

Evaluating the Impact of Transportation Infrastructures on Social Equity: A Review Study

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Abstract: Evaluating infrastructure's impact on social equity is an emerging area of research in transportation construction engineering. Transportation agencies have been trying to include sustainable development. The three components of sustainable development are environmental protection, social equity, and economic development. Although social equity is one of the essential components of sustainable development, most transportation agencies do not consider this component. The research publications in this area are limited. The principal objective of this study is to synthesize existing studies related to the impact of transportation infrastructures on social equity. This study will also identify social equity indicators, the correlation between social equity and transportation infrastructures and their services, and the impact of transportation infrastructures' on social equity. In addition, this study will identify current issues of social equity and will provide some recommendations. This synthesis study revealed that transportation infrastructures impacted social equity in various ways. Some effects are positive, such as new job creation on the market. Other effects are adverse, such as diminishing socio-economic and environmental degradation. Studies also showed that the current practices evaluated infrastructures' impact on a case-by-case basis. The authors recommend adopting a multi-disciplinary holistic for assessing infrastructure's effects on social equity. The multi-disciplinary fields of study include civil engineers, construction engineers/managers, public policy researchers, environmentalists, and social scientists.

Keywords: Social Equity, Transportation Infrastructure Effects

1. INTRODUCTION

Since the start of civilization, transportation has been the lifeline of communities and a vital index of prosperity and strength. In modern societies, it has become an essential daily interaction (and sometimes impossible not to) with some transportation mode, either as a commuter, transit user, pedestrian, or simply as an end-user of frights. In civil engineering, the study of transportation is one of the essential fields and has international interest. In the past decades, the environmental effects of transportation projects have been well recognized, and their mitigation strategies have been incorporated into transportation projects. However, assessing the impact of placing and operating transportation infrastructures on social equity was not addressed yet. Although Public Transportation agencies emphasize sustainability and sustainable development; however, most

agencies do not consider social equity as a priority, although this is one of the key components to achieving sustainable development.

The term "social equity" is used differently in different fields of application. In public policy, social equity refers to "the fair, just and equitable management of all institutions serving the public directly or by contract; and the fair and equitable distribution of public services, and implementation of public policy; and the commitment to promote fairness, justice, and equity in the formation of public policy" [1 pp.3]. Other researchers adopt "Distributive Justice", a more general definition of the fair distribution of rights and responsibilities and fairness in the distribution of resources and costs [2]. Social equity is one of three components of sustainability [3,4]. Figure 1 illustrates the three components that are social equity, economic growth, and environmental protection. Without addressing the social equity issues, sustainable development cannot be achieved.

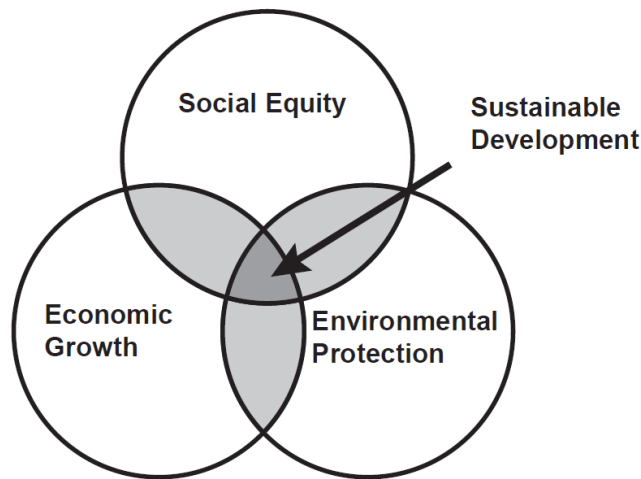


Figure 1. Three components of sustainable development [3]

The subject of social equity in human society was a classic subject. Many sciences, including social, physiological, and economical. Infrastructure's effects on social equity are an emerging area of research in civil engineering. The subject of social equity has been getting more attention among researchers since the 2000s [5]. In 2003, Agyeman and Evans studied sustainability and its practices and found that social equity is getting more attention between researchers and engineers, especially when addressing environmental and sustainable cities [6]. In 2015, a study further affirmed that social equity is still not fully understood nor fully addressed in transportation projects [5]. The knowledge or research to support standard research procedures in place in this area is limited, and most data metrics are in the developing stages [7,8,9]. The literature research revealed that civil infrastructure has a variety of effects. These effects are unquantifiable without a semi-arbitrary data-bias removing model. Some of the variable factors used to evaluate social equity were demographics, income, family, transportation, and education [10].

This study aims to synthesize existing studies related to transportation infrastructures' effect on social equity. To achieve this goal, this study will synthesize existing studies on

1. Social equity indicators,
2. Correlation between social equity and transportation infrastructures and their services, and
3. Impact of transportation infrastructures on social equity

This study will also identify current social equity issues, and the authors will suggest recommendations for future studies.

2. METHODS

Most of the data and citations were found by using keywords in a Google Scholar web search and ASCE Library search. Using keywords such as "social equity", "infrastructure and human equity", and "environmental equity", the authors were able to access over 165 articles with varying degrees of relevance. The first screening method applied to the relevance of the full articles' titles. Seemingly relevant titles were set aside for further review. 10–12 articles were found to be relevant to the subject of infrastructure and human equity. If the publications showed promise in having relevance to the research subject, the author did a full review of the publications. Most of the publications were irrelevant to the civil/construction engineering field, as was anticipated initially. The focus of this review is five papers that were relevant to social equity and social vulnerability in the field of civil engineering. The five studies were summarized by evaluating the source of data they used, methodology, and conclusions. The summary of each paper did not include a detailed evaluation of the methodology; however, the main body of information was extracted from the conclusion sections. The summary of each paper differs because they used a different method for evaluating data; therefore, the authors present results based on the total evaluation of the subject.

3. RESULTS

3.1. Social Equity Indicators

A 2021 study proposed two groups of indicators [11]. The racial Equity Models and Well-being Models. Racial equity is related to minority groups and underrepresented communities such as Black, Hispanics, and Native Americans. At the same time, well-being indicators are related to education, access to health services, and income. While it might be intuitive to use these indicators in evaluating equity, engineers and policymakers assume these indicators are inclusive and can be treated as direct virtualization of social equity questions. American Planning Association (APA) considers qualitative surveys as one of the important methodologies to gain knowledge on how inequity is affecting the community members. APA also advised using interviews, questionnaires, and other direct data collecting methods [12]. A recent study conducted in 2021 affirmed that our knowledge of human behavior contradicts rational thinking [13].

3.2. Correlation Between Social Equity and Transportation Mobility Resilience

Communities with more substantial social equity recovered faster from disasters and crises [14]; however, another study showed that firm public policy that does not specifically address social equity might have a fast disaster recovery [15]. More sustainable the society is, the less it meets social equity. For example, cities that adopt more stringent parking policies reduce travel methods among low-income class travelers. A study identified a conflict between the three components of sustainable development. Thus, moving toward more sustainable development will reduce the focus on human equity and further from the social equity component of sustainable development [16].

3.3. Impact of Infrastructures on Social Equity

Most of the existing works of literature show that only short-term evaluations of the population affected by a structure's placement can be tracked [5]. This is due to the lack of tracking and collecting information once the structure is placed and the numerous variables affecting social equity [17]. Another sub-factor was that the process for gathering social equity information was

not explicitly designed for evaluating infrastructure's effects. It was apparent from the existing works of literature that there are effects of placing infrastructures on human equity; however, these effects are unquantifiable without a semi-arbitrary data-bias removing model [5]. The optimized data can be used as input data on research methods by removing bias and normalization factors. The research models generally consist of a defined baseline area sample with available census and analyze critical interest structures (bridge, highway, port, etc.). Each of the vital interest structures is considered to be affecting a buffer base. Sets of data within the buffer and outside the buffer are then compared [5].

Most construction infrastructure projects typically have four stages of the life cycle. They are preconstruction, construction, operation, and dismantling phases. The findings of the existing studies showed that all stages of the infrastructure life cycle impact social equity in various ways. In the case of bridges, it was found that the placement of bridges has a more significant effect than other phases [5].

Studies showed the effects of transportation infrastructures on social equity. Some effects last much longer than the life of the structure itself [18,19]. A recent study conducted in 2021 explained the effects of transportation developments [20]. Some effects are positive, and others are negative [21]. Positive effects are well established in the social science field. They are the addition of new jobs to the people in the community, improvement with the option of mobility for transportation, etc. One of the adverse effects of transportation projects is disproportionately displaced and isolated families, which causes difficulty accessing jobs and essential services [21]. It is also caused by the unbalanced sharing of positive and negative benefits brought by such projects. For example, in developing a highway project connecting two major cities, the benefits of mobility options are shared by a wide range of highway users; however, the environmental impacts are concentrated in smaller communities that the highway is crossing in. The transportation infrastructures also minimized green space and decreased air quality [21,22,23].

3.4. Current Issues of Social Equity

There are policymakers across many levels in transportation agencies. When transportation projects are planned to be constructed, agencies rarely consider the social equity part of transportation project life cycle phases. This is a current gap that must be bridged [20]. However, it seems that policymakers well address environmental issues of transportation projects from the highest level of agencies. For communities, both social equity and environmental issues are essential. Nevertheless, no nationwide initiatives are visible to address the social equity issue. It is worth noting that the number of research papers published and the number of project reports on transportation projects per year has increased in the last two decades [24,25,26,27,28]. This is an indication that more transportation professionals are interested in research. However, the number of research papers and research projects is limited in social equity. Studies also indicated that the recent studies evaluated transportation infrastructures on a case-by-case basis.

5. DISCUSSIONS

There are many studies conducted, and their findings have been published in the domain of transportation infrastructures [29,30,31,32]; however, a limited study has been conducted in the area of social equity. As transportation agencies are aware of the importance of sustainable development, it seems that they are not fully aware of the importance of social equity inclusion in developing sustainable transportation infrastructure.

As is mentioned in the results section, the issue of social equity is well diverse to be addressed by a single discipline's approach. Thus, this study recommends adopting a multi-disciplinary holistic approach to evaluate the impact of transportation infrastructures on social equity. It might

be reasonable to evaluate communities based on their health approach on apparent equity factors, such as the quality of life, assets that everyone possesses, or the level of education—no studies conducted in the area of mental health or psychology as part of the evaluation. Existing studies collected community data in that community as a sample; however, raw data of individual families (or individuals) were not collected and studied yet. The literature also took on its face value that communities with a higher number of vehicles or higher education per person are more equitable than communities with less-educated individuals and so on. This logic appears to be based on a legacy understanding of communities' living standards. It fits an era closer to the mid-1950s or 60s.

6. CONCLUSIONS AND RECOMMENDATIONS

For a long time of civilization, transportation infrastructures have been a lifeline for communities. Sustainability is a part of development today, including transportation infrastructure construction and agencies prioritizing sustainability. To place an infrastructure sustainably, three pillars of sustainable development are to be considered: environmental protection, social equity, and economic development [3]. For the last decades, in the domain of transportation infrastructures, many research have been carried out [33,34,35,36], including environmental protection [23,23], and economic development [37] and their conclusions have been published; however, social equity is left behind. There are limited studies conducted in the area of social equity compared to environmental protection and economic development. Most agencies have not kept the social equity component on their priority yet. Therefore, the primary objective of this paper is to synthesize the studies conducted in the domain of transportation infrastructures' impact on social equity and provide some recommendations.

This study synthesized studies on the domain of transportation infrastructures' impact on social equity. Studies showed that the social equity indicators could be categorized into two types: racial equity models and well-being models. The racial equity model is related to disadvantaged races, such as Hispanics and Native Americans. In contrast, well-being equity models are related to individuals' level of education, health services available to them, the annual income of families, etc. Studies also stated that more substantial social equity and solid public policy positively impact the communities. In addition, the existing studies revealed that placing most transportation infrastructures have both positive and negative impacts during the life cycle of the projects in nearby communities. The positive impacts are job opening and availability of job options increased, transportation mobility service improved, etc. The negative impacts are the unequal sharing of environmental impacts of such infrastructures to the communities, displaced communities with difficulty in accessing jobs and essential services, minimized green space, decreased air quality, and communities facing floods, accidents, etc.

This study also found some issues of social equity. They are i) transportation agencies kept the environmental protection on their priority, but they did not keep the social equity on their priority, ii) the authors also did not see any nationwide initiatives in place to consider social equity, iii) limited studies are conducted in the area of how infrastructures impacted the social equity, and iv) the impact of infrastructure on social equity was not evaluated using a multi-disciplinary holistic approach.

This study recommends adopting a multi-disciplinary holistic approach for assessing infrastructure's effects on social equity for both the subject matter (i.e., bridges, highways, etc.) and the sample (communities, individuals). The multi-disciplinary fields may include construction engineers/managers, transportation professionals, public policy researchers, economists, environmentalists, and social scientists.

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