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Assessing the Sustainability Alignment of Smart Mobility Projects

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Abstract

This study examines the sustainability alignment of smart mobility projects with the United Nations Sustainable Development Goals and targets. A total of 32 smart mobility projects from Finland were analyzed. The results highlight commendable efforts in sustainable urbanization and infrastructure development but significant gaps in environmental sustainability and responsible consumption in urban areas. Projects in rural areas focus on innovation and resilient infrastructure, while urban projects aim to enhance inclusive, sustainable cities and ensure safe, affordable, and accessible transport systems. The UN's specific SDG targets, especially those related to the responsible use of renewable energy, require constant attention in both rural and urban contexts. The findings underscore the need for a comprehensive, integrated approach to address the identified gaps.
Keywords: smart mobility; sustainability assessment; SDGs

1. Introduction

Sustainable mobility systems are essential to the UN Sustainable Development Goals (SDGs) that aim to achieve sustainable global development in terms of social inclusion, and environmental protection [1],[2]. The transport sector is a major emission source that can be minimized through e.g. clean fuels supportive policies [3-6]. Studies show the potential of reducing carbon emissions using renewable sources of energy and clean fuels [6-8]. Sustainable mobility is also essential for economic development and provides opportunities and prerequisites of a good life: access to healthcare, education, and other services. Despite the obvious challenges of the green transition of the mobility system, a balanced planning of the system is essential [9-11].

Research shows that accessibility improves public health, and innovative solutions support the SDGs by reducing carbon emissions and increasing urban resilience [12], [13]. Investments, innovation, and development projects are essential in improving the system towards sustainability. For example, the contribution of the mobility system to SDG3 (good health and well-being) is substantial, mainly when it comes to providing access to healthcare and when traffic accidents can be reduced [14-16]. Furthermore, in the context of SDG5 (gender equality), the mobility system is crucial

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for providing access to vital healthcare services, particularly maternity and reproductive health services for pregnant women [17 -19]. Women, on average, are more dependent on public transportation and other mobility services, and their access to maternal health, for example, may be challenging, particularly in rural areas [19]. Mobility systems are crucial in achieving SDG7 (affordable and green energy), especially in terms of lowering greenhouse emissions [20], [21]. This emphasizes the urgent need for solutions to fulfill renewable energy targets and combat climate change. Similarly, promoting economic growth and sustainable industrialization are within the goal of SDG 8 (decent work and economic growth) [22], [24]. A structured vision is vital to establish sustainable logistic systems that help long-term objectives and minimize the environmental impact of freight transport.

The development of physical and digital infrastructure, innovation, and economic growth can be contributed by smart transportation in the pursuit of SDG 9 (industry, innovation, and infrastructure) [25-27]. Examples include wireless sensor-based monitoring algorithms and hydrogen-based transportation that support resilient infrastructure and innovation. The role of transport in empowering and promoting socioeconomic and political inclusion is related to SDG 10 (reduced inequalities) [28], [29]. Economic development, integrated mobility systems, and digital mobility services help in reducing inequalities in society. In addition, transport connectivity plays a key role in achieving SDG 11 (sustainable cities and communities) by providing community-based solutions that facilitate growth, social inclusion, and accessibility [16], [27-30]. There is a need for mobility-inclusive policies to achieve the UNSDGs on accessible, sustainable urban environments. Furthermore, transportation infrastructure contributes significantly to SDG12 by reducing adverse impacts on human health and the environment and promoting environmental sustainability through the reduction of transport-related wastes [31], [32]. Mobility systems can incorporate climate change mitigation solutions into national policies, programs, and strategies to address SDG 13 (climate change) [31], [33-35]. Because of its impact on emissions, it is important to incorporate climate change considerations into transportation planning and policies for an affordable, safe, and sustainable future.

1.1. Research objectives and research questions

This study aims to assess to what extent Finland's smart mobility projects are aligned with SDG targets. By evaluating these alignments, the research aims to shed light on the nature of the convergences with or divergences from the SDGs and provide insights into how balanced the overall addressing of sustainability in smart mobility projects is. Furthermore, the study aims to investigate potential differences between urban and rural projects to detect if there are spatial differences in addressing sustainability. Also, this research seeks to identify overlooked or underrepresented sustainability targets in smart mobility projects. The research questions are as follows:

- to what extent do the aims and objectives of the smart mobility projects in Finland align with the SDG targets?
- are there noticeable differences in the SDG targets between urban and rural projects?
- which specific SDG targets are prominently addressed by the projects, and which are less or not targeted?

2. Methodology

2.1. Description of the data

The data used in this study consists of publicly available documents relating to smart mobility projects in Finland between 2016 and 2022. Importantly, the analysis for this study focused on the stated goals and objectives identified in the project documentation, excluding reported outcomes or claimed impacts. It should be noted that a portion of the projects were in progress or did not have a final report at the time of data collection. Some publicly available information only includes websites and press releases related to these ongoing projects. However, in completed projects for which final reports are available, project objectives and aims were assessed based on the report. Due to resource constraints and the availability of comprehensive data, this study analyzed 60 identified projects. The collected data has been analyzed and filtered using the following steps.

The first step of this research involved extensive data seeking and collection. Information was obtained from various open data repositories and the websites of local councils in Finland, where a large proportion of the information required was available. By law, the project data for publicly funded projects is made open in Finland. Additional information was obtained from the websites of partners involved in the identified projects. Data was

collected from a total of 60 identified projects. This was followed by a comprehensive search, extracting relevant information from the reports and documents. The focus of this step was to look at the goals and objectives of the projects and to identify the specific targets and aspects of sustainability addressed in these projects. The aims and objectives of the projects were critically reviewed and analyzed, whereafter a data reduction process was developed. Some project documents did not match the requirements of the study resulting in their exclusion from the data set. For example, ambiguity of project materials, lack of credibility, incompleteness, or missing relevant sections in project documentation led to exclusion. Subsequently, 32 projects met the criteria and were accepted for inclusion in this study. Notably, most of these projects were related to passenger transport, while only a few were about freight and logistics.

2.2. Systematic approach to assessing mobility projects

This methodology is structured to identify, classify, and evaluate transport projects related to the UN SDGs as shown in Figure 1 depicting the research steps. First, a detailed analysis to identify UN SDG targets associated with mobility and transport systems was done – these SDGs are listed in Table 1. The targets selected were either directly related to sustainable mobility or have the potential to achieve the targets through accessible and sustainable mobility services. After identifying relevant SDG targets related to transport, the authors defined and collected specific keywords that align with these identified targets. The keywords were carefully selected through discussion among authors and based on selected scientific articles [36-41]. The intention behind the choice of these keywords was to facilitate the process of scrutinizing the project documentation and helping to assess the extent to which the project was in line with the identified SDG targets. The authors looked for both exact keywords as well as similar words or themes to the keywords. For example, in Table 1, the keywords "traffic fatalities," "safety," "accident," "road casualty," and "dangerous situation were defined to determine the projects' compliance with specific target 3.6, which aimed to reduce global deaths and injuries from road accidents. This approach allowed for the exploration of the project's aims and objectives, making it easier to assess their alignment with the broader sustainability targets defined by the SDGs.

The next step involved a comprehensive analysis of the aims and objectives identified in the selected projects. The objective was to assess the extent to which previously identified targets were incorporated or articulated. The authors used the collection of keywords to review the project's documented objectives, ensuring a comprehensive assessment of the alignment of the project.

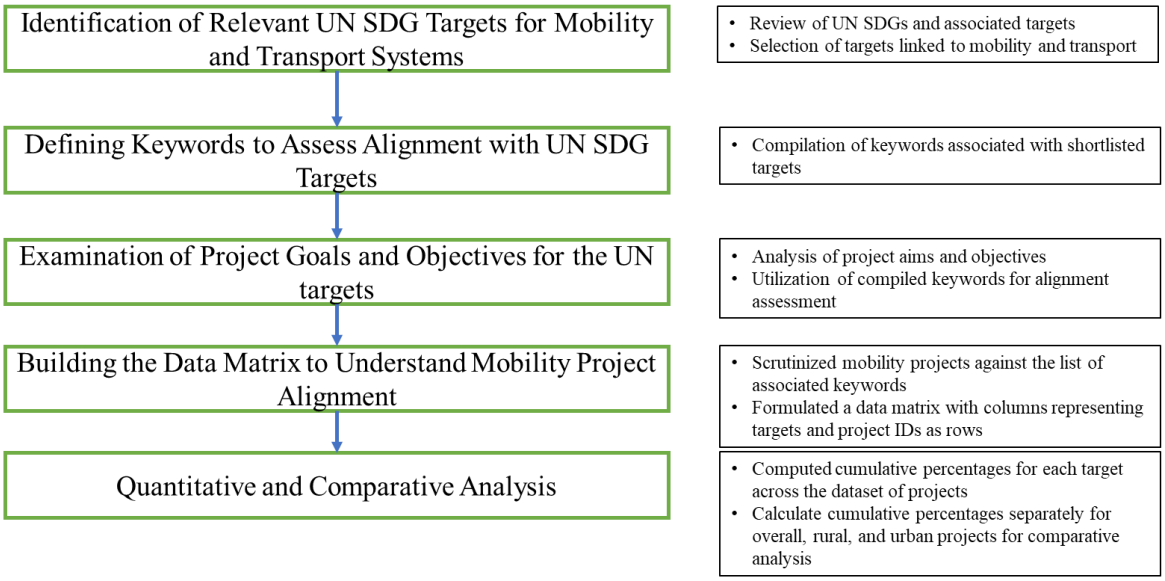

Figure 1 Research methodology and steps

Table 1 Transport system-related targets and keywords to assess alignment with UN SDG targets

Targets	Related terms/keywords
SDG 3: Good health and well-being	
3.6	Traffic fatalities, Safety, Accident, Road casualty, Dangerous situation, Injuries
3.9	Air pollution, Human health impacts, Reduce Emissions, Low emission, Air quality, Reduce pollution
SDG 5: Gender equality	
5.1	Gender equality, Anti-discrimination, Inclusive, Gender/Equity mainstreaming, Gender sensitivity
SDG 7: Affordable and clean energy	
7.2	Renewable energy growth, Clean energy, Use of biofuels
7.3	Energy efficiency, Energy consumption, Energy use,
SDG 8: Decent work and economic growth	
8.3	Job creation, Entrepreneurship support, Decent work environment, Knowledge/Innovation base, Knowledge and competence, Business opportunities, Digital skills, Recruiting new entrepreneurs, Viable business models
8.5	Decent work, Gender equality, Inclusive, Encourage women-led businesses
SDG 9: Industry, innovation and infrastructure	
9.1	Resilient infrastructure, Accessible infrastructure, Sustainable infrastructure, Infrastructure costs, Consumer costs,
9.2	Inclusive, Employment, Sustainable growth
9.4	Resource efficiency enhancement, Environment friendly, CO2 emissions, Sustainable infrastructure
SDG 10: Reduced inequalities	
10.2	Equity/Fairness
SDG 11: Sustainable cities and communities	
11.2	Accessible transport systems, Safe and affordable, Improved safety, Inclusive transport, Transport equity, Accessibility, Minimize traffic congestion/Reduce travel time, Congestion and delays, Multimodal integration, User satisfaction, Transport diversity
11.6	Environmental impact reduction, Air pollution reduction, CO2 emission reduction, Transport system waste reduction
11.7	Access to green spaces, Inclusivity, Safe access, Community cohesion, Reduce noise pollution, Satisfaction
SDG 12: Responsible consumption and production	
12.4	Health and environment protection, Minimize transport-related waste
SDG 13: Climate action	
13.2	Climate integration in policies, Climate change, Air pollution, Greenhouse gases

The objectives of each project were carefully reviewed against a collection of SDG targets-related keywords, which generated a data matrix. The column represented specific targets, while the project ID in the row. A score of '1' indicates that the target is included in the project objectives, while '0' indicates absence. At the same time, projects were categorized as urban or rural based on their location. This systematic review helped to conduct a quantitative analysis of the extent of SDG target integration in transport and mobility services in Finland.

The cumulative percentage of 32 projects provided an overview of alignment across the dataset. The analysis includes calculating the cumulative percentage for all projects, rural projects, and urban projects. Using a visualization of these percentages, from 0 to 1 or 0 to 100%, facilitated our comparative analysis to identify differences among the projects. The next section will delve into findings and detailed discussion from these analyses to shed light on the nuances of project alignment to SDG targets.

3. Analysis and Findings

3.1. Alignment of Mobility Project with UN Sustainability Goals and Targets

From the thirty-two mobility projects, it is clear that the SDG goals and targets are integrated at various levels in

the Finnish transport projects. Figure 2 shows that targets 11.2 (47%) and 11.6 (47%) reflect the maximum inclusion in overall Finnish mobility projects. These targets focus on sustainable cities, which aim to make cities inclusive, safe, stable, and resilient. Their significant presence indicates a greater emphasis on urban mobility, which could prioritize infrastructure for sustainable urban transport systems, infrastructure, and access. Many targets fall into the moderate inclusion category, representing 9% to 31% of Finland's mobility projects. Targets such as 3.6, 5.1, 7.2, 8.5, and 13.2 fall into this category. These goals include better health and well-being (target 3.6), clean and affordable energy (target 7.2), decent infrastructure and economic growth (target 8.5), and climate action (target 13.2). The moderate inclusion shows significance but does not focus strongly on the projects. Targets 11.7 (3%) and 12.4 (3%) have the least representation in the Finnish mobility projects. This could include strategies to incorporate more green spaces into mobility infrastructure or to increase the environmentally friendly use of transport systems. The minimal inclusion of these targets can identify areas where the current transport system in Finland can expand or modify its approaches to sustainability or can be developed.

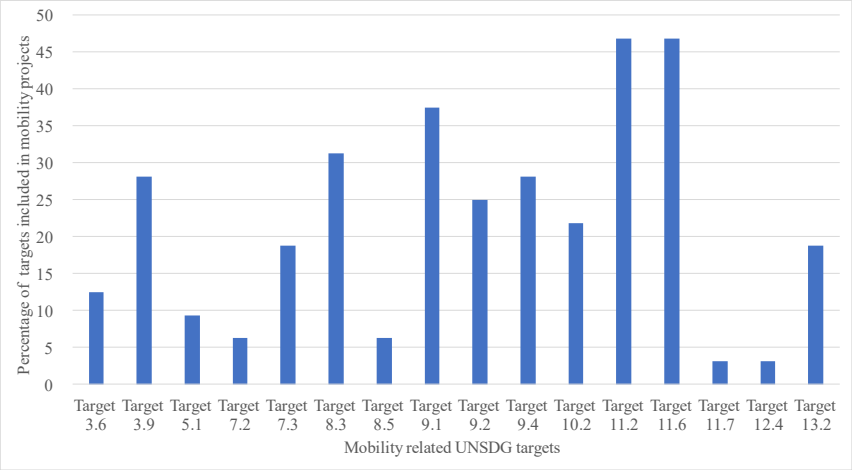

Figure 2 Percentages of UN sustainability targets in Finnish mobility projects

The evaluation of the inclusion of targets in rural projects reveals a significant difference in emphasis on mobility. Figure 3 shows that targets 9.1 and 11.2 appear to be the highest priority, with more than 50% presence among rural projects. These targets highlight important aspects of sustainable development that focus on infrastructure and accessibility in rural areas, reflecting concerted efforts to improve transport infrastructure and connectivity in these areas. However, a concerning trend emerges with targets 7.2, 11.7, and 12.4 being completely absent in rural areas, showing neglect of responsible consumption and renewable energy, etc. in rural projects. Moderate inclusion of other targets, ranging from about 20% to 43%, in rural projects showing emphasis on various aspects such as economic development, energy, and environmental sustainability. The

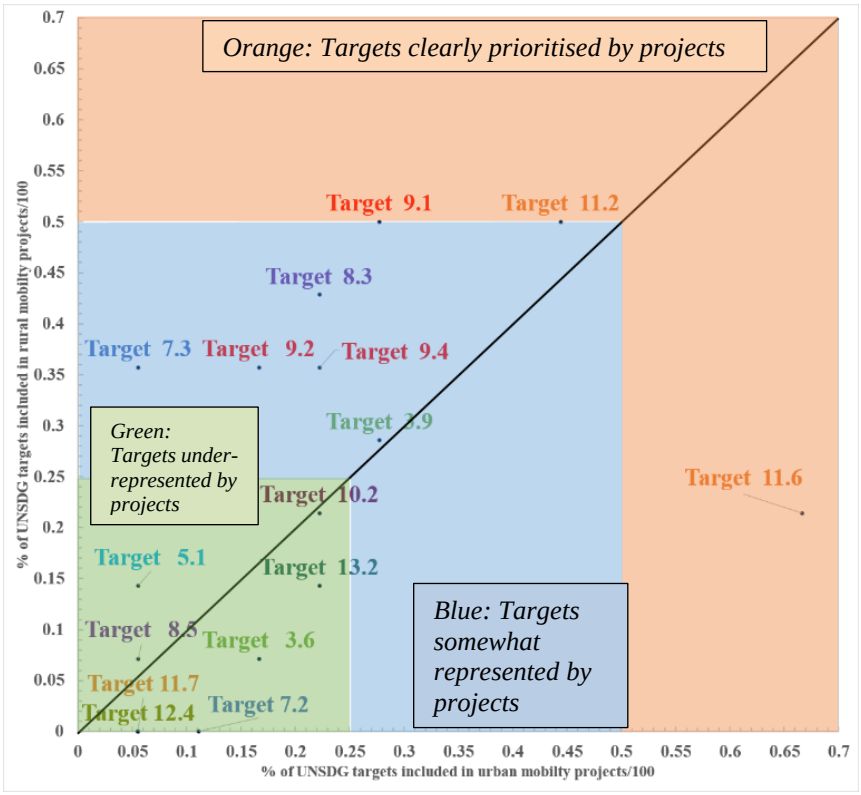

Figure 3 UN sustainability targets in Finnish rural and urban mobility projects

analysis highlights the critical need for a balanced and comprehensive approach to sustainable transport projects in rural areas.

The analysis of urban projects reveals diverse priorities of targets in urban Finland. Importantly, targets 11.6 and 11.2 appear as the most fulfilled as shown in Figure 3, with 67% and 44% coverage respectively. This highlights the important roles of sustainable cities and accessible transport in urban development. However, targets 7.3, 5.1, 8.5, 11.7, and 12.4, have the lowest inclusion rates in urban projects reflecting 6% or less. This low inclusion shows potential oversight in addressing responsible consumption, renewable energy, and environmental sustainability-related urban transport projects. Targets with moderate integration, such as 9.1, 9.4, and 3.9, indicate a balanced but not focused perspective in the urban regions. The targets include infrastructure, economic development, and renewable energy. Achieving sustainable growth in urban mobility will require more concerted efforts to balance policies.

3.2. Alignment of Mobility Project with UN Sustainability Goals and Targets

Comparing the percentage of coverage of different SDG targets in rural and urban sectors provides important insights into the allocation of effort and resources in this context as shown in Figure 3. The x-axis indicates the percentage (%/100) of target inclusion in urban projects (values range from 0-1) and rural transport projects indicate the y-axis. The graph has been divided into three different zones of values less than 0.25, between 0.25 to 0.5, and 0.5 to 0.7, showing the level of different targets included in rural and urban projects. Analysis of differences and similarities provides a nuanced understanding of how targets are prioritized in rural and urban projects as follows.

- Target 9.1 (Infrastructure Development): Rural and urban sectors exhibit significant attention on infrastructure, with urban being less present (28) compared to rural projects (50%).
- Target 11.2 (Sustainable transportation): Notably, emphasizes inclusive, sustainable, and sustainable transport, and reflects a high level of integration in both urban (44%) and rural projects (50%).
- Target 8.3 (Economic Development): Although economic growth is the focus in both areas, the percentage of inclusion is higher in rural (43%) than in urban (22%).
- Target 11.6 (Air quality): The environmental impact in terms of air pollution from mobility systems is more critical in urban areas with 66% as compared to 20% in rural areas.
- Targets 7.2, 11.7, and 12.4: These goals, covering clean energy, employment, and responsible consumption, show no representation exists entirely in rural projects as compared to urban projects.
- Targets 5.1, 7.3, and 9.2: Similarly, these targets are rarely associated with urban projects, and highlight potential areas where urban projects may overlook aspects of gender equity, clean energy transport, and inclusive employment in the mobility sector.
- Targets 3.9, 8.5, and 10.2: These targets indicate moderate integration between rural and urban projects, indicating a similar focus on areas like health impacts from transport pollution, indiscriminate employment opportunities for all, and reducing inequalities in the transport sector.

4. Discussion and Conclusion

The evaluation of mobility projects showed distinct patterns and disparities in the integration of targets throughout rural and urban Finland. The prioritization of SDG targets within mobility tasks reflects commitments to sustainability and areas that need attention in sustainable transport development.

The disparities within the inclusion of SDG targets among rural and urban projects unveil an emphasis on various aspects of sustainability. Urban projects prominently prioritize targets associated with sustainable urbanization (Targets 11.2 and 11.6), aligning with the need for inclusive and resilient cities and additionally echoing the development mentioned in the UN report [41]. Conversely, rural projects prioritize infrastructure improvement (Targets 9.1 and 11.2), aiming to decorate connectivity and accessibility in remote areas. However, minimal representation of targets like 7.2, 11.7, and 12.4 in both implies neglect in addressing those areas.

The findings highlight some specific gaps in the mobility sector. In particular, the environmental (target 7.2, 11.7, and 12.4) and some socio-economic dimensions (target 8.5 and 12.4) indicate the need for a comprehensive approach to ensure compliance. Addressing these gaps may be required to provide policies to encourage the adoption of clean

energy, the use of sustainable practices, and the integration of waste and chemical management into transportation systems.

While some targets, notably 11.2 and 11.6, exhibit strong representation in urban projects, emphasizing urban sustainability, their focus on urban-centric solutions raises questions about inclusion and balanced development in rural transport. However, the limited representation of environmental sustainability goals and responsible consumption identifies areas for improvement to achieve an overall impact in all aspects of sustainability.

The analysis of the Finnish smart mobility projects through the lens of the UN SDGs reveals a narrow landscape of various key anomalies and areas of improvement. While the transport sector shows commendable efforts in sustainable urbanization and infrastructure for project development, there are obvious gaps in addressing different dimensions of sustainability, responsible resource consumption, and social aspects, suggesting a need for a more comprehensive approach. Considering the initial research questions, the analysis implies the following:

RQ#1: Alignment of smart mobility projects with UN SDGs: the analyzed smart mobility projects revealed alignment with the UN SDGs and targets commitment, as far as stated project objectives are concerned, to sustainable cities, inclusive cities, and infrastructure are more prominent in urban and rural sectors and focus on concerted efforts to address these critical areas of development but significant differences in addressing renewable energy, responsible use, and environmental protection emerged as well.

RQ#2: Differences between urban and rural projects: A comparison of urban and rural transport projects revealed very different priorities. The urban projects mainly focused on sustainable urban development (targets 11.2 and 11.6), which is to be expected and is consistent with the need for inclusive and resilient cities. In contrast, the rural projects' emphasis on infrastructure development and accessibility (targets 9.1 and 11.2) in particular, reflects the specific needs of remote and isolated areas. Both in urban and rural areas, targets related to renewable energy and responsible use received little attention. This is particularly interesting when thinking of Finland's very ambitious carbon neutrality targets [43,44]. It can be concluded that the projects do not very well support this national objective.

RQ#3: Prominent vs. neglected UN SDG targets: The analysis identified specific SDG targets that received more attention in smart mobility projects, such as targets 11.2 and 11.6 (focusing on sustainable transport), and target 9.1 (emphasizing infrastructure development). In contrast, the targets relevant to renewable energy (targets 7.2, 11.7, 12.4) and responsible use, revealed that urban and rural infrastructure have not been fully covered, highlighting gaps to emphasize a comprehensive approach to sustainable development.

The findings underscore the importance of revisiting balanced approaches to be more aligned throughout the different dimensions of the UN SDGs. Leveraging technological innovation, implementing sustainable policies, and fostering cooperation across sectors will be critical to achieving an inclusive, accessible, environmentally sustainable approach to addressing the identified gaps. In practice, it is also a question of funding decision criteria: if more balanced addressing of SDGs is required as a condition of project funding, the gaps are probably bridged almost automatically.

In conclusion, the Finnish mobility projects show efforts in many aspects of sustainability, but there are significant gaps that require attention and reassessment when going forward. An integrated approach that aligns rural and urban priorities as well as addresses environmental concerns, and encourages responsible resource consumption, will be essential for reaching a sustainable mobility system better aligned with the comprehensive UN SDG framework.

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