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ROJECT OF NATURAL HAZARD MITIGATION BY INFRASTRUCTURE DEVELOPMENT

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BULGARIA

Abstract: *Insufficient attention is paid to the manner in which governments, private sector investors and communities handle the threat of natural hazards to their development. Failure of infrastructures due to natural hazards can have a strong, negative impact in economies. Failure of lifeline infrastructure can disrupt economic development and divert resources originally earmarked for new development to the repair or rehabilitation of what was damaged. The failure of one bridge or the flooding of one section of roadway can cut access to a significant proportion of the national population. The natural disasters are one of the biggest problems around the world, as well as and in Bulgaria, especially in the last few years. The purpose of this paper is to examine the decision making process underlying the design and construction of infrastructures, to determine whether the failures could have been prevented by appropriate design and construction principles and by effective use of hazard and vulnerability information in the planning of the project.*

Key words: *Investment Project, Natural Hazards, Hazard mitigation, Infrastructures, Cost benefit*

INTRODUCTION

Rates of destruction after earthquakes, hurricanes, floods, droughts, desertification, and landslides increase decade after decade around the world. The adverse effects on employment, balance of trade, and foreign indebtedness continue to be felt years after the occurrence of a disaster. Activities intended to further development often exacerbate the impact of natural hazards. International relief and rehabilitation compensates the stricken countries for only a small part of their losses. The good news is that, of all the global environmental problems, natural hazards present the most manageable of situations: the risks are most readily identified; effective mitigation measures are available; and the benefits of vulnerability reduction may greatly outweigh the costs. Moreover, experience shows that the impact of natural hazards can be reduced. Improved warning and evacuation systems have cut the death toll of hurricanes dramatically. Combinations of structural and non-structural mitigation measures have been shown to alleviate the effects of earthquakes, landslides, floods, and droughts. Many factors determine the ability of a facility to withstand the effects of natural hazards. Decisions made throughout the life of an infrastructure project or a building—from design and construction through ongoing maintenance—affect the resilience and, consequently, the life span of these investments. The purpose of this paper is to examine the decision making process underlying the design and construction of infrastructures, to determine whether the failures could have been prevented by appropriate design and construction principles and by effective use of hazard and vulnerability information in the planning of the project. As results, it is clear that incorporation of hazard and vulnerability information into the earliest stages of project design or reconstruction is essential to ensure both hazard resilience and the lowest costs over the life of the project.

ANALYSIS OF INFRASTRUCTURE FAILURES

The premise of hazard mitigation is that infrastructure failures can be prevented or minimized by addressing hazards in the conceptual planning and preliminary design of the project and by enforcement of appropriate design and construction standards. The investigations have to be focused on factors in the design stage, the construction stage and in the choice of materials that contributed to the failures and how these factors should be modified to minimize the failures.

NATURAL HAZARD MITIGATION IN DESIGN AND IMPLEMENTATION OF INFRASTRUCTURE PROJECTS

The best protection against natural hazards is to select project locations that are not hazard prone. It is not always possible, however, to avoid siting infrastructures in vulnerable areas. The effects of most natural hazards can be avoided or mitigated by applying design principles appropriate to the prevailing hazards. Therefore, the owner must be aware of the vulnerability of the infrastructures at the earliest stage of the project design. For most infrastructure projects, natural hazard mitigation should be addressed during the conceptual development of the project. The consultant contracted for the conceptual or preliminary design should present to the owner a report containing information on prevalent hazards and on available methods that can be used to avoid or to minimize the effects of the extreme natural events. Since the engineer who will be contracted for the detailed design will typically accept this preliminary design, it is essential that the existence and magnitude of any hazard that may affect the project be established during the preliminary design phase. The factors to be taken into account include:

- *Design of the buildings and structural system* (transportation infrastructures) to minimize effects of high winds and earthquake forces, and, in the case of protection works, to avoid unwanted effects;
- *Construction materials* that are corrosion resistant and of appropriate durability and strength (FRP Advanced Composites);
- *Structures have to avoid* flooding, soil erosion, exposure to high winds and unstable soils, and to minimize exposure to storm surge.

Throughout the design and implementation process of an infrastructure project, there are several distinct but complementary instances where specific attention needs to be given to natural hazards and appropriate resources need to be dedicated to the necessary investigations. These instances can best be described in the typical Project Cycle:

Project Identification → Pre-investment Investigation → Submission of Investigation → Review of Investigation → Proposal to Financing Agency (be of Preliminary Design Stage of Project Cycle) → Project Appraisal → Project Approval (be of Project Review Stage of Project Cycle) → Detailed Design (be of Detailed Design Stage of Project Cycle) → Construction → Inspection (Supervision) → Final Inspection (Final Supervision) (be of Construction Stage of Project Cycle).

The most effective approach to reducing the long-term impact of natural hazards is to incorporate natural hazard assessment and mitigation activities into the process of integrated development planning and investment project formulation and implementation. Natural hazard management is often conducted independently of integrated development planning. It is important to combine the two processes. Of the many components of hazard management, the following techniques are the most compatible with the planning process:

- *Natural hazard assessment:* an evaluation of the location, severity, and probable occurrence of a hazardous event in a given time period;
- *Vulnerability assessment:* an estimate of the degree of loss or damage that could result from a hazardous event of given severity, including damage to structures, personal injuries, and interruption of economic activities and the normal functions of settlements;
- *Risk assessment:* an estimate of the probability of expected loss for a given hazardous event.

Integrated development planning is a multidisciplinary, multisectoral process that includes the establishment of development policies and strategies, the identification of investment project ideas, the preparation of projects, and final project approval, financing, and implementation.

COST – BENEFIT ANALYSIS OF HAZARD MITIGATION

The general question is: *"What mitigation measures would have been required during the design and construction of each project, to avoid losses from the particular extreme event that affected the projects?"* For this purpose, one can consider a mitigation measure as an addition to the original design and construction of the project, designed to minimize the likelihood of failure due to the particular historic event. The mitigation measures introduce an incremental cost to the project at the time of construction, and produce a benefit—avoided loss—if and when an extreme event affects the project. Incremental cost of the additional mitigation measures consists of: (1) the cost of additional investigations into the hazards that may affect the project and the vulnerability of the project to the hazards; (2) the cost of additional design work; and (3) the cost of additional construction.

Sum (Hazard and Vulnerability Study + Addtional Design Costs + Additional Construction Costs) = Incremental Costs of Hazard Mitigation

The benefits associated with investment in additional mitigation measures derive from losses avoided due to a reduced probability of failure and a reduced expected loss per failure. These benefits accumulate over the lifetime of the project and are discounted for comparison to the incremental cost incurred at the project's inception. Whereas it is fairly straightforward to estimate the components of the incremental cost of hazard mitigation, it is much more difficult to estimate the components of avoided losses, i.e. the failure probabilities and the likely losses per failure. Instead, the cost of reconstruction is taken as an approximation of the avoided losses, with the following adjustments:

- *Price deflation:* A construction cost index is used to deflate reconstruction costs to the year of initial construction;
- *Depreciation:* It is recognized however that any infrastructure asset will need to be replaced and/or upgraded at some point in time, thus becoming less valuable the closer it comes to that point. Replacement costs therefore may overstate the value of the damage;
- *Discounting:* Applying a discount rate to damages suffered from future disasters has the effect of reducing the economic justification for applying mitigation measures at the outset of the project. It can be argued that lifeline infrastructure plays a critical role in achieving sustainable development. The decision to invest in failure prevention should not be dictated by the selection of a discount rate. It was therefore decided to apply a zero discount rate to future avoided losses.

Applying no depreciation to the value of the structure, and using a zero discount rate on the cost of future reconstruction, each contribute to overstating the avoided losses, and thus make a stronger economic case for investing in mitigation. The cost of reconstruction is only a fair approximation for the direct damages. Catastrophic events cause indirect and collateral damages that often exceed the direct damages. Using the cost of reconstruction has the effect of understating the avoided losses.

CONCLUSIONS

Additional mitigation measures taken at the time of the original construction would have led to significant savings over the costs of reconstructing the infrastructures. The cost of reconstruction is a conservative estimate of the losses suffered by a failed project, since it does not include various indirect and collateral losses associated with the interruption in functioning of the damaged facility. The pre-investment investigation should clearly explain the nature of the risks and the costs and benefits of the hazard mitigation strategy being recommended. Only with full information on hazards and vulnerability can the client and financing agency make informed decisions about appropriate design alternatives. The consultant undertaking the pre-investment investigation should be responsible for conducting or coordinating all necessary hazard and vulnerability assessments, to ensure that all are completed within the appropriate time. During project appraisal by the financing institution, analysis of the hazard information and the associated mitigation strategy should be standard, in the same way that environmental considerations are now integral parts of project review. Current appraisal procedures, which focus on financial and economic risks and benefits of the project while ignoring the risk posed by recurrent natural hazards, do not ensure the least-cost alternative over the lifetime of the project—or the loan. In post-disaster reconstruction of lifeline facilities, such as bridges along main roads, the incorporating hazard mitigation is also focused on the early stages of reconstruction. Consequently, planning for reconstruction must be carefully thought out—even where the urgency to reopen the facilities demands hasty action. Maintenance of important facilities, including institutional buildings, roads, waterways and bridge structures, is a critical component of a long-term hazard mitigation strategy. The practice of contracting an independent review consultant or 'check' agency (supervision), to review the work of the design consultants and periodically inspect construction, is strongly encouraged. Through this mechanism, the owner and/or the financing agency receive a professional opinion on the effectiveness of the hazard mitigation strategy being recommended and can monitor its implementation.

RECOMENDATIONS

The preceding recommendations are meant to be implemented within the context of established procedures for project formulation, appraisal and implementation. Such procedures may vary widely according to the nature of the project, of the owner or client, and of the financing source. Governments are more likely to seek financing from multilateral financing institutions, such as the European Bank, following published procedures for project review and procurement of engineering services. Private sector investors are more likely to use their own or commercial bank funding and will follow the applicable planning and review procedures. Insurance companies may impose additional requirements, when catastrophe protection is sought for the investment. Three distinct but complementary opportunities can be identified for interventions in existing procedures to more effectively incorporate disaster mitigation in infrastructure investment decision making. *The first one* is to fully integrate the assessment of natural hazards and the analysis of the potential impact of these hazards on the project into the existing Environmental review guidelines or Impact Assessment procedures. All multilateral and bilateral financing institutions, and most governments, require that infrastructure investment projects be subject to an Environmental Impact Assessment. *The second* opportunity consists of fully integrating natural hazard risk in the economic and financial analysis of investment projects. Such analysis routinely addresses risk posed by uncertainty in prices on both costs and benefits, but fails to address the risk posed by disruption of the project's ability to produce the benefits due to a hazardous events over its lifetime. Various techniques have been developed to incorporate risk into the traditional cost-benefit analysis and are available to deal with the uncertainty inherent in the frequency and intensity of hazardous events. The costs of alternative mitigation options and their benefits in terms of reduction in expected losses need to be evaluated. *The third* opportunity to promote hazard mitigation occurs when the insurance industry is called upon to underwrite catastrophe protection for the investment project. It is clearly in the underwriter's interest to minimize the likelihood of future payouts for damages and/or business interruption caused by natural hazards. To achieve this, the project has to be designed using adequate standards and mitigation measures and has to be properly constructed. Insurance companies can ensure that these conditions are met by reviewing design and construction work with in-house engineering staff or contracted consultants. Alternatively, the insurance company can make such review a condition for obtaining insurance, in which case the owner of the project contracts the service of a check consultant, as recommended above.

Bulgaria is prone to a comparatively wide range of natural hazards (earthquakes, floods). Incorporation of hazard information and mitigation techniques into infrastructure planning is critical in the quest towards sustainable development within the region. Substantial institutional change remains to be made in the various institutions involved in infrastructure development, to address hazard risk more effectively and to ensure a more disaster-resistant development.

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ПРОЕКТ ЗА НАМАЛЯВАНЕ ПОСЛЕДСТВИЯТА ОТ ПРИРОДНИТЕ БЕДСТВИЯ ВЪРХУ ИНФРАСТРУКТУРНОТО РАЗВИТЕ

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АНОТАЦИЯ

Резюме: *Разрушенията в инфраструктурата, вследствие на природните бодствия, могат да имат голямо негативно влияние върху икономиката. Разрушаването на жизненоважни инфраструктурни обекти може да растрои икономическото развитие и да отклони ресурси, предвидени първоначално за изграждането на нови такива, като ги насочи за ремонт и възстановяване на щетите. Дефектирането на едни мост или наводняването на част от дадена магистрала или път, маже да прекъсне връзката с голяма част от населението в засегнатите райони. Пиродните бедствия са един от най-големите проблеми навсякъде по света, както и за България, и то по-специално през последните няколко години. Целта на тази статия е да разгледа процеса на вземане на решение при проектирането и строителството на инфраструктурните обекти, да определи дали разрушенията могат да бъдат предотвратени чрез подходящо проектиране и изпълнение на строителството, и чрез ефективното използване на натрупаната информация за опасността от природни бедствия по места в момента на проектното планиране.*
Keywords: *Инвестиционен проект, Природни бедствия, Намаляване последствията от природните бедствия, Инфраструктура, Стойностен анализ*