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SUSTAINABILITY IN ROADWAY BIDDING FOR CONTRACTORS

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Abstract

Sustainable development requires impartial consideration from all stakeholders. In the context of construction and public works projects, this requires both project owners and contractors to emphasize sustainability considerations during the construction phase. In public projects, this process is highly dependent on government agencies. From the perspective of such agencies, this study uses descriptive quantitative analysis to investigate the degree of relevance of integrating alternative sustainability and social costs resulting from the inclusion of roadway project work zones as requirements for contractor technical evaluation. Analysis results indicate that, among the three main pillars of Sustainable Development Goals (SDGs), for government agencies, the social dimension is the most relevant while the economic dimension is least relevant.

Keywords: SDGs, Social cost, Perception of government, Work zone, Roadway project bidding.

Introduction

Aging road infrastructure requires reconstruction or at least intensive maintenance, which not only inconveniences road users and increasing road user costs (RUC), but also disrupts adjacent communities through financial impacts to local businesses, referred to as social costs (Margorínová & Trojanová, 2019). The cost-time bidding method requires contractors to propose a project duration, which is then multiplied by the daily RUC as determined by the project owner (Choi et al., 2021). To win a bid, contractors must make use of all available resources to reduce overall project duration, such as by adding crew, equipment, and technology, or adjusting work shifts. However, this solution only addresses the concerns of road users, not the environmental and social concerns of local communities and businesses (Miralinaghi et al., 2020). Governments, as the central authority for development implementation, have the power to establish policy strategies for planning and executing sustainable development (Opoku et al., 2022). This study investigates the integration of developmental sustainability and social costs into technical requirements for determining roadway project contract bid winners during the construction phase. Expanding on Chen & Liem (2023), this study primarily explores the perspective of government agency officials as project owners and financiers.

Data Collection and Analysis Methods

We start by identifying sustainable development goal (SDG) targets and indicators based on the UN DESA (2023) that are pertinent to the construction phase in highway work zones. This encompasses work zone social cost elements that are not included in the RUC, which consist of travel delay costs (TDC) / time costs (TC), vehicle operating costs (VOC), accident costs (AC), and emission costs (EC). Meanwhile, social costs such as noise, negative business impacts, and inconvenience to local communities are not traditionally considered in calculating work zone impacts due to project activities (Mallela & Sadasivam, 2011). To align each component with the triple bottom line (TBL), which serves as the primary criterion for determining sustainability sub-criteria and alternatives, the extraction of social costs and SDG components are summarized in Table 1.

This study uses quantitative methods to develop a structured questionnaire with 3 criteria, 9 sub-criteria, and 36 sustainability alternatives. Replies were scored using a 5-point Likert scale from 1 (not relevant) to 5 (absolutely relevant), distributed to government officials with expertise in road construction and sustainable development. Respondents were asked to rate the relevance of alternative sustainability components to the implementation plans for road project work zones using the A+B bidding method. A total of 26 valid responses were received from government officials in Taiwan and Indonesia. Pearson correlation test results revealed that three alternative items for economic criteria were invalid, and were thus excluded from the analysis. Reliability testing performed on the remaining 33 sustainability alternative items confirmed the consistency of the instrument with a Cronbach's alpha value of $0.76 > 0.70$.

Table 1. Extraction scheme for sustainability components

Criteria/pillar	Economic	Social	Environment
SDGs	SDG 8: Support economic growth through - Providing employment opportunities for all - Using domestic materials	- SDG 3: Reduce death and injury rates from traffic accidents - SDG 8: Protect workers' right	- SDG 3, SDG 11, SDG 12: Minimize adverse health effects caused by contamination of water, air, and soil - SDG 9: Use technology and environmentally friendly industrial processes
Social cost	Local business impact	Inconvenience to local community	Noise

Subsequently, the data obtained from respondents' evaluations was analyzed using SPSS v22 software to present descriptive statistical analysis results, show correlations, and assess government officials' perceptions of the sustainability alternatives introduced in this study.

Analysis and Discussion

Respondent profile.

More than 60% of participating government officials held a master's degree, while 64% had experience in construction/project management, procurement, or transportation management/engineering, and 6% had expertise in the environmental and sustainability/SDG fields. Respondents' positions within governments varied from policy/decision makers to technical staff. Most respondents (73%) had over five years of work experience in their current position. Respondent demographic data are summarized in Table 2.

Table 2. Respondent Descriptive Statistics

Category	Items	Number	%
Educational level	Bachelor	8	31
	Masters' degree	16	62
	Doctorate degree	2	8
Expertise field	Construction/project management	11	19
	Procurement	9	16
	Transportation Management/Engineering	17	29
	Road pavement	7	12
	Highway geometry	4	7
	Engineering/Transport Economics	4	7
	Environmental Engineering	2	3
	Sustainability / SDGs	2	3
	Other	2	3
Job position	Procurement section	2	8
	Technician	2	8

	Engineer	8	31
	Surveyor	1	4
	Section Chief	5	19
	Supervisors	2	8
	Deputy head of department	4	15
	Technical staff	2	8
Work experience	< 1 year	2	8
	1-5 years	5	19
	5-10 years	9	35
	10-15 years	4	15
	> 15 years	6	23

Data analysis.

Participant responses were analyzed using SPSS, with Table 3 summarizing analysis outcomes, with the accuracy of the data representation presented in column five in terms of standard deviation value. Respondent perceptions are presented in column 6, based on the mean values in column 4. The mean value serves as a gauge of the importance of each sustainability alternative (column 3) as a technical requisite for roadway contractors in the project work zone. The collective mean value for all the alternatives is used as a threshold to determine the respondent's perception of the relevance of each alternative. If an alternative's mean value exceeds the average of 4.14, then the level of perception is high, and low otherwise.

Table 3. Perception of Sustainability Alternatives

Criteria	Sub-criteria	Sustainability Alternatives	Mean	σ	Perception
Economic (EC)	Provide employment opportunities for all (EC.1)	Consider gender equality	3.54	1.279	L
		Priority use of productive age workers	3.85	1.239	L
		Recruit local workers	3.85	1.007	L
	Reduce material footprint (EC.2)	Priority use of domestic materials	4.08	0.885	L
		Priority use of recycled materials	4.00	0.830	L
		Use waste processing products as construction materials	3.92	0.947	L
	Minimize impact on local businesses (EC.3)	Avoid project operations during peak hours for local business	3.69	0.884	L
		Set lane closure schedules	4.42	0.717	H
		Accelerate work in business areas	4.12	0.776	L
Social (SO)	Reduce death and injury rates from traffic accidents (SO.1)	Implement a work zone risk evaluation for traffic accident prevention	4.35	0.761	H
		Provide first aid specifically for traffic accidents	4.38	0.770	H
		Maximize the use of traffic control signs	4.23	0.721	H
		Use advanced technology to control work zone traffic	3.58	0.929	L
	Protect workers' rights related to occupational security, health, and safety (SO.2)	Provide personal protective equipment for workers	4.31	0.794	H
		Guarantee workers' health	4.23	0.761	H
		Limit the number of working hours for workers	4.27	0.737	H
		Provide social security for workers	4.27	1.103	H
	Minimize inconvenience to local communities (parking; utility outages) (SO.3)	Adjust schedules and work sections appropriately	4.12	0.929	L
		Manage the proper placement of project equipment and materials	4.62	0.654	H
		Communicate with local residents prior to starting the project	4.38	0.761	H
		Coordinate utility outages with business owners	4.38	0.702	H
ron-ment (EN)	Minimize adverse health impacts caused by contamination of water, air,	Prevent air, water, and soil pollution due to operation activities	4.46	0.717	H
		Realizing fresh water savings	4.35	0.868	H
		Publish the project's environmental management report	4.27	0.779	H

	soil (EN.1)	Minimize the use of hazardous substances	4.04	1.160	L
	Use environmentally friendly industrial processes (EN.2)	Use environmentally friendly materials	3.96	1.018	L
		Prioritize the use of recycled materials	4.27	0.794	H
		Correctly process project waste	4.23	0.884	H
		Use renewable energy	4.19	0.761	H
	Reduce noise due to work operations (EN.3)	Implement noise barriers in the work zone area	4.14	0.830	H
		Use low-noise project vehicles, e.g. type of tire rubber and muffler	4.08	0.780	L
		Monitor and control noise in the work zone	4.04	0.751	L
		Use on-site project equipment with noise suppression	4.08	0.806	L

Note: H-high, L-low

Discussion.

Table 3 presents the sub-criteria positions in descending order of relevance, further illustrated in Figure 1. The majority of respondents ranked "overcoming inconvenience to local communities" as the most relevant aspect of implementing sustainability requirements for road project contractors in the work zone, while economic dimension was ranked least relevant. Even sustainable alternatives aiming to enhance economic growth by "providing employment opportunities for all categories" and "reducing material footprint" received low perception scores.

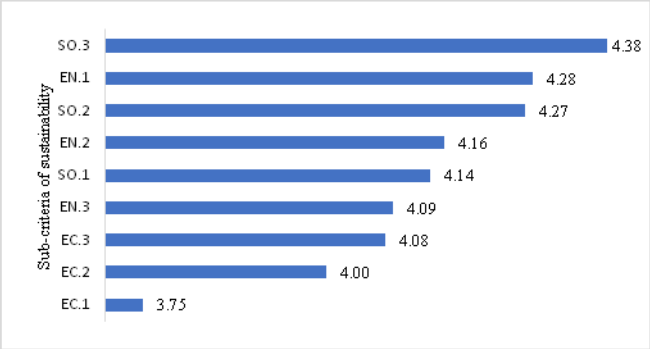

Figure 1. Perception of Sustainability Sub-criteria

This result implies that government officials consider the social dimension involved in local community inconvenience as a particularly pressing issue. This finding is noteworthy as no existing literature indicates this degree of relative significance during road project construction, and in fact contradicts recent findings by Opoku et al. (2022) that ranked social aspects as less important than environmental, political, and economic concerns. In the social dimension sub-criteria, workers' rights ranked third overall, while reducing work zone traffic accidents ranked fifth.

Water, air, and soil pollution concerns were found to be the most relevant sub-criteria in the environmental dimension, ranking second overall. Environmental aspects figure prominently in sustainability discussions. According to

Ahn et al. (2013), the carbon emissions intensity of roadway construction projects is more than double that of general construction. In addition, construction activities can contaminate water and soil with hazardous substances, posing a grave threat to biodiversity preservation (Myklebust & Myklebust, 2018). The promotion of environmentally friendly industrialization processes ranks fourth overall, while noise reduction ranks sixth.

All sustainability dimensions are shown to have high perceived relevance (all with mean values above 3.50). However, these rankings exclusively reflect the views of government officials, and the different results found by Opoku et al. (2022) may result from their sample including respondents with more diverse professional backgrounds. Interestingly, of the 9 alternatives in the economic dimension, only 1 alternative was ranked highly by the government official respondents, while 1 sub-criteria (EC.1) had a mean value of 3.75 < 4.00, indicating that government agency officials prioritize sustainability issues over improving the local economy and providing employment opportunities. On the other hand, the mean values for alternatives in the sub-criteria "reduce material footprint (EC.2)" exceed 4.00 and also have low perception results in the economic dimension. Although the alternative items for sub-criterion EC.2 are nearly identical to those for EN.2, a higher score is given to EN.2 in the environmental dimension. This also occurs for sub-criterion EC.3 which shows that the local business sector has lower priority than the local community, despite sharing the same location. These findings look slightly different from the findings of previous studies (Gilchrist & Allouche, 2005). Therefore, we argue that the perceptions of government officials tend to view sustainability issues only in terms of the environmental and social dimensions, while de-emphasizing the economic dimension.

Conclusions and Future Research

This research seeks to promote the integration of sustainable development items to preserve the environmental and enhancing human well-being through the concept of SDG and social costs by utilizing the success of the A+B bidding system in road construction projects. Seeking to integrate the SDGs and the components that make up social costs into the conditions for evaluating the bids of road contractors involved in work zones, government officials emphasize social and environmental concerns over economic concerns. Future work will focus on the development of a bid evaluation instrument that includes sustainability and social cost items as standards in road project tenders. Differences in importance scores need to be analyzed in depth using appropriate methods to determine the weight of each item. Each alternative requirement item should be assigned a weight based on its relevance. Thus, efforts to integrate sustainability aspects and factors contributing to social costs resulting from work zone construction will allow for a more holistic response to sustainability demands, better-guiding contractors in allocating resources in ways that not only minimize project durations, but also reduce social, economic, and environmental impacts in accordance with sustainability principles.

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