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Integrating the SDGs into Urban Regeneration: A Madrid Nuevo Norte Case Study Using an Adapted Voluntary Local Review Framework

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Abstract: While the Sustainable Development Goals (SDGs) have emerged as the preeminent sustainability framework across various spatial scopes, the reporting and assessment of new urban developments and regeneration projects often remain tethered to sustainability frameworks that lack direct alignment with SDG targets. This paper proposes a framework to integrate SDG reporting within urban regeneration initiatives. This approach leverages existing resources, such as the Joint Research Center's (JRC) European Handbook for SDG Voluntary Local Report (VLR) and UN-Habitat's Global Urban Monitoring Framework (UMF), to report potential contributions towards SDG progress. The framework is validated through the case study of Madrid Nuevo Norte (MNN), one of the largest urban regeneration projects currently developed in Europe, located in the northern district of the Spanish capital and encompasses the regeneration of a 3.2 million square meter area. The methodology evaluates MNN potential contributions through a set of indicators based on input–output/outcome–impact framework to track the causal pathways arising from MNN activities. This paper presents an analysis of the methodological framework developed for the MNN SDG report during the project-planning phase, with a focus on evaluating the framework's capacity to accurately estimate the project's contributions to the SDGs.

Keywords: urban regeneration; sustainability; SDG localization; Madrid; Madrid Nuevo Norte; SDG reporting

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1. Introduction

With the global urban population surpassing 50% and reaching 55.3% in 2018, it is expected to rise further to 68.4% by 2050 [1]. As a result, the functioning of cities, urban activities, and consumption habits have become central to ensuring a sustainable society [2,3]. In addition to population growth, urban areas are expanding at a faster rate compared to other areas [4].

This rapid urbanization has made urban systems increasingly complex, involving numerous interdependent factors. The interactions between human and natural systems in urban environments are significantly more intricate than in rural areas [5]. As a result, a systemic approach is necessary to encompass the various dimensions of sustainability comprehensively [6,7].

Since their adoption in 2015, the Sustainable Development Goals (SDGs) of the 2030 Agenda have proven to be a valuable and cross-cutting tool for evaluating progress towards

sustainability across both public administrations and private entities [8,9]. Given the growing complexity of urban systems and their wide-ranging impacts, the SDGs provide a structured framework for addressing these challenges and promoting sustainability.

Moreover, international organizations have established comprehensive frameworks to facilitate reporting across different territorial scales. In the case of urban areas, key frameworks are the Global Urban Monitoring Framework (UMF) [10] developed by UN-Habitat, focused on city sustainability, or the Voluntary Local Report (VLR) manual [11] produced by the Joint Research Center (JRC) of the European Union. The use of these reporting tools has expanded globally, generating both gray and scientific literature that document the advancements achieved in pilot projects and pioneering cities [8,12,13].

Projects that focus on the regeneration of socially, economically, or environmentally deteriorated urban spaces hold greater potential for improvement. These initiatives should enhance resilience to climate change [4,14] and natural disasters, promote sustainable and efficient modes of transport and energy [15], foster more efficient consumption patterns, and contribute to healthier, less polluted environments within connected and diverse ecosystems [16–18].

In parallel, these projects must also aim to create more inclusive and equitable societies, supported by employment models that encourage the transition towards sustainability and the decarbonization of the economy [17,19,20]. Establishing partnerships between various stakeholders, including public–private collaborations [21], is essential for reinforcing active participation and cooperation [22–25]. To achieve this, it is necessary to strengthen adaptive and innovative capacities, which may require organizational changes within public administrations [5,26,27].

Urban regeneration projects serve as catalysts for sustainability by addressing inequalities, implementing climate agendas, enhancing human and ecosystem health, improving urban spaces, and fostering cultural and digital transformation [28]. There is a paradigm shift from focusing on how new urban areas impact sustainability to understanding how the regeneration of degraded areas can enhance sustainability [28,29].

While sustainability has long been integrated into urban regeneration models and large-scale urban development projects, the measurement frameworks used in these contexts are generally not grounded in SDGs [30–34]. To enhance coherence between sustainability strategies at various levels, any process of urban transformation or renewal should be aligned with the Sustainable Development Goals (SDGs) [31,35].

Consistent with the above, this paper applies advancements in translating global priorities to the local scale by utilizing the localization of the 2030 Agenda and the development of Voluntary Local Reviews (VLRs) [36,37] to assess the progress made by the Madrid Nuevo Norte development project in achieving the SDGs.

This megaproject [29] situated in the northern part of Madrid, Spain (Figure 1), MNN seeks to transform an area of over 3 million square meters into a sustainable, inclusive, and economically vibrant district. The project envisions the development of new residential, commercial, and public spaces while incorporating advanced transportation infrastructure and smart city technologies centered around one of the city's major transport hubs (https://creamadridnuevonorte.com/, accessed on 4 August 2024) [38].

As one of Europe's most ambitious urban regeneration projects, Madrid Nuevo Norte provides a compelling case study for examining how SDG-oriented methodologies can be applied in practice.

Through this case study, we examine how the SDGs can be integrated into the planning and execution phases of a project using a set of interlinked indicators. While indicators designed to measure SDG targets typically assess the status of variables related to those targets, they often fail to capture the relationship between the underlying causes, namely the activities and resources of urban regeneration projects, and their subsequent effects, which ultimately influence the state reflected by the SDG indicator.

This paper tries to respond to this gap by proposing a methodology for reporting the contributions of urban regeneration projects and new urban developments to the

achievement of the SDGs within the context of their specific urban environment. This methodology is based on a set of tailored indicators that can be adapted throughout the various stages of the project, enabling the evaluation of the contribution to the SDGs during different phases of development.

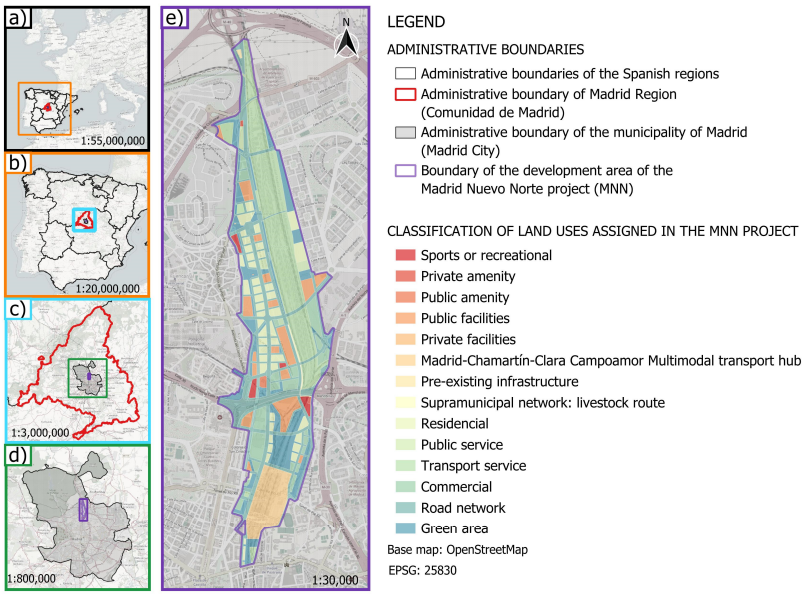

Figure 1. Location of the Madrid Nuevo Norte project in Madrid, Spain, and Europe. (From left to right, top to bottom): (**a**) Spain within Europe (black frame); (**b**) Madrid Region within Spain (orange frame); (**c**) Madrid City within Madrid Region (blue frame); (**d**) Madrid Nuevo Norte within Madrid City (green frame); (**e**) Detail of Madrid Nuevo Norte Development plan (purple frame).

2. Materials and Methods

This Section delineates the analytical framework employed for the contribution to SDGs contained in the MNN SDG report. The methodology is founded upon established evaluation frameworks designed to assess contribution to the Sustainable Development Goals (SDGs) [10,11,39]. The development of this methodology occurred concurrently with its application to the planning stage of the case study, such that the steps outlined herein reflect those implemented in the case study analysis.

The analytical approach involves five sequential steps, as illustrated in Figure 2: Methodological outline.

As shown in Figure 2, the main steps for the application of the methodology are as follows:

- 2.1 Target localization involves identifying relevant SDG targets and prioritizing them within the local context. Box 2.1 (yellow) illustrates the processes for target localization within the case study. On the left side of this Figure (in lowercase), the primary information sources are summarized, while on the right (in uppercase and underlined), the analysis results for each step are presented.
- 2.2 Indicator selection entails the identification and selection of potential indicators for measuring progress towards the selected targets, considering data availability at the local level. In Box 2.2 (green), the indicator selection process is represented. The sources analyzed for indicators are listed on the right (in lowercase), while the progressively refined indicator sets, leading to the final selection applicable to the case study, are shown on the left (in uppercase and underlined).
- 2.3 Indicator classification categorizes selected indicators into the input–output/outcome–impact framework [40], enabling the assessment of project effects during planning, implementation, and operation phases. In Box 2.3 (orange), the classification of indicators within each framework block is displayed.

- 2.4 Data processing involves calculating indicators for each subset. Box 2.4 (blue) details the data sources (lowercase) and the necessary methodological adaptations (uppercase) for indicator calculation across each subset (uppercase and underlined). The process culminates in the generation of input–output/outcome–impact values.
- 2.5 Reporting during project life cycle involves a qualitative research design complemented by quantitative data analysis where applicable. Box 2.5 (purple) illustrates the reporting process, based on the assessment of each indicator subset. The aspects evaluated are noted in lowercase, while the results (in uppercase and underlined) lead to the development of contribution reports throughout the project life cycle. The qualitative approach allows for an in-depth understanding of the processes and strategies used to integrate the SDGs into Madrid Nuevo Norte, while quantitative data provide measurable indicators of contribution towards the goals. Qualitative analysis is employed during the planning phase, and quantitative evaluation of performance indicators becomes central during implementation and operation. Although this last step is outlined here, its full implementation is contingent upon project progression, as indicated by the dotted line in Figure 2.

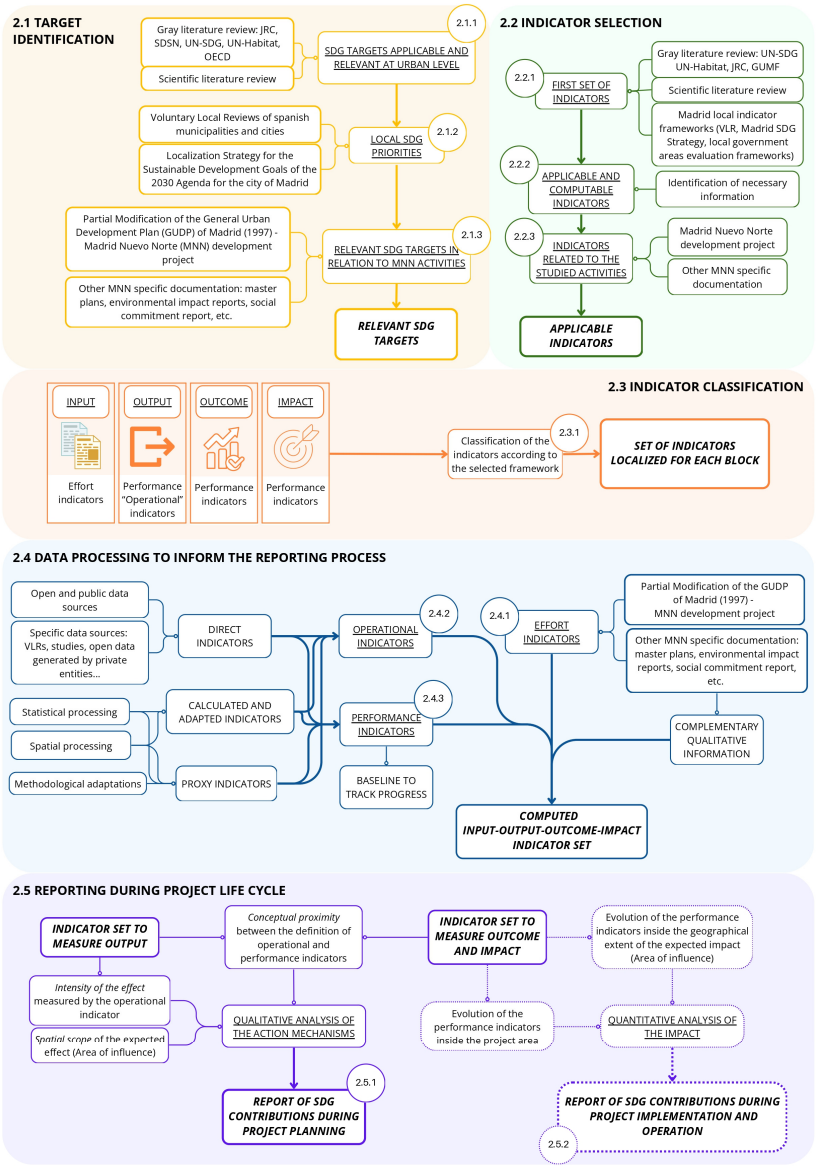

Figure 2. Methodological outline. Dotted lines identify the steps of the process that are described but not applied to the MNN case study.

Each step is detailed in the following subsections, where identification numbers correspond to the codes used in Figure 2 for each methodological step.

2.1. Target Identification

The localization of targets and indicators is guided by the UMF [10], which prioritizes the following principles:

- Leveraging existing resources: maximizing the use of existing frameworks and data sources.
- Human-centric focus: prioritizing the needs and perspectives of urban residents.
- City-specific relevance: tailoring indicators to the unique characteristics of the urban context.
- Resilience: ensuring the adaptability of the indicator set to respond to emerging challenges and shocks.
- Practicality: designing indicators that are user-friendly and actionable.
- Internal consistency: maintaining coherence among the selected indicators.

As described in the following subsections, the methodology advocates for an iterative approach to refining and improving indicators, in line with the JRC's observations on the evolutionary nature of VLR development processes. These processes are characterized by their incremental, reiterative, retrofitting, and interactive characteristics [11].

2.1.1. SDG Targets Applicable and Relevant and Urban Levels

The universal relevance of the SDGs is particularly pronounced in urban contexts. Cities, as hubs of economic activity, cultural exchange, and innovation, also grapple with significant social and environmental challenges [41]. Of the 169 SDG targets, at least 105 require active engagement from regional and city authorities [42]. These targets span a wide range of urban concerns, including poverty reduction, inequality, health, education, and environmental sustainability [43]. Additional emphasis on target localization, as well as the capacity and competencies of public entities, is supported by various non-peer-reviewed sources [10,11,42,44] and scientific literature [45–48].

2.1.2. Local SDG Priorities

To ensure alignment with Spain's established SDG priorities, a comprehensive analysis of local-level initiatives was conducted. This involved reviewing Voluntary Local Reviews (VLRs) from Spanish municipalities and cities, drawing data from the JRC and UN-Habitat repositories [39,49]. By focusing on Madrid's VLR [50], key SDG targets relevant to both the city and the Madrid Nuevo Norte (MNN) project were identified.

The MNN project is a pivotal catalyst in Madrid's broader pursuit of the SDGs. Its scale and transformative approach make it a central component of the city's long-term strategy and highly relevant to the broader Madrid functional urban area [50]. By integrating the Voluntary Local Review (VLR) framework at both the city and project levels, Madrid can effectively monitor progress, identify challenges, and implement strategic solutions to foster sustainable urban development [51].

The collaborative relationship between Madrid's and MNN's VLRs enhances the impact of sustainable development efforts through data sharing, knowledge exchange, and policy alignment [52,53]. This synergy highlights MNN's critical role in driving the city towards a more inclusive, resilient, and sustainable future. Consequently, the evaluation of MNN's activities prioritizes the specific SDG targets identified in Madrid City VLR.

2.1.3. Relevant SDG Targets in Relation to MNN Activities

To further refine target identification, the project documentation generated during the approval process for the Partial Modification of the General Urban Development Plan of Madrid (1997) was analyzed [54]. This documentation can be categorized into three primary groups:

- Modification Reports and Plans:

These foundational documents serve as the blueprint for the project, detailing infrastructure operations, plot allocation, and service distribution within the designated development area.

- Public Consultation Evaluation Reports:

During the public consultation phase, a series of evaluation reports were issued. These reports, compiled by both MNN and external stakeholders, provide critical insights and data regarding environmental impact mitigation and compensation strategies, minimum quality benchmarks for the urban regeneration project, and additional measures deemed essential for plan approval.

- Thematic Master Plans:

MNN has established a series of Thematic Master Plans that define the optimal characteristics for key sectors such as energy infrastructure, landscape architecture, and water management tools. These plans serve as a roadmap for achieving desired outcomes upon project completion and operation.

In essence, the first set of documents provides baseline information on housing, infrastructure, and service location and scale. The second group focuses on potential negative environmental impacts and proposed corrective measures, enabling a direct correlation with relevant SDG targets. Finally, the Thematic Master Plans present a range of scenarios that illustrate potential variations in the project's contributions or negative environmental impacts. Together, these documents enable a robust alignment of MNN activities with SDG targets.

2.2. Indicator Selection

2.2.1. First Set of Indicators

Following the identification of relevant targets, the next step involves selecting appropriate indicators for measuring progress towards their achievement. This process entails a comprehensive analysis of proposals formulated by official bodies alongside the voluntary local reports referenced earlier. Table 1 provides an overview of source documents whose indicator frameworks were evaluated for their potential to quantify various aspects of the identified objectives.

Table 1. Overview of indicator sources.

Organization	Source
UN-SDG	Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development [55]
UN-Habitat	The Global Urban Monitoring Framework—A Guide for urban monitoring of SGDs and NUA and other urban-related thematic or local, national, and global frameworks [10]
European Commission—Joint Research Center	European Handbook for SDG Voluntary Local Reviews [11]
Sustainable Development Solutions Network	The SDGs in 100 Spanish Cities [44]
Madrid City Council	Localization Strategy for the Sustainable Development Goals of the 2030 Agenda in the City of Madrid [56]

2.2.2. Applicable and Computable Indicators

While the sources provide a rich pool of potential indicators, a key challenge lies in data availability [57,58]. Not all indicators can be readily calculated at the local level, particularly within sub-municipal contexts [59–62]. To address this limitation, we conducted a preliminary assessment of data availability and information sources, which acts as a filtering mechanism for eliminating indicators that lack sufficient data for calculation.

2.2.3. Indicators Related to the Studied Activities

Following the assessment of data availability, the indicator selection process prioritizes those exhibiting the strongest correlation with activities identified within the Madrid Nuevo Norte (MNN) project [61,63,64]. This ensures the chosen indicators directly measure the project's contributions towards achieving the SDGs. As the project evolves, this set of indicators remains flexible. Indicators deemed unsuitable at this stage are not permanently discarded but may be reintroduced as

- New MNN activities develop that align more closely with previously discarded indicators.
- New data become available, enabling the calculation of these indicators.

This approach ensures that indicator selection is data-driven and focused on the most relevant aspects of MNN's impact on the SDGs while maintaining flexibility to adapt to evolving project activities and data availability.

2.3. Indicator Classification

To measure changes and effects of MNN activities, the OECD input–output-outcome–impact was selected. This framework establishes a causal chain linking the activities undertaken and resources used to the results, outcomes, and impacts produced (Chain of results) [40,65]. It has been widely used in development cooperation [66] and more recently in sustainability assessment [10]. This framework establishes a causal chain linking the activities undertaken and resources used to the results produced.

2.3.1. Classification of the Indicators According to the Selected Framework

To directly connect this framework to urban regeneration projects, a structure with four indicator subsets is adopted [67,68]:

Input Subset

This subset measures the resources mobilized by an entity for a specific activity (e.g., financial resources, materials). These resources are quantified using effort indicators, which track the extent of the input invested (e.g., kilometers of pedestrian routes constructed).

Output Subset

This subset assesses the direct results derived from the input, capturing the performance of the activities undertaken. It employs a specific type of performance indicator, here referred to as operational indicators (e.g., pedestrian/vehicle ratio), suggested by the UMF [8] in cases where outputs are directly influenced by the entity's actions, such as infrastructure provision. These indicators bridge the gap between invested resources and the observable progress made towards a target.

Outcome Subset

This subset measures the expected short-to-medium-term changes resulting from the activities. Performance indicators are used to track progress towards achieving the desired targets over time (e.g., school dropout rate, net enrollment rate in primary education). These indicators focus on the initial impacts that the activities are designed to generate.

Impact Subset

This subset evaluates the long-term effects of the implemented activities. Performance indicators in this group are centered on broader societal changes, such as the reduction in traffic accidents resulting from increased pedestrian infrastructure. These indicators capture the enduring impacts that the activities are intended to achieve.

It is important to highlight that performance indicators may be applicable across different subsets (output, outcome, or impact), depending on the stage of the project—whether in planning, implementation, or operation [67]. For instance, during the operational phase, a

direct correlation might be established between inputs and outcomes, potentially bypassing the need for an operational indicator. In such cases, performance indicators associated with the outcome become paramount for assessing project effectiveness.

A comprehensive list of the input–output–outcome–impact indicator chain for each SDG target can be found in Supplementary Materials Table S1.

2.4. Data Processing to Inform the SDG-Reporting Process

This section outlines the process of adapting and computing the indicators relevant to each subset. As mentioned before, the methodology was developed during the planning stage of the MNN project, consequently, the primary focus of indicator adaptation efforts has been on the input-output subsets. However, groundwork has also been laid thorough the acquisition of the baseline data necessary for subsequent project phases (outcome-impact subsets).

All raw data used for indicator calculation originate from publicly accessible sources or specific strategic documentation. Table 2 provides an overview of the primary data sources.

Table 2. Primary data sources.

Type of Data Source	Name of Data-Producing Entity
Public international databases	World Health Organization (WHO)
	Eurostat
	Copernicus Land Monitoring Service
Public national databases	National Statistics Institute (INE)
	Ministry of Health, Social Services and Equality (MSSSI)
	Ministry of Finance and Public Administration (MHFP)
	Ministry of Economy, Trade and Business (MINECO)
	Ministry for the Ecological Transition (MITECO)
	Ministry of Transport, Mobility and Urban Agenda (MTMS)
	Ministry of Housing and Urban Development (MIVAU)
	General Treasury of Social Security (TGSS)
	General Directorate of Traffic (DGT)
	Canal of Isabel II [1]
Public local databases	Open Data Portal—Comunidad de Madrid (CAM)
	Consorcio Regional de Transportes de Madrid (CRTM)
	Open Data Portal—Madrid City Council
Privately sourced open data	Spanish Consumers' Organization (OCU)
	EXCELTUR—Alliance for Tourism Excellence
Specific strategic documents	Localization Strategy for the Sustainable Development Goals of the 2030 Agenda in the City of Madrid
	Madrid Voluntary Local Review (2023) [50]
	Partial Modification of the General Urban Development Plan of Madrid (1997) [54]—Madrid Nuevo Norte
	Thematic Master Plans—Madrid Nuevo Norte
	Preliminary evaluation reports—Madrid Nuevo Norte

[1] Public company that manages the water supply in Madrid and surrounding areas. It is often considered part of the public administration due to its essential services.

2.4.1. Effort Indicators

Logically, all effort indicators directly utilize data obtained from MNN. All relevant documentation is publicly accessible through the Madrid City Council's electronic record viewer [54]. As mentioned before, effort indicators measure the number of resources invested, for example, the number of plots allocated to health or education services in the Urban Planning documentation.

In instances where data necessary for calculating or transforming information into effort indicators are not readily available, the input subset is supplemented with qualitative information. This qualitative information highlights relevant initiatives or design outlines associated with the targets studied and the corresponding operational and performance indicators.

2.4.2. Operational Indicators

While effort indicators capture the resources invested and the foundational steps taken in the project's early stages, operational indicators offer insights into the immediate outputs and performance outcomes. This transition from measuring inputs to assessing tangible results is critical for understanding how effectively resources are being translated into on-the-ground improvements.

The set of operational indicators linked to the output subset has undergone various developments and adaptations. These adaptations can be categorized based on the type of data processing required for their calculation:

- Statistical indicators: these indicators involve calculations using arithmetic operations of varying complexity (e.g., total water consumption per inhabitant per day.)
- Geographical indicators: The calculation of these indicators necessitates the use of geo-referenced data and Geographic Information System (GIS) software (QGIS 3.22.12 LTR). In some instances, data availability necessitated adaptations (e.g., population with access to primary schools.)
- Qualitative information: In two specific instances, qualitative information was substituted for operational indicators due to data limitations. Detailed information regarding the targets affected can be found in the results section (e.g., description of projects involving Madrid Nuevo Norte related to research and sustainability.)

From a methodological standpoint, three types of indicators can be distinguished:

1. Indicators with direct application methodology: These indicators did not require any adaptations for application within the MNN project. The existing methodology was directly applicable, and the necessary data were readily available.
2. Indicators with adapted methodology: For certain indicators, minor adaptations to the established methodology were necessary to accommodate data availability limitations. This was particularly relevant for some geographical indicators. For example, according to the methodologies established by UN-Habitat and the JRC [69–72] for evaluating population access to services, green spaces, or public transport, it is necessary to employ a geolocated census that assigns a population figure to each entrance of every residential building. However, no such census exists for Madrid or the MNN area, as there are no residents until construction is completed. To address this limitation, we approximate the resident population in Madrid's buildings using the Urban Atlas 2018 prepared by Copernicus, which provides population estimates for each polygon. For the MNN area, we utilized the data presented in the MNN documentation, which delineates the anticipated number of dwellings within each residential building. By incorporating the average housing occupancy rate in Spain, we were able to derive an estimated resident population for each building inside the project area.
3. Proxy Indicators: When the original indicator methodology proved incompatible with available data for MNN, proxy indicators were developed, according to the definition of the European Environment Agency [73]. These indicators adhere to the principles of the original indicator but utilize alternative methodologies tailored to accessible information. For instance, to analyze progress on SDG target 11.1 (Ensure access to housing), a housing affordability index would typically be used. This index is a statistical indicator that compares the average income of the population to the average housing prices, determining the number of years of work required to afford a decent home. However, with no resident population or established housing prices in MNN, the proposed operational indicator—"Difference in land value for free housing compared to basic prices for social housing"—is used as a proxy. This indicator estimates the potential reduction in housing prices due to social housing development and, in doing so, it substitutes the traditional housing affordability index with a similar, contextually relevant measure.

Many of these indicators are classified as Tier III SDG indicators [57,74,75]. This designation signifies that they are experimental. Even with well-developed calculation processes, the methodology remains under review and may require further adaptation to specific contexts. Despite this classification, the methodologies outlined by the reference sources have been followed as closely as possible.

The detailed elaboration methodology for each of the operational indicators is available at Madrid Nuevo Norte—Learn about the SDGs that we are helping to achieve [76].

2.4.3. Performance Indicators

As operational indicators focus on the measurable outputs of project activities, performance indicators take this analysis a step further by evaluating the longer-term societal outcomes. These indicators play a crucial role in determining the broader impact of MNN initiatives on social, environmental, and economic sustainability.

Most performance indicators (associated with the outcome and impact subsets) are directly obtained from official databases at the local, subnational, national, or international level, without requiring further processing. This approach ensures replicability for other Spanish territories and facilitates periodic updates. For any indicators requiring additional elaboration, the methodology strictly adheres to the guidelines outlined by the reference sources listed in the indicator selection section.

The complete list of indicators is available in the Supplementary Materials Table S2. This file comprises the set of indicators classified according to the input–output–outcome–impact framework, as well as the classification of Effort–Operational–Performance indicators.

2.5. SDG Reporting During Project Life Cycle

2.5.1. Report of SDG Contributions During Planning Stage

This section explores the methodology for assessing a project's potential contribution to achieving the SDGs during the planning phase. A qualitative evaluation is conducted based on the characteristics of the effects measured by the operational indicators. Three key aspects are considered:

Spatial Scope of the Effect

Identifies the geographic area within which the project's effects are expected to be felt [77–79]. This is determined by analyzing the "area of influence" for each specific action. The area of influence is established by evaluating the input scale (associated with the project action) in relation to average values at various territorial levels (national, regional, municipal, and district levels) [80]. For instance, consider an operational indicator measuring the percentage of the population with access to educational services within a 5 min walking distance (approximately 400 m). The spatial scope, or area of influence, would encompass the 400 m radius extending beyond the Madrid Nuevo Norte (MNN) project boundaries. Spatial resilience plays a crucial role in determining how these areas can adapt to changes induced by urban development projects, as highlighted in studies of large-scale economic regions [81].

Intensity of the Effect

Represents the anticipated magnitude of change in a measured variable, which can be qualitatively assessed comparing two indicator values: the baseline (in the case study pre-project conditions) and the projected value (the expected value after project implementation in the case study) [80]. The resulting effect is categorized as high, medium, or low based on this comparison.

Conceptual Proximity

Characterizes the degree of alignment between operational indicators and the corresponding performance indicators associated with desired outcomes and impacts [82].

While operational indicators directly measure immediate project effects, their alignment with ultimate goals may be limited. To evaluate this alignment, a qualitative analysis of the indicator methodologies and aims was conducted to identify shared terms within indicator definitions [82–84]. Additionally, the influence of unmeasured factors on the performance indicators associated with outcome and impact was considered. Based on these assessments, a conceptual proximity scale was established, ranging from very high proximity, when the operational and outcome indicators are identical, to low proximity, when the operational indicator captures only a minor portion of the factors influencing the performance indicator's evolution (e.g., the operational indicator measures physical accessibility to education, whereas the indicator associated with the outcome subset measures early-school-leaving rates. While proximity to educational services is relevant to school enrollment, factors such as school quality, socioeconomic conditions, and others ultimately determine early school leaving rates).

The project's potential contribution to achieving SDGs in the influence area is categorized based on a combination of the intensity of effect and conceptual proximity. The contribution levels are assigned as follows:

- High Contribution: This categorization is reserved for situations where the operational indicator closely aligns with the intended objective (high conceptual proximity) and the intensity of the effect is deemed high.
- Medium Contribution: This category applies to scenarios where the intensity of the effect is high, but conceptual proximity is considered medium, or the intensity of the effect is medium, but the conceptual proximity is high.
- Low Contribution: All other combinations of intensity and conceptual proximity factors result in a low contribution designation.

Figure 3 shows the graphical representation of how the project's potential contribution is evaluated.

		CONCEPTUAL PROXIMITY			
		LOW	MEDIUM	HIGH	VERY HIGH
INTENSITY OF IMPACT	LOW	**LOW**	**LOW**	**LOW**	**LOW**
	MEDIUM	**LOW**	**MEDIUM**	**MEDIUM**	**MEDIUM**
	HIGH	**LOW**	**MEDIUM**	**HIGH**	**HIGH**

Figure 3. Evaluation of the projects' potential contribution based on the intensity of the effect and the conceptual proximity between operational and performance indicators.

The assessments of the contributions as well as the calculated values from each operational indicator are available in Supplementary Materials Table S3.

2.5.2. Report of SDG Contributions During Project Implementation and Operation

The focus of reporting on progress towards SDG achievement undergoes a significant shift during the implementation and operation phases of an urban regeneration project. The emphasis transitions from assessing the project's potential contribution (established during the planning phase) to actively monitoring and evaluating SDG target evolution.

The reporting framework utilizes performance indicators associated with the outcome and impact subsets to carry out this monitoring of SDG progress. As outlined in the data collection section, baseline values are established for these performance indicators during the planning-phase SDG Report.

3. Results

3.1. Target Localization

This Section presents the findings regarding the localization of SDGs and their associated targets at the local level in Spain, as described in Section 2.1 Target identification.

The analysis of national Voluntary Local Reviews (VLRs) identified a total of 145 SDG targets (85.8%) deemed relevant by at least one Spanish city that conducted a VLR.

The city of Madrid identified 64 of these 145 targets as relevant to its local context. Notably, 76.6% of these targets (49 targets are directly related to the urban regeneration activities of MNN.

While Madrid's VLR highlights a specific set of targets, Madrid Nuevo Norte (MNN) prioritizes additional SDG 7 targets ("Ensure access to affordable, reliable, sustainable, and modern energy for all"). This focus on energy efficiency and renewable energy production is aligned with MNN's role as a pilot project in the European Union's initiative "Healthy, Clean Cities: European Cities for Carbon Neutral Construction" (HCC EU) [85–87]. The project's emphasis on building design and urban planning is instrumental in achieving carbon footprint reduction through these strategies [88].

Figure 4 illustrates the distribution of relevant targets identified in this analysis. The yellow area represents the total set of SDG targets. The green section indicates the number of SDG targets localized in at least one of the analyzed Spanish VLRs. The blue section denotes the targets identified in the Madrid SDG Strategy and VLR, while the purple section reflects the number of targets related to MNN activities.

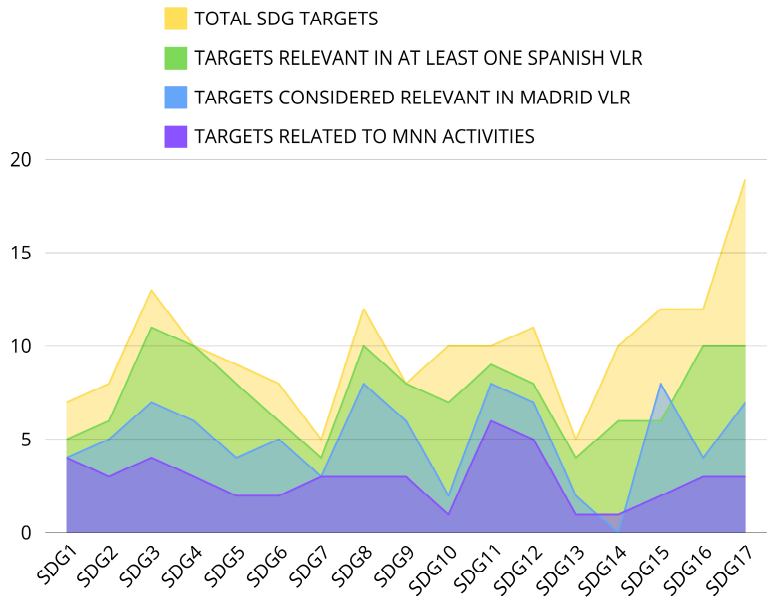

Figure 4. Distribution of relevant SDG targets identified in Spanish VLRs, Madrid VLR, and MNN-specific documentation.

Spanish localities place particular emphasis on water management targets (SDG6), unsurprisingly given the country's vulnerability to drought and the significant impact of agricultural activities on groundwater resources and nutrient pollution [89–91]. Similarly, a strong focus on SDG 5 (Gender Equality) is observed, which can be attributed to the cross-cutting nature of gender equality in policy implementation, particularly as local administrations oversee inclusion policies and address gender violence [92,93].

SDG 7 is also one of the top priorities for Spanish municipalities. The Clean Energy Transition is a main driving policy in Spain at all levels, including Renewable Energy implementation, Energy Efficiency, and Electromobility [94]. All these aspects have special focus at the local level: municipalities are managing a relevant share of European Next Generation funding for building regeneration and photovoltaic self-consumption projects [90,95]. New

developments, such as MNN, particularly emphasize Energy Efficiency and Renewable technologies [96]. Additionally, the recent energy price crisis has increased awareness of energy poverty, further driving resource allocation for mitigation efforts [97–99].

Given the predominantly urban nature of the analyzed localities, SDG 11 (Sustainable Cities and Communities) is prominently represented in the dataset. Local governments, possessing inherent authority over urban planning and management, are well-positioned to address the dimensions encompassed within this [36,37,100–102].

The high coverage of MNN activities within relevant targets underscores the significance of urban regeneration projects for all dimensions of sustainability. This project is particularly relevant for targets affected by the provision of public services, infrastructure, energy efficiency, and pollutant emission reductions.

3.2. Indicator Selection and Data Availability

Through comprehensive analysis, a total of 193 indicators were identified as applicable to the sub-local context of the Madrid Nuevo Norte (MNN) project (Section 2.2 Indicator Selection). The selected indicators primarily align with SDGs related to public infrastructure (health, education) and urban development (SDG 11). However, a significant proportion also contribute to economic-focused goals (SDG 1, SDG 8).

Regarding their classification by subset (see Section 2.3 Indicator classification), 30% of the indicators belong to the output subset (operational indicators), while 25% and 19% correspond to outcome and impact subsets (performance indicators), respectively. The remaining 25% belongs to the input subset (effort indicators and qualitative information).

Thirteen indicators are shared across multiple SDG targets, with most falling under the input subset, reflecting MNN's multidimensional impact. For instance, indicators related to job creation and wealth generation contribute to both SDG 1 (Poverty) and SDG 8 (Economic Growth). Similarly, indicators related to sports facilities and healthy consumption habits align with SDG 3 (Health), SDG 11 (Sustainable Cities and Communities), and SDG 12 (Sustainable Consumption and Production).

The remaining repeated indicators are performance indicators associated with the outcome subset that measure dimensions common to multiple targets, such as transport infrastructure's contribution to both SDG 11.2 (Sustainable and affordable transport for all) and SDG 9.2 (Inclusive and sustainable industrialization).

As outlined in Section 2.2: Indicator selection, data availability presented a significant challenge in indicator selection. Despite rigorous filtering based on data availability, some instances emerged where performance indicators associated with the outcome subset were retained despite data constraints for calculation on top of the previously mentioned qualitative inputs.

Figure 5 provides a visual summary of the number of indicators across subsets, corresponding SDGs, and data availability (see Supplementary Materials: Table S2 for detailed indicator information).

Approximately one-third of the information within the input subset is qualitative. This information has been kept as input to avoid overlooking activities that may influence the SDG targets, although at this point in the project's development it is not possible to perform a quantitative calculation of the effort indicator. For example, due to the developmental stage of the project, there are currently no data on actual recruitment and representation of women, which is critical for addressing SDG target 5.1 (End all forms of discrimination against all women and girls everywhere). Nevertheless, the existence of an analytical framework that prioritizes gender, childhood, adolescence, and family, combined with recruitment policies that target women during the construction and operational phases, is considered a foundational step towards achieving positive gender equality outcomes. This qualitative or narrative input, when aligned with output, outcome, and impact indicators, completes a results chain that begins with these early actions. Specifically, for SDG 5.1, the presence of this analytical framework, which identifies key factors affecting female employment, is expected to result in an increase in women's contracts (output). As an

outcome, this will contribute to reducing the gender income gap and will positively impact on the Gender Equality Index in the area.

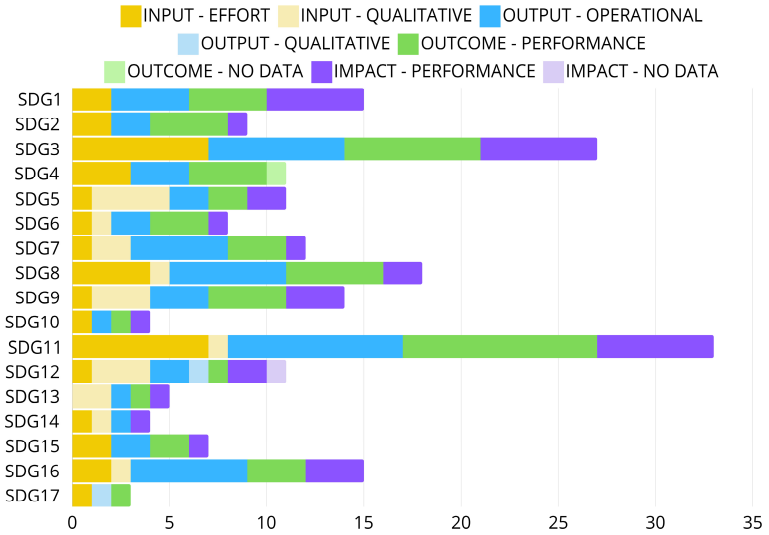

Figure 5. Indicator distribution by subset, corresponding SDGs, and data availability.

Another example of relevant qualitative information is the creation of a new transport interchange, including the addition of bus stops and increased bus frequencies, that combined with geographical data, serves as a narrative qualitative input for calculating the proportion of the population with access to public transport (following JRC methodology) [103].

As illustrated in Figure 5, certain indicators pose specific challenges. For example, within SDG 12 (Sustainable Consumption and Production), an operational indicator measuring the construction-waste-recycling rate at the MNN site is included, although it cannot be calculated until the construction phase is complete. In this case, the operational indicator available is a narrative description of the planned mechanisms for reuse and recycling of construction materials. This underscores the importance of complementing numerical indicators with qualitative data, ensuring that critical dimensions of the SDG contribution are not overlooked due to data limitations at the time of the initial report. Additionally, while the recycling rate (SDG 12.4) is a key indicator, its availability at the municipal level remains limited.

Another example of incorporating qualitative information to avoid losing relevant insights is the operational indicator for targets 17.17 (Encourage public-private partnerships) and 17.18 (Build capacity in science). In this case, a brief description of international initiatives, in which Madrid Nuevo Norte serves as a pilot project for energy innovation and sustainability research, is provided. This indicator, which could be conceptualized as a binary variable indicating the presence or absence of such projects within the MNN framework and the city of Madrid, has been maintained as a narrative due to its significance in linking with the outcome indicator in the city of Madrid's reporting framework: "Number of strategic projects with a positive impact being developed within the city". Additionally, it remains relevant for other SDG targets, such as 7.3 (Double the rate of improvement in energy efficiency) and 13.2 (Integrate climate change into national policies, strategies, and planning), particularly as future reports are developed during later phases of the project. This indicator highlights the strategic role of MNN in the city's broader sustainability agenda.

Regarding SDG 4 (Quality Education), the absence of a city-level net enrolment rate for secondary education is notable, contrasting with the availability of these data for primary education. Despite this limitation, the indicator has been retained due to its anticipated inclusion in the city's open data portal.

As described in the Materials and Methods Section 2.4: Data processing to inform the SDG reporting, a primary challenge encountered during operational indicator selection and calculation was the adaptation of established methodologies to the sub-local context and the project's planning phase. Figures 6 and 7 illustrate the distribution of operational indicators based on their nature and the specific methodological adjustments implemented.

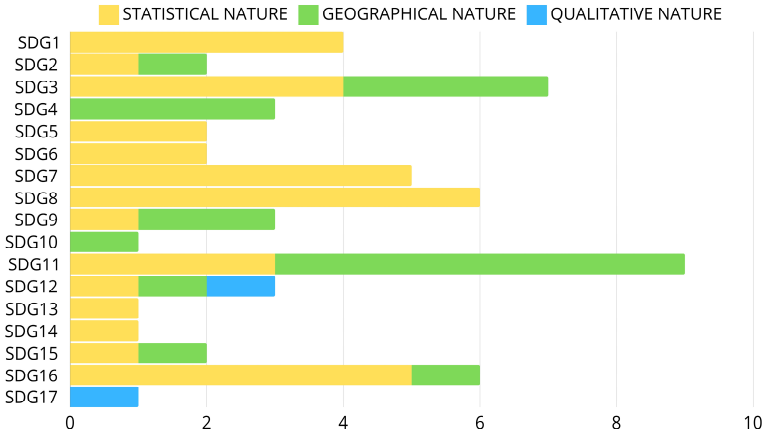

Figure 6. Number of operational indicators by SDG and nature.

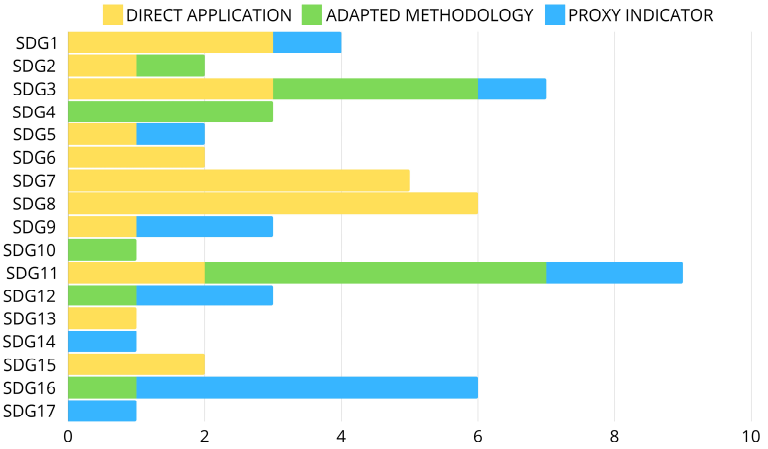

Figure 7. Number of operational indicators by SDG and methodological adaptation.

Figure 6 presents a categorization of operational indicators based on their nature: statistical (yellow), geographical (green), or qualitative (blue). A significant proportion of these indicators are geographical, particularly those related to the distribution of basic services, green spaces, and transport infrastructure, which were calculated using European geographical datasets [70,104–107].

The distribution of operational indicators across these categories is relatively balanced, with statistical and geographical indicators evenly represented. SDGs related to the provision of services and infrastructure feature a higher proportion of geographical indicators, while dimensions focused on economic and environmental accounts are predominantly represented by statistical indicators.

It is important to note that in future phases of the project, the reliance on operational indicators will diminish. At that stage, the combination of performance indicators associated with outcome and impact will provide greater insight into the effects of the redistribution of services and infrastructure, as measured by the geographic operational indicators, on achieving the SDG targets.

Figure 7 further illustrates the methodological adaptations required for some indicators, as described in Section 2.4 on Data Processing for SDG Reporting. Indicators for which

no methodological adaptation was needed are shown in yellow, those requiring adaptation are shown in green, and proxies used in cases where standard indicators were unavailable are represented in blue.

The comparison between Figures 6 and 7 reveals that statistical indicators, particularly those linked to economic dimensions (SDG 1, SDG 8), were more readily adaptable to the sub-local level mainly due to the availability of disaggregated data from the Spanish National Institute of Statistics.

As described in Section 2.4.2: Operational indicators, methodological adaptations have focused on geographic indicators, for which it has been necessary to seek alternative data sources to those proposed by the organizations that define the methodologies applied.

Regarding the proxies used when the original indicator was not possible to compute or obtain, Table 3 details the original and proxy indicators applied in the output subset.

Table 3. Original and proxy indicators for the output subset.

SDG Target	Original Performance Indicator	Proxy Indicator
1.2;1.4	Persons living in households with very low work intensity, by age group	Jobs that require low skill level
3.9	Potentially soil polluting activities and contaminated soil inventory	Proportion of remediated soil
5.5	Proportion of women in managerial positions	Proportion of women in owners' associations
9.1;11.a	Transport performance	Proportion of population reached by MNN intra and intercity public transport
9.2	Daily accessibility	Proportion of industrial areas reached by MNN intra and intercity public transport
11.1	Housing-access index	Difference in land value for free housing compared to basic prices social housing
11.b	Degree of integrated water resources management	Increase in the SUDS capacity
12.2	Proportion of reused materials during construction	Distribution of construction waste management options
12.4;12.5	Proportion of population living in households with access to waste collection	Municipal recycling and disposal points
14.1	Proportion of domestic and industrial wastewater flow safely treated	Reduction in the pollutant load of the discharge from the Valdebebas WWRP
16.6	Presence of direct participation structure of civil society in urban planning and management that operates regularly and democratically	Number of participation activities carried out
16.6	Presence of direct participation structure of civil society in urban planning and management that operate regularly and democratically	Number of involved groups
16.6	Presence of direct participation structure of civil society in urban planning and management that operate regularly and democratically	Number of allegations analyzed and answered during the public information phase of the projects
16.6	Presence of direct participation structure of civil society in urban planning and management that operate regularly and democratically	Proportion of allegations considered in the final PGOUM modification
16.7	Participation in local forums or similar district participation bodies	Associative–civic spaces
17.17;17.18	Number of strategic projects with a positive impact for the city that are being developed	Projects involving Madrid Nuevo Norte related to research and sustainability

Given the absence of a resident population and the lack of real-time data within Madrid Nuevo Norte (MNN) during the planning phase, most proxies presented in Table 3 are designed to align with the conceptual framework of the original indicators while offering an alternative means to measure MNN's potential impact in the context of a non-resident population. These proxies are constructed to address the dimensions of the

original indicators that can be directly attributed to MNN's activities. For instance, the proxy for SDG targets 1.2 (Reduce relative poverty in all its dimensions) and 1.4 (Ensure access to basic services and financial resources) assumes that expanding demand for low-skilled jobs—positions that require minimal training—can help reduce the proportion of the population living in households with low work intensity. These jobs are more accessible to diverse segments of the population, potentially leading to an improvement in social equity within the area.

3.3. SDG Reporting During Planning Stage

As described in Methodology Section 2.5.1: Report of SDG contributions during planning stage, a qualitative analysis of the expected effects was conducted to determine the level of influence MNN will have in the consecution of the SDG targets within Madrid City.

The first step in this qualitative analysis was the evaluation of the spatial scope of the expected effects originated by MNN activities. The analysis of spatial scope distribution, shown in Figure 8, reveals that only 10% of anticipated effects extend beyond the municipal scale. While most of these broader impacts relate to job creation, the influence on SDG 14 (Life Below Water) is notably regional, spanning from pollution source to coastal waters.

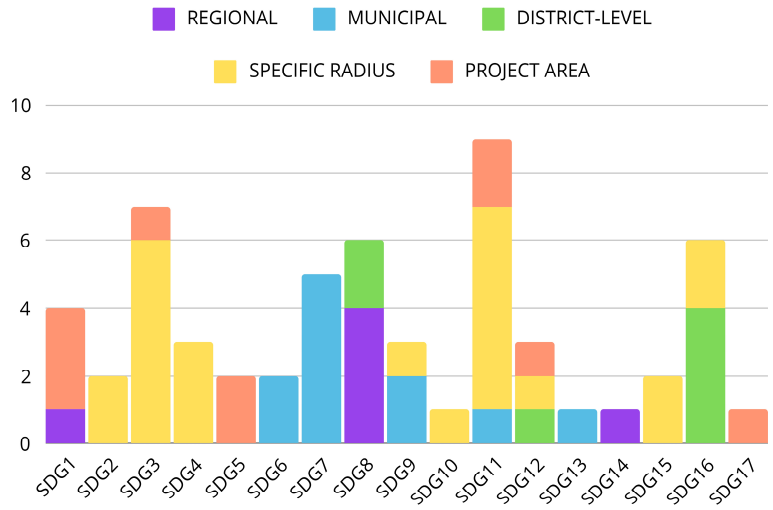

Figure 8. Spatial scope of the effects measured by operational indicators.

Approximately 41% of effects are localized within specific areas of influence, the remaining effects are distributed between the project implementation area (17%) and the municipal or district level (31%).

A significant portion of these localized effects occurs within 400–800 m of the Madrid Nuevo Norte (MNN) project site. These areas are directly tied to indicators previously discussed, such as accessibility to public service infrastructures, green spaces, and public transport services. The high concentration of effects in these areas of influence is not surprising, as they are closely linked to infrastructure provision and plot allocation, two aspects heavily affected by the project.

Since the operational indicators rely on accessibility analyses, it is logical that the areas of influence remain within the maximum walkable distances, typically 5 to 10 min or 400 to 800 m.

Figure 9 highlights the spatial extent of the various areas of influence in relation to Madrid Region (Comunidad de Madrid).

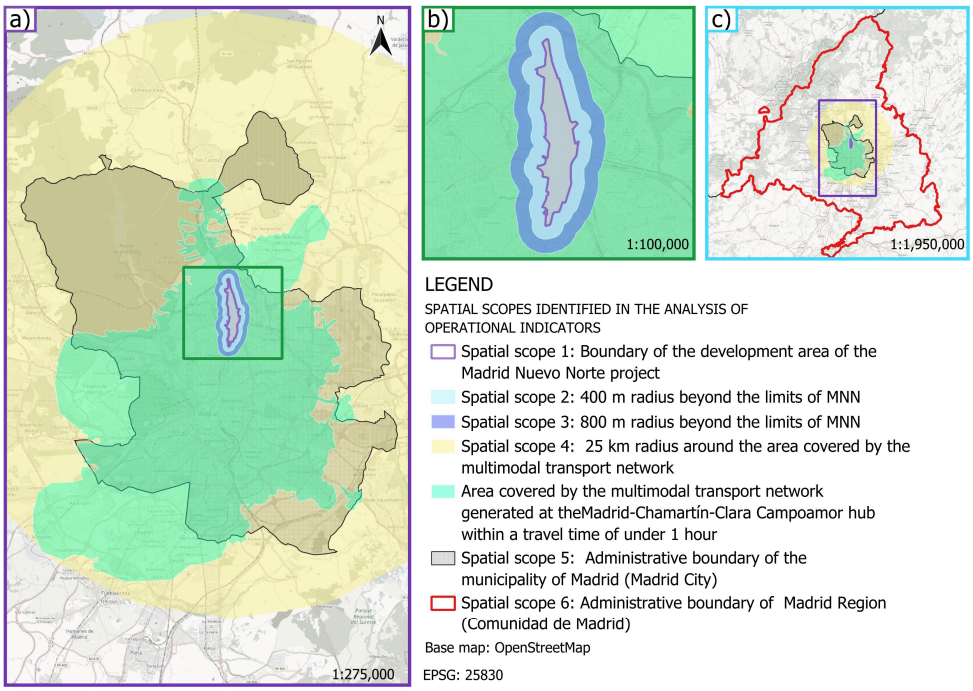

Figure 9. Areas of influence identified in the MNN case study. (From left to right: (**a**) spatial scopes 1, 2, 3, 4, and 5 within the city of Madrid (purple frame); (**b**) detail of spatial scopes 1, 2, and 3 (Green frame); (**c**) spatial scopes 1 to 6 within Madrid Region (Comunidad de Madrid) (Blue frame)).

The effects related to territorial actions—such as plot allocation and infrastructure construction—are predominantly confined to Spatial Scopes 1 to 4, with the extension of improvements to public transport systems, notably extending beyond municipal boundaries. As illustrated in Figure 8, the economic dimension of the project demonstrates the most extensive territorial impact, underscoring the substantial capacity for transformation attributed to the project's economic significance for the region of Spain.

The second step in assessing Madrid Nuevo Norte's (MNN) capacity for change is the evaluation of the intensity of these effects, as indicated by the operational indicator values. As detailed in Section 2.5 on SDG Reporting during the project life cycle, the intensity of the effects is determined by the change observed between the baseline values and the expected values after MNN's implementation. Figure 10 presents the percentage changes in operational indicators when comparing the pre-development baseline with post-development projections (see Supplementary Materials, Table S3, for further details on percentage changes and calculated values).

The most significant variations are observed in SDG 11.b (Implement policies for inclusion, resource efficiency, and disaster risk reduction) and SDG 9.c (Increase access to ICT and the Internet). In both cases, MNN's interventions markedly improve the current situation. For SDG 9.c, MNN resolves an existing issue by eliminating the lack of coverage for next-generation networks in certain homes. Similarly, SDG 11.b, which assesses the capacity of sustainable drainage systems in Madrid, is expected to see a 127% increase in capacity once MNN is operational.

Other goals—such as SDG 11.1 (Ensure access to housing), SDG 13.2 (Integrate climate change into policies, strategies, and planning), and SDG 6.4 (Increase water-use efficiency)—also show significant percentage variations. These were analyzed based on the projected conditions with and without the implementation of MNN's rigorous environmental and social sustainability frameworks. Despite the project's negative impacts—such as rising housing prices (SDG 11.1), increased CO2 emissions (SDG 13.2), and greater water consumption (SDG 6.4)—compensatory measures, including social housing policies,

energy-saving initiatives, sustainable mobility promotion, and water reuse systems, are expected to offset these effects by 67.2%, 25%, and 5%, respectively.

Based on this percentual change analysis the intensity of the effects is classified into three categories: high intensity, medium intensity, and low intensity.

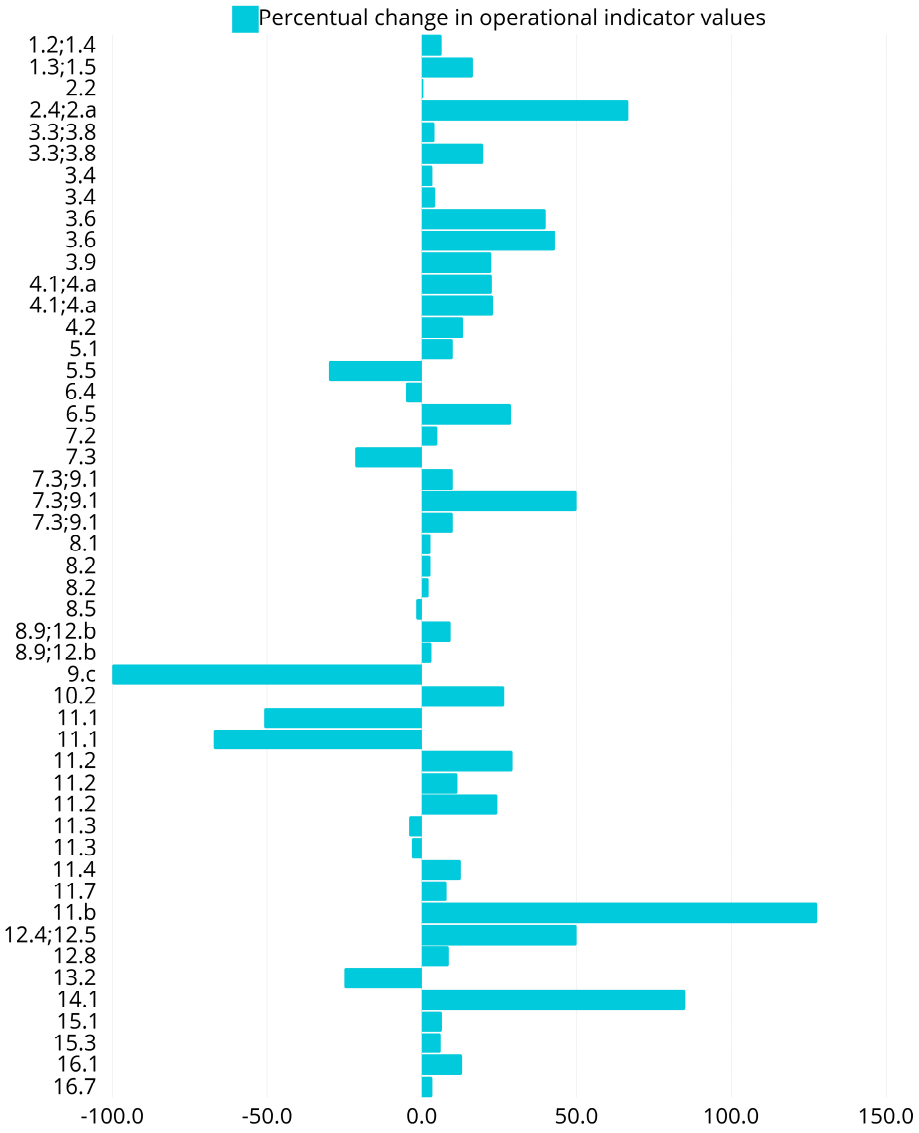

Figure 10. Percentual changes in operational indicators compared with baseline values by SDG target.

Figure 11 visually represents the number of effects by SDG and level of intensity.

Approximately 60% of measured effects exhibit a high intensity. The anticipated high levels of job creation associated with the Madrid Nuevo Norte project are expected to significantly affect SDGs 1 (Poverty) and 8 (Economic Growth), primarily during the construction phase. Furthermore, MNN's role as a pilot project within the EU's "Healthy, Clean Cities: European Cities for Carbon Neutral Construction" initiative positions it to substantially contribute to SDG 13 (Climate Action) through reduced greenhouse gas emissions. This effect is amplified by the project's emphasis on sustainable transport initiatives.

The close alignment between urban regeneration, territorial planning, and the provision of basic infrastructure results in high- and medium-intensity effects on SDGs 4 (Quality Education), 9 (Industry, Innovation, and Infrastructure), and 11 (Sustainable Cities and Communities). These effects are primarily driven by operational indicators focused on physical accessibility to basic and public services.

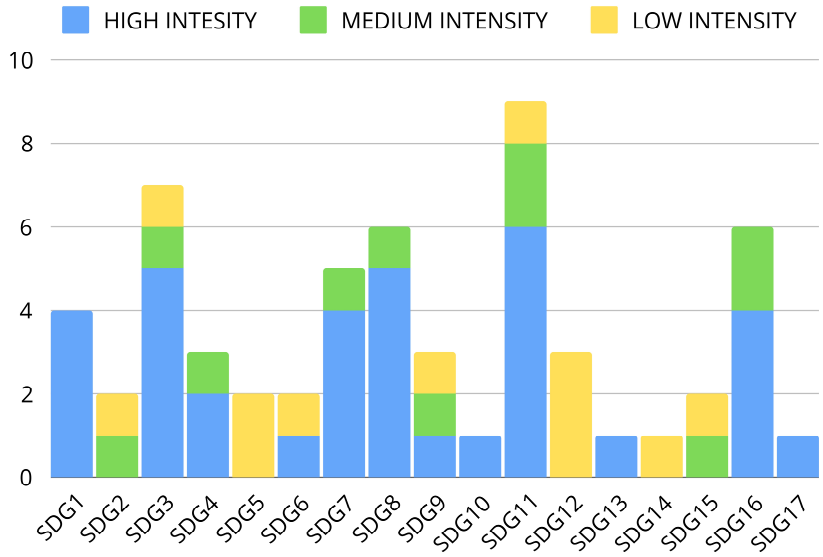

Figure 11. Intensity of the effects measured by operational indicators.

As outlined in the methodology, while operational indicators are essential for measuring immediate project outputs, they may not fully capture the broader outcomes and impacts defined by performance indicators. Therefore, the third step in the qualitative analysis involves evaluating the conceptual proximity between operational and performance indicators. Figure 12 illustrates the varying degrees of conceptual proximity between these two subsets.

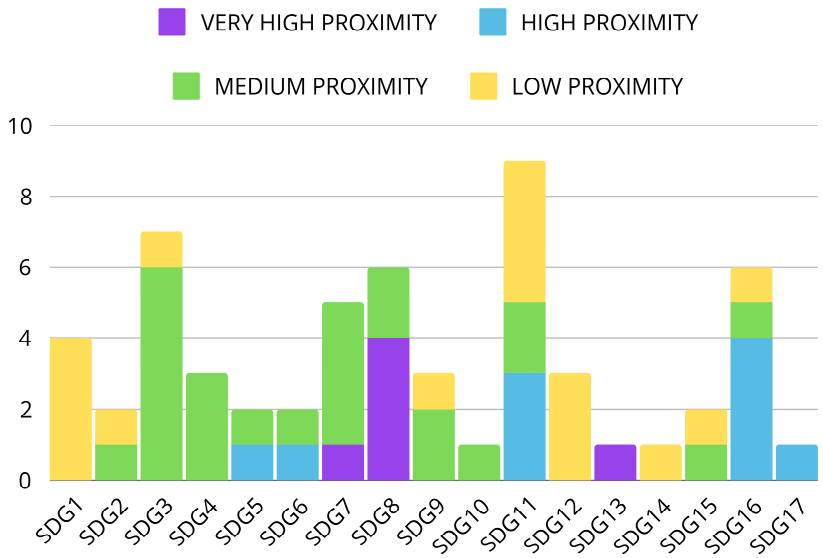

Figure 12. Conceptual proximity between operational and performance indicators.

In a limited number of cases (10%), a high degree of alignment was observed, with operational indicators directly measuring the same concepts as performance indicators, particularly for SDGs 7, 8, and 13. Additionally, 17% of operational indicators exhibited a strong conceptual relationship with outcome indicators in targets directly influenced by the project's implementation strategies, such as gender equality and transparency. Conversely, 43% of operational indicators demonstrated a medium level of concept alignment, predominantly observed in targets related to service provision, traffic management, and green infrastructure development. While there is a clear connection between these operational indicators and broader project outcomes, the relationship is less direct than in cases of

high proximity. The remaining 29% of operational indicators exhibited lower conceptual proximity, primarily attributed to the project's limited influence on certain target areas.

The varying degrees of conceptual alignment highlight the need for continuous evaluation of MNN's contributions to the SDGs, adapting to new data and activities that may provide a more accurate measurement of outcomes and impacts over time. As discussed in Section 2.5.1, the final step in this assessment involves classifying the estimated contribution. Figure 13 presents this final assessment of MNN's contribution to the SDGs within the city of Madrid.

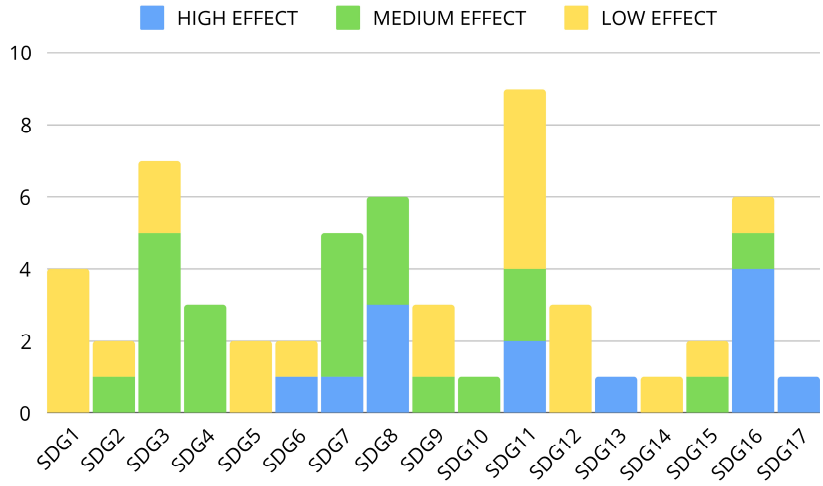

Figure 13. Contribution towards SDGs during planning phase.

A significant proportion (40%) of effects assessed during the planning phase were categorized as low due to uncertainties surrounding population demographics and project implementation specifics. Despite high-intensity effects anticipated for SDG 1 (Poverty), the limited conceptual alignment between operational and outcome indicators constrained the initial contribution assessment to a low level. However, ongoing monitoring is expected to refine this estimation. Conversely, while SDG 5 (Gender Equality) indicators exhibit high conceptual proximity, the projected low intensity of effects resulted in a similarly low initial contribution assessment. It is unlikely that subsequent monitoring will significantly alter the evaluated contribution for these targets.

In contrast, a significant proportion (38%) of contributions are categorized as medium, primarily characterized by high-intensity effects and moderate conceptual proximity. While the precise assessment of these contributions may evolve over time, the expectation is that the overall impact will remain substantial.

Lastly, 22% of contributions exhibit high levels of both intensity and conceptual proximity, indicating a strong likelihood of sustained and significant impact on SDG achievement.

From this analysis we can determine that MNN's contributions to SDGs in Madrid can be accurately measured during planning stage for goals 2, 3, 4, 6, 7, 11, 13, 16, and 17. However, goals 1, 5, 9, 10, 12, 14, and 15 will require improved operational indicators in future evaluations to better assess the intensity. Most of the accurately evaluated contributions are positive, albeit of average magnitude. It is important to note that the high contributions to SDGs 13 and 6 are primarily due to compensatory measures, suggesting that while these efforts significantly reduce adverse effects, they do not represent a net positive contribution.

4. Discussion

The evaluation paradigm for mega-projects, particularly those that entail large urban regeneration initiatives, is evolving. Rather than solely focusing on the project's direct positive or negative impacts, the emphasis is shifting towards understanding how these

initiatives can catalyze a more sustainable city model, through the positive externalities and systemic changes induced by such projects [29]. This shift highlights the importance of evaluating such projects within the common sustainability framework the SDGs represent. The high degree of alignment between the SDGs relevant to Madrid Nuevo Norte (MNN) and those considered priorities for the broader city of Madrid underscores the capacity of these projects to contribute meaningfully to local SDG achievement, potentially expanding the spectrum of goals contemplated at the city level and bringing about changes that are difficult to achieve in the consolidated city.

Evaluating the impact of new developments like MNN on SDG targets is inherently challenging. New projects are at an initial phase where long-term outcomes have yet to materialize fully, making traditional evaluation frameworks designed for projects with observable outcomes, which are often inadequate or incomplete.

To address this issue, we present an input–output–outcome–impact framework. This framework identifies causal chains to enable project effects monitoring throughout all the project stages. In order to do so the framework includes a subset of effort indicators linked to inputs, which measure the resources invested by the urban development project; a set of operational indicators, linked to outputs, which capture immediate results of the actions implemented [10]; and a set of performance indicators, which align with outcomes and impacts, providing a more traditional evaluation of the medium- and long-term effects once they materialize.

Within this framework, another major challenge in measuring SDG contributions in regeneration projects arises, the availability of data. To overcome this, different strategies have been applied to the various sets of indicators.

For input indicators, flexibility has been essential. Where quantitative data were unavailable, qualitative information has been used to ensure no initiatives linked to SDG achievement were overlooked. Qualitative narratives have been critical in tracing the chains of effects initiated by the project's actions, highlighting the importance of qualitative information in sustainability assessment processes [31,33,80].

For output indicators, methodological modifications were made to official guidelines, with alternative data sources identified. In the case of statistical indicators, the availability of disaggregated data from national and local sources, along with specific documentation, has enabled the direct application of official methodologies in most instances. However, for geographical indicators, the use of alternative data sources and formats has been necessary in nearly all cases. For some indicators that cannot be calculated at a sub-municipal level, proxies are adopted to capture the dimensions of the ideal indicators where MNN could have the most significant influence.

As for performance indicators linked to outcomes and impacts, these have been excluded from the monitoring set unless data are expected to become available soon. This pragmatic approach ensures that only actionable and measurable indicators are prioritized during the project's early stages while allowing for future updates as the data improve.

This adaptive framework ensures the project remains aligned with the SDGs, even in the face of data limitations, while establishing a foundation for more comprehensive evaluation as the project evolves.

Since the evaluation framework for Madrid Nuevo Norte (MNN) is developed during the project-planning phase, the reporting of contributions mainly focuses on operational indicators. To evaluate the case study's capacity to affect change, three key aspects have been qualitatively assessed.

The spatial scope evaluates the territorial extension of the project's effects on each SDG target. Regeneration and urban development projects, like MNN, are closely tied to the provision of infrastructure in the study area and its connections with surrounding areas [3,4,10]. As a result, most effects are linked to the specific areas influenced by the newly implemented infrastructure. However, the project's economic impact—especially regarding job creation and regional economic growth—extends its influence beyond the immediate area to a much larger scale, with broader effects on related SDG goals.

The intensity of change produced by MNN is evaluated by comparing indicator values before and after project implementation [80]. Effects related to the provision of services and infrastructure stand out in this analysis, particularly in cases where the project corrects existing deficiencies in the area. Given that urban development projects that increase the local population tend to negatively impact certain sustainability dimensions—especially those related to the environmental footprint of cities—this evaluation considers a baseline scenario where strict environmental and social sustainability measures are not implemented. This approach allows for an accurate comparison to determine whether the compensatory measures taken by the project are sufficient to mitigate negative impacts, such as on CO_2 emissions or water consumption.

Although the first two dimensions (spatial scope and intensity) provide a sense of the expected effect, it is important to acknowledge that the operational indicators may have limitations in reflecting actual progress once implementation begins. Therefore, an analysis of conceptual proximity between operational indicators and performance indicators has been conducted. Performance indicators, which reflect the project's actual contributions to the SDGs, are more aligned with long-term outcomes and impacts. This step is crucial to assess whether the operational indicators are truly indicative of the project's contribution to sustainable development or if adjustments need to be made as the project progresses. As shown in Section 2.5.1, there are varying levels of conceptual proximity between the two sets of indicators. A limited number of operational indicators demonstrate a high degree of alignment with performance indicators, particularly those related to dimensions directly tied to the project's action mechanisms; nevertheless, many indicators related to the provision of infrastructure and services show a medium level of conceptual proximity. While these indicators can capture the immediate outputs of the project, they may fall short in reflecting the broader socio-demographic factors that will influence the eventual outcomes. These factors, such as population dynamics and social changes, will ultimately affect the values of the performance indicators, yet operational indicators alone may not fully capture these complexities. Certain indicators have a lower degree of conceptual proximity, primarily because the project has a limited capacity to influence certain aspects (when whole city dynamics exceed local impacts) or the available information at the stage of the project is insufficient.

Despite the project's ambition as one of the most extensive urban regeneration efforts in Europe, its capacity to influence goals unrelated to infrastructure development and design measures remains limited. Nevertheless, the characterized contributions reveal significant potential for change, particularly in areas related to technological innovation and modern urban planning practices. This emphasizes the need for continuous monitoring and adaptive strategies as MNN moves from planning to implementation, ensuring that contributions to the SDGs are accurately assessed and optimized. It also highlights the importance of supplementing operational indicators with more nuanced performance metrics, especially in areas where indirect or broader systemic effects are expected.

Ideally, as data become available throughout the project lifecycle, these limitations can be addressed through ongoing refinement of the reporting process. This refinement might involve (a) data collection adjustments: ensuring the accuracy and completeness of data used to calculate performance indicators; (b) indicator refinement: potentially adapting or replacing operational indicators with more appropriate measures as the project unfolds and unforeseen circumstances arise.

The combination of these factors has enabled the evaluation of MNN's contribution to the SDGs during the project-planning phase. A significant portion of the measured effects exhibits a low contribution level, primarily due to the limited conceptual proximity between operational and performance indicators. However, it has been possible to ascertain with sufficient precision that the expected effects for approximately 60% of the SDGs will be medium to high. Still, effective assessment of the project's impact relies on tracking changes in the baseline values of the performance indicators (associated with the outcome and impact subsets identified in Section 2.3: Adaptation to the reporting framework) over time.

Periodic reports should analyze the time series trends associated with these indicators. Also, by monitoring changes in performance indicators over time and incorporating data from effort and operational indicators, it becomes possible to address critical dimensions often neglected in standard SDG reporting, such as temporal dynamics through the disaggregation of project effects across different development stages and the spatial contextualization through the definition of both the project and its wider influence area (as described in results Section 3.3: SDG Reporting during planning stage), both sources of complexity [6].

Moreover, impact assessment requires considering various external factors and influences that affect outcomes but are beyond the project's direct control.

For instance, while MNN might implement numerous initiatives to promote sustainable transport and reduce carbon emissions, the overall impact on air quality and public health also depends on regional traffic patterns, industrial emissions, and broader economic activities. Therefore, measuring the true impact of MNN on SDG targets necessitates a holistic approach that accounts for these external variables.

To address these challenges, existing indicator calculation methodologies must be adapted to accommodate the project's evolving dynamics. This necessitates the development of operational or intermediate indicators capable of predicting long-term impacts based on initial inputs and short-term outputs, and robust systems for continuous monitoring and iterative evaluation to enable real-time adjustments and recalibrations [108]. A similar process must be designed to integrate multi-level participation [109].

To account for dynamic factors such as demographic shifts, economic fluctuations, and technological advancements, a systems-based approach can enhance the evaluation process by considering complex interrelationships and feedback loops [108,110]. Capacity-building initiatives for local authorities and stakeholders are crucial to effectively harness these tools and methodologies.

Adopting these approaches combined with a VLR-like reporting process can help ensure alignment with broader local sustainability objectives and facilitate the communication of progress towards SDG achievement, enhancing transparency and accountability, stakeholder engagement, and the replication of successful strategies across other projects and regions.

5. Conclusions

The Sustainable Development Goals (SDGs) offer a robust framework for assessing sustainability at the local level. By providing a structured set of targets and indicators, the SDGs facilitate the alignment of projects and initiatives with broader sustainability objectives. This alignment is particularly important for evaluating the contributions of large-scale urban regeneration initiatives, such as Madrid Nuevo Norte (MNN). The widespread adoption of the SDG framework also enhances the potential of these monitoring reports to inform the development of future urban regeneration policies and plans.

While the SDG framework is useful, its application to urban regeneration projects like MNN requires careful adaptation. Several considerations are critical to ensure the framework's relevance and efficacy in such contexts. First, the selection of indicators must be tailored to the specific characteristics and priorities of the project, ensuring that the evaluation process accurately captures the impacts most relevant to the local context. Second, the dynamic nature of urban environments necessitates flexible and adaptive evaluation methodologies, which allow for continuous assessment and recalibration as the project progresses and new data become available. Third, an integrated approach is essential to capture the complex interrelationships between different SDG targets, thereby providing a holistic evaluation of the project's contribution to sustainability.

To enhance the evaluation process of the MNN case study, this paper proposes a dual-faceted process that integrates these considerations. The first component involves localized monitoring focused on indicators directly relevant to the development's activities during each phase of the project, and the second component entails a continuous tracking system feeding into the VLR process to refine and ensure the usefulness of the indicator framework.

By adopting these strategies, a more comprehensive and accurate assessment of the project's contribution to sustainable urban development can be achieved.

Another significant challenge in assessing progress toward the SDGs is the absence of established benchmarks to determine the adequacy of progress. However, the urban development context offers a potential solution: establishing city-level performance as a baseline for assessing project impact. In the case of MNN, this process involved two key steps: (i) identifying local priorities through the analysis of VLRs from Spanish cities; and (ii) defining local baselines within the project's spatial scope by calculating the values of operational and performance indicators for pre-project conditions.

The proposed methodology offers a robust framework for assessing the contribution of urban development projects to the SDGs. By integrating project-specific indicators through the input–output–outcome–impact approach and aligning these indicators with the SDG framework, the methodology enables a detailed analysis of project impacts across its entire lifecycle. This provides a comprehensive understanding of the project's role in fostering a more sustainable and resilient urban environment.

Moreover, by adopting this methodology, urban development projects can effectively communicate their contribution to sustainable development to a wider audience, including policymakers, investors, and the public. This enhanced transparency can foster trust and support for future urban regeneration initiatives.

While the proposed methodology is effective, it should be considered a foundational step toward integrating the SDGs into the evaluation of sustainability in urban development and regeneration projects. Further research is needed to explore the complementarity of various indicators and to develop more reliable methods for estimating contributions. Incorporating such sets of indicators into more advanced impact prediction frameworks and automating the reporting process for large-scale project developers are promising avenues for research. This approach is particularly relevant for ensuring consistent monitoring and reporting of SDG progress in urban areas.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su16229727/s1, Table S1: Causal chains by target; Table S2: Indicator classification; Table S3: Operational indicator contributions.

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