfall exploitation goes up to 80% at the maximum, which is less than LEED-ND. There are also various resilient strategies for preserving rainwater using permeable surfaces and equipment. However, there is still a certain vulnerability in addressing issues such as monitoring water quality and quantity in the long term, treatment and management of grey water, and long-term water storage units as can be seen in table 3. Furthermore, it can be noticed that flood risk has not been covered as an independent measure of climate change impacts as was the case for the other two tools, though it has been implicitly considered in disaster prevention in various infrastructure. There is still a need to clarify what mechanisms and what buildings/facilities aim to be protected.

To Sum up: Despite the large number of resilient strategies that the tools indicate, the level of physical management is still inadequate with respect to its efficiency and reliability in handling natural resources of water, especially in issues such as sensitivity and responses of habitats and

TABLE 3: The A.C. evaluation of the physical indicators of water/ CASBEE-UD.

CASBEE UD	Resilience–Vulnerability analysis in short & long term
Indicators: - Reduction of discharge sewerage amount, - Disaster prevention of various infrastructure, - Rain water utilization in buildings and outdoor areas, - Rain water utilization, utilization of common treated water supply, - Treated water, Greening ratio, - Natural Resources, Reduction of discharge sewerage amount, - Block management, Capacity for detention pond: suppressing outflow of rain water from the block, - Rain water permeable surfaces and equipment	**Resilience** **Supply:** Rain water utilization in buildings and the outdoors, measures for utilizing common treated water facility in the area, water treatment to be installed on site, measures on equipment and piping for flood damage prevention, a common facility for storing portable water, management of water supply and demand by a comprehensive management system utilizing ICT. **Consumption:** Water saving toilets systems, greening of ground surfaces. **Disposal:** Temporary rain water storage equipment such as a detention pond, retarding basin, a crushed stone type reservoir and rooftop greening. **Vulnerability:** There is a need to address climate change impacts in specific and clear sections. Indicators and restrictions on treatment issues, monitoring water quality and quantity in the long term, treatment and management of grey water, long-term water storage units, the relation between the water quantity and long-term usage, addressing the impacts, indicators on maintenance issue, bonding with flood risks prevention, and storm management, The protection of sewerage units, no identification to a long-term management plan for conserving water as a natural resource, reliable data on existing local coastal processes and associated impacts, and no information for the present uncertainties in climate science.

species, impacts on wetlands, as also for matters associated with utilities, accessibility, maintenance, updatability and expandability indicators, as the tables show, which are significant strategies for resilience to protect the water resources. There is also their vulnerability in terms of poor indicators when a specific technical failure happens in drought or flood scenarios. For instance, if a reservoir storage capacity exceeds demand under drought conditions, how can that be measured? There is an ambiguity in the required level of the adaptive capacity in the long term and risk analysis due to the complicated relationship/dialogue between the levels of assessment of resilience and vulnerability, ranging from addressing significant resilient strategies to having a high level of uncertainty in the projected risks. In particular as some of these indicators, such as water pollution, wetland management, and flood management, are *optional indicators* in these NSAs, may also add another level of sensitivity/vulnerability to the NSAs physical performance.

4.2 Social scenario

4.2.1 Social short-term scenario

The short-term analysis for the social part of the three NSAs is focused on the required strategies for promoting resilient governance and management, through assessing issues such as collaboration, participation, and openness among the actors, with learning, trust, and awareness as the main outcome for sustainability in the water sector.

4.2.2 Social long-term scenario

The long-term scenario will similarly assess the issues identified above but in the context of long-term impacts and risks.

- **Discussion**

In general it was found that BREEAM COM. focuses more on the social indicators when it comes to issues as community participation and consultation plans than the other two tools. The latter two tools are therefore combined in one table, and have approximately the same weaker features in planning/operating the social strategies for adaptation.

Table 4: The A.C. evaluation of the Social indicators of Water/BREEAM COMMUNITIES.

BREEAM COM. Resilience–Vulnerability analysis in short & long term	
Indicators: - Consultation plan Consultation and engagement Utilities - Adapting to climate change, - Consultation plan, Community management of facilities - Flood risk management	**Resilience:** The developer engages with water suppliers, the local authority, and the appropriate regulatory body, such as the Environment Agency and the Internal Drainage Boards, to develop overall water consumption targets for development, taking into account evidence that has been sourced from the local authority and statutory bodies to understand the existing and predicted impacts of climate change for the site. **Vulnerability:** Indicators restriction, clear plan for stakeholders cooperation with both local community and authority, economic role in the decision making, inclusion of post-occupancy stage in water governance plan, clear economic plan, government/authority role in support of water supply and sanitation management.

Table 5: The A.C. evaluation of the social indicators of water in LEED-ND & CASBEE-UD.

LEED. & CASBEE. Resilience–Vulnerability analysis in short & long term	
LEED Indicators: - Waste water management, - Community Outreach & involvement, - Long-Term Conservation and Management of Habitat or Wetlands **CASBEE Indicators:** - Block management, - Observation of applicable laws and regulations, - Securing system for cooperation, - Disaster response ability	**Resilience:** Create a guaranteed funding source for management, preliminary indicators to protect life and property, encourage the creation of a neighborhood association in the block for short-term management, **Vulnerability:** Indicator restriction, openness and transparency in early decision making among parties, link between water characteristics and climate change impacts at the initial stage of decision-making, clear plan for stakeholders' cooperation with both local community and authority and inclusion after occupancy stage in water governance plan, state/local barriers to taking action on climate change impacts, planning efforts towards adaption to and mitigation of existing coastal hazards, community management through surveillance functions, quantitative assessment of the functioning or 'health' of freshwater ecosystems, continuous learning programs and workshops, long-term community management of ecological and natural resources, health indicators of water quality in drought and flood scenarios, clear economic plans for risk prevention, role of political and local authority in support of water supply and sanitation management, integrated operational management that combines the decentralized and centralized management

BREEAM COMMUNITIES has included the local community as a part of the dynamic, sustainable decision-making process. However, there are three major weaknesses—a detailed and 'mandatory' point that describes the water strategy, how it is affected by climate change, and how people can understand and interact with this issue are not found in the consultation plan indicator. In the long term, the main vulnerabilities are associated with finding indicators for flood risk communications and the functioning of these communication routes at the time of floods. BREEAM COM. has only partly addressed this issue in the consultation plan indicator. Nevertheless, there are insufficient practical mechanisms to tie up water governance with the government as there is no evidence that the government will provide a permanent supportive role for the governance process. Furthermore, it is noticed that the management of the long-term impacts and risks requires application of knowledge management within social networking, to regulate monitoring and maintenance in supply and sanitation issues. For example, the liaison between the user's behavior and the required monitoring and maintenance for a septic system, to overcome quantity and quality problems in water when risks occur, is not part of it. Even, with the existence of the flood risk management indicator, the local community participation in the management process is not indicated in the long-term water and risk governance. As Table 4 shows in BREEAM COMMUNITIES, evidence from the local statutory bodies is required to understand the existing and predicted impacts of climate change for the site. But, again this level of sharing climate action plans with the local community and other parties needs to be further clarified and enhanced.

It is found that in both LEED-ND and CASBEE-UD there is no explicit plan to demonstrate the stakeholders' identity, roles, and the social networking in the decision-making. And again, as in BREEAM COM., the tools do not have implied indicators that account for the pivotal role of government/authority in the decision-making process and reveal how open they can be with the diverse stakeholders. Meanwhile, despite having indicators, such as waste water management in LEED-ND and Block management in CASBEE-UD as can be seen in table 5, there is still a gap in the knowledge of how the water facilities are to be monitored and maintained and, more importantly, by whom? This is considered vital to establish a line of communication among the households of the climate change impacted community, with responsible management parties to reduce failure when the impact is felt. This lack of indicators for local community participation in governing water risks, this will likely make these communities unaware of the inherent vulnerability of flood or drought, which, as a result, can affect the level of preparation to face these risks, including maximizing the potential for community exposure to health and security problems.

To sum up: It has been established that vulnerability in the social context is more apparent because of the absence of detailed and restricted indicators, needed to plan and implement the organization and operation for social–social and physical–social dialogue in both natural and human water governance and management. It has also been found that while flooding has been considered as a hazard across all the NSAs, there is a limitation in strategies that relate to the well-being or health of occupants or end users and that support the surrounding economy or investment in future developments and educational practices and training courses.

5 CONCLUSION

In this paper, we have addressed the link between scientific sustainability assessment processes and adaptation to climate change impacts The literature reviewed in this paper, which is a major part of the analysis, demonstrates the need to integrate both resilience and vulnerability assessment measures to provide greater procedural inspection in the study of adaptation to climate change. Simultaneously, it is argued that when presenting the NSAs, as a system that combines physical and social indicators, the process of addressing the analysis of adaptive capacity to climate change can become practically more approachable and effective. Furthermore, the examination of the tools' ability to enable adaptation to both short-term and long-term impacts, are found to provide a focus in building a practical framework for the analysis. The analysis of the adaptive capacity provided by the three NSA tools in the water sector has highlighted three important aspects—first, that the NSAs have incorporated resilience principles in the physical context and that this was particularly and strongly identified in the short-term analysis. Second, that weaknesses in resilience strategies exist currently in the social context, due to insufficient coverage of plans for both governance and management issues. Finally, it is recognized that both physical and social indicators in the long term are currently found to be insufficient to provide or support climate change adaptive capacity, and that this lack is particularly evident in incorporating resilience management mechanisms for flood and drought scenarios.

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