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Identification and Assessment of Environmental Risks Factors in Building Construction

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ABSTRACT

The requirement of the shelter is essential for the sustenance of the dynamism of livelihood of human being, and it lead to urbanization. The urbanization results in concentration of human population in a smaller area, densify the construction of buildings for living and other civic purposes and other constructions to fulfill the needs of the human being such as, water supply, drainage system, roads, power generation units and many more. The construction activities of all these facilities impacts negatively on the environment. The environmental risk is the probability and consequence of an undesirable impact due to the human interventions in natural processes. The overall scale of construction activities are extremely high and the same is its impact on various elements of environment. In the presented study the four elements of environment, i.e. human health, general atmosphere, ecology and society, on which the impact takes place due to building construction activities are taken into consideration. A total of nine factors and the forty sources are considered for finding out their ranking, with the help of questionnaire survey, in which 102 construction professionals participated. The five point Likert scale is used for probability and impact and analyzed by using the weighted score approach. The outcome of the analysis gives the risk factors and their sources for four elements, which have the highest probability and the impact of occurrence. The ranking of the risks perceived are obtained through analysis.

Key words: *Building construction, Environmental impact assessment, Environmental risk assessment, Risk elements.*

Introduction

The shelter either may be permanent or temporary is the necessity of life for the sustenance of dynamism of livelihood. The tremendous increase in demand for the housing structures has led in urbanization, which turn results in various negative impacts on environment. The environmental impact mainly refers to effects of human activities on its environment and the building construction activities are having a major share of it.

The planning, designing, construction, use and the maintenance of structures have impacts on the environment; some of the important impacts are energy impact, ecological impact, visual impact and material impact. The building construction projects have both direct and indirect impacts on the environment. Determining the likely environmental impacts in order of severity is a task that must be done so that the environmental impact of the construction project is realized as less as possible. The environment, includes water, air, land and the plants/animals or people that live there and the relationship between each other.

The Environmental Impact Assessment (EIA) is the process of identifying, predicting, evaluating

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and mitigating the biophysical, social and other significant impacts of a development proposal before a large-scale commitment is made. According to the International Impact Assessment Act (IAIA, 2000), the purpose of EIA is to ensure that decision makers consider all possible impacts when deciding on a project. With this in mind, it should be used as a decision-making tool rather than a decision supporting tool. The protection of environment needs the action to be taken at several levels; i.e. as major as preventing global warming to protecting living things, to a small environmental issues such as air pollution around a habitat, i.e. at the minor level. At the global level the United Nations always advocate to protect and save the environment by improving the energy efficiency of buildings and efficient economic growth through more efficient use of resources such as waste reuse, recycling and disposal. The National Government also authorized many government agencies to actively monitor the air for pollutants, control emission sources, provide compliance assistance to industry, and initiate enforcement actions such as public education. They are also involved in the prevention and regulation of water pollution in industry, in domestic sewage treatment plants, and in the monitoring of construction sites and urban areas. The mitigation measures are taken to reduce the environmental impact of construction projects, but their application and implementation needs to be studied.

The effective environmental protection is important for sustainable development, but human development and growth are considered ephemeral if the nature and its resources are not conserved. Hence, it is necessary to assess the basic environmental impacts of construction projects in order to promote sustainability.

The objectives of the study is to find out the various factors in the building constructions which are associated with the environmental risks. The outcome of the research is to get the ranking, which is obtained by the survey conducted through questionnaires among the various stake holders of the building construction projects. This would be helpful to develop a better understanding of the critical environmental risk factors and thus would also be helpful to avoid the ill impacts in the surrounding environment due to construction activities. It would also lead to the development of risk management processes during the construction stages including the evolution of the planning design and estimation phase. In the long run, the better understanding of the environmental risks associated with building construction, would be helpful for the adoption of sustainable construction techniques and ensuing performance of the construction industry.

Literature Review

There are many risks in the construction projects due to distinctive features of the various construction activities such as the its duration, the complicated processes, offensive environment, heterogeneous financial intensities and dynamic organization structures Flanagan and Norman (1993). The risk assessment and management is a very important task for a project manager, to accomplish the objectives of the project in terms of time of completion, cost optimization, quality of construction, safety of human resources and environmental sustainability of surrounding area Zou *et al.* (2006). Many of the researchers have focused primarily on risk factors associated with cost, time, resources and safety Shen (1997). Some of the researches are conducted in the context of construction phase's i.e. conceptual, design execution of construction activities etc. rather than from the perspective of project life cycle Chapman (2001).

In the construction industry, risks associated projects may cause overrun of time and the cost of which results in financial losses, legal complications, difficulties in settlement among the various stakeholders, ill reputation of the company and total abandonment of the project Singh (2009). It is essential that all the risk factors related to the construction work in all of its stages should be properly understood, evaluated and mitigated to avoid the chances of failure of a project Alberto and Muhammad (2013). The process of risk management involves the identification, assessment, response plan, monitoring and controlling of risks. The proper implication of the process of risk management avoids failures in projects, protects and grows corporate assets, ensures profitability, enhances reputation and shareholder value (Ankit *et al.*, 2013).

The ERA is the subset of EIA, i.e. it is tool which is being used increasingly in the process of EIA. However the approach of ERA may vary according to the laws of state or national Government Zou, *et al.* (2006). The EIA is a process that involves identification of the impacts of a proposal on the environment, including ecological, social and economic aspects and evaluation of the importance of those im-

pacts Abdou, (1996). However the ERA in context of EIA is termed as methods of assessment of risks and the process of their management to identify and respond to the ecological, social and economic issues associated with the construction project (Elliot *et al.*, 2009).

The environmental risks are particularly challenging to manage because much of the risk occurs upfront while the value comes later over time Chua, e*t al.* (2003). The success of construction in context of lesser impacts on the environment and natural resources, health, well-being and productivity of occupants, creating new economic development, and applying a lifecycle approach during planning heavily relies on willingness of construction managers and executers to adopt the new mindset associated means and methods Smith, (2003).

Methodology and Data

The weighted score approach is used in assessment of the probability and impact of each factor. The concept of weighted score for probability and impact are shown in equation (1). Dalya Ismael and Tripp Shealy (2018)

$WS_{(p)} = \Sigma[NR_{LR(p-j)} \times LR_j]$ ….(1-a)

$WS_{(i)} = \Sigma [NR_{LR(i-j)} \times LR_j]$ ….(1-b)

Where; $WS_{(p)}$ = Weighted Score for probability, $NR_{LR(p-j)}$ = Number of Respondent corresponding to value of Likert Scale (j = 1-5) and; LR_j is the corresponding Likert Scale (j=1-5)

Similarly; $WS_{(i)}$ = Weighted Score for impact, $NR_{LR(i-j)}$ = Number of Respondent corresponding to value of Likert Scale (j = 1-5) and; LR_j is the corresponding Likert Scale

The value of probability "P" and impact "I" were obtained in the scale in between 0 to 1 by using the equation (2) as mentioned below –

$P = WS_{(p)} / (TNR \times 5)$ ….(2-a)

$I = WS_{(i)} / (TNR \times 5)$ ….(2-b)

Where; TNR is the total number of respondents.

The degree of risk which quantify the risk is the product of probability occurrence and impact of occurrence. It can be expressed in equation (3) -

$R = P \times I$ ….(3)

In this equation, the "R" is the degree of perceived risk, P is the probability of the risk occurring, and I is the degree of impact of the risk measured between 0 and 1. In this scale of 0 to 1, the degree of risks, probability of occurrence and impact scales from high, i.e. close to 1 and low i.e. close to 0, by considering both weighted scores of the probability and impact Akintoye and MacLeod (1997).

The step by step procedure for the study is as under –

(1) The various sources in the building construction which may affect the environment are summarized from the literature review.

(2) These sources are clubbed under the different factors i.e. air, water, land, noise, solid waste, flora and fauna, socio cultural, accident and incident and resource consumption. These factors are also taken from the literature review and modified in present context.

(3) The sources and the factors are discussed in a focus group of ten persons who are specialized in the field of building construction and are well aware of environmental risks during various construction activities. The list of sources and factors are redefined after discussions and the process is continued till all the members did not arrived into consensus.

(4) A survey is conducted in which various professionals from building construction field are queried to respond the probability and impact of various sources on health, general atmosphere, ecology and society, i.e. the four elements which constitute the environment. In a first part of survey, the personal description of each respondent are recorded which includes, the name, age, qualification, experience, area of experience and acquaintance with environmental risks. In the second part, the respondents are requested to give their response regarding the probability and impact of various sources on Likert Scale, i.e. 1 to 5 and the description of the same for probability and impact are given in Table 1 and 2.

(5) The weighted score of probabilities are calculated as per equation (1-a) and the corresponding probabilities by equation (2-a) for each source. Similarly the weighted score and corresponding impacts are calculated for each source by using equation (1-b) and (2-b) respectively for four elements of environment.

(6) The probabilities and impacts as obtained for different sources are averaged for all nine factors and four elements.

(7) The averaged values of probabilities and impacts as obtained for all nine factors and four elements are normalized.

(8) The normalized values of probabilities and impacts as obtained are multiplied to get the de-

gree of risks (R) for all nine factors and four elements.

(9) The average values of degree of risks (R) for four elements of environment, corresponding to the each factor is taken as overall impact.

(10) The degree of risks (R) is then ranked for overall impact, impact on health, general atmosphere, ecology and society.

(11) The weighted degree of risks (R) are also calculated for factor-element (i.e. for 36 = 9 factors x 4 elements) and ranked accordingly.

(12) The acquaintance with environmental risks assessment environmental impact assessment of the respondents were questioned in first part of the survey. The respondents are asked to respond in Likert's scale 1 to 5, the details of which are mentioned in Table 3.

Results and Discussion

The focus group of constructional professional, who participated in finalizing the sources and factors to be taken for the study, are 12, out of them 1 is contractor, 2 are planner and designer, 2 are the project managers, 2 are the material manager/supplier and 5 are field engineers. All participants of the focus group are experienced in the field of building construction and well acquainted with the environmental risks from various construction activities. The experts of focus group are taken, from construction companies which are having more than 50 regular employees.

A total of 102 respondent, replied with their perceptions on Likert's scale about the probability and impact of sources, out of which, out of which 10 (9.80%) were owners, 12(11.76%) contractors, 10 (9.80%) planner and designer, 20 (19.61%) project managers/management consultant, 20 (19.61%) material suppliers/manager/management consultant and 30 (29.41%) field engineers, who are familiar with the construction practices and degradation of environment due to building construction activi-

Table 3. Description of acquaintance of Respondents with ER and EIA Ratings on Likert's Scale

Likert's Scale	Description
1	Do not know about it.
2	Perceived about it
3	Recognized but never used
4	Recognized but barely used
5	Recognized & recurrently using

Table 1. Description of Impact Ratings on Likert's Scale

Rating	Probability	Description
5	Almost Certain	The event is expected to occur in most circumstances.
4	Likely	The event will probably occur in most circumstances.
3	Possible	The event might occur at some time.
2	Unlikely	The event could occur at some time.
1	Rare	The event may occur only in exceptional circumstances.

Modified from Alberto and Muhammad (2013)

Table 2. Description of Impact Ratings on Likert's Scale

Rating	Impact	Description
5	Critical	Extensive long term environmental harm and / or harm that is extremely widespread. Impacts unlikely to be reversible. Widespread /catastrophic detrimental long term impacts on the environment, which could include extensive pollutant discharges.
4	Major	Widespread, unplanned environmental impact on or off the site. Major detrimental long term impacts on the environment, which could include substantial pollutant discharges.
3	Significant	Significant, unplanned environmental impact contained within the site or minor impact that is off the site.
2	Moderate	Moderate, unplanned localized environmental impact (maybe of a temporary nature) or discharge contained on-site or with negligible off-site impact.
1	Minor	Minor environmental impact. Any impacts are contained on-site and short term in nature. No detrimental effect on the environment.

Modified from Alberto and Muhammad, (2013)

ties. Out of the total number of constructional professionals surveyed, 28 (i.e.27.45%) were having the experience of 15 years and above, 40 (i.e.39.22%) in between 10 years to 14 years and 34 (i.e.33.33%) in between 5 years to 9 years. The acquaintance with environmental risks assessment environmental impact assessment of the respondents were questioned in first part of the survey. The respondent were asked to answer in Likert's scale 1 to 5, and response as received were 11.76%, 17.65%, 46.08%, 13.73% & 10.78% respectively,

The respondents have evaluated the risks on the basis of probability and the impact of occurrence to identify the risks which have the higher probability and the impact of occurrence. The ranking of the degree of risks on the basis of weighted score for probability are shown in Figure 1. It is evident from the analysis that the probability of RS is highest followed by NE, SC, LE, AE, AI, SW, WE and FF as per perception of the respondents.

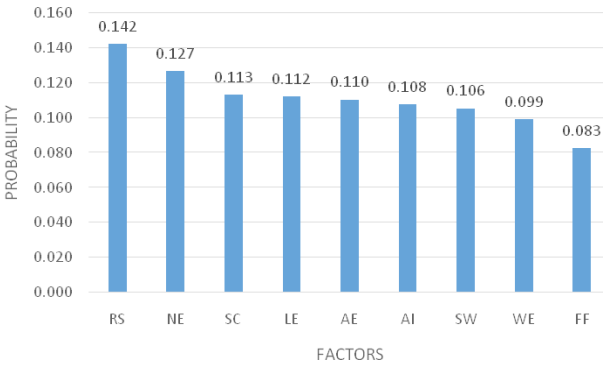

Fig. 1. Ranking of Factors

The ranking of the degree risks on the basis of weighted score for impact on four elements of environment are shown in Figure 2 to 5. The ranking of impact on health is maximum for AE followed by WE, LE, NE, SW, FF, SC, AI and minimum for RS. It is obvious as any ill impact on the air, water, land, noise, solid waste directly influence the health of human being. The ranking of impact on atmosphere is maximum for RS and minimum for WE. The maximum impact on ecology is for NE and minimum for SC. The society is being affected maximum for RS followed AI, SC, NE, LE, SW, AE, WE and minimum for FF.

The average value of impacts for all four elements are taken and considered as overall impact. The ranking of same are shown in Figure 6. The

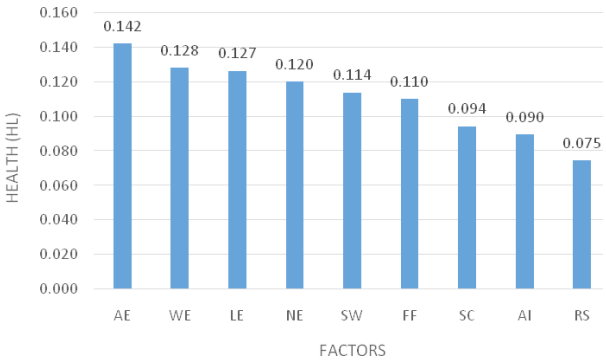

Fig. 2. Ranking of Factors Impact on element Health (HL)

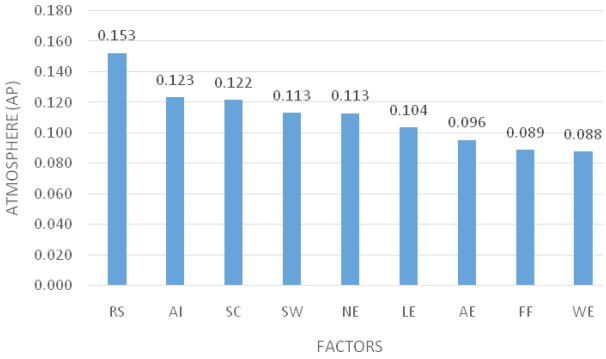

Fig. 3. Ranking of Factors Impact on element Atmosphere (AP)

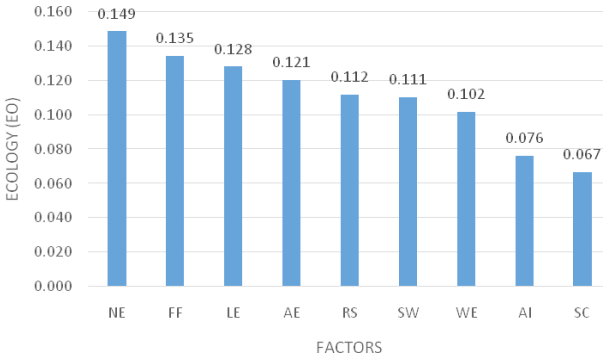

Fig. 4. Ranking of Factors Impact on element Ecology (EO)

overall impact is utmost for RS followed by NE, AI, LE, SC, AE, SW, WE and minimum for FF.

A plot of impact versus probability for all four elements are shown in Figure – 7. The overall impact versus probability is also shown in the same plot. It is obvious from the plot that the overall impact increases linearly with the probability of occurrence. It is evident from the plot that impact on all the four elements are scattered with respect to value of probability but in general they increases with increase in

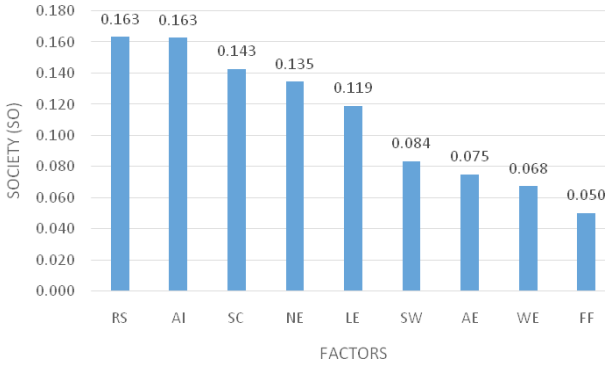

Fig. 5. Ranking of Factors Impact on element Society (SO)

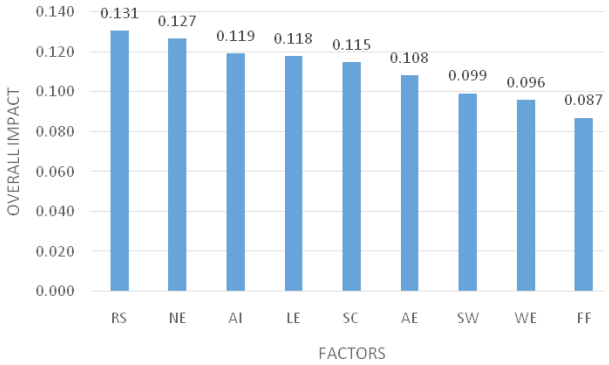

Fig. 6. Ranking of Factors for Overall Impact (Average of all four)

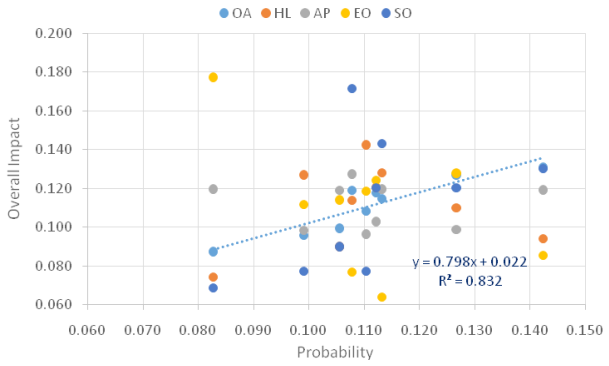

Fig. 7. Impact versus Probability

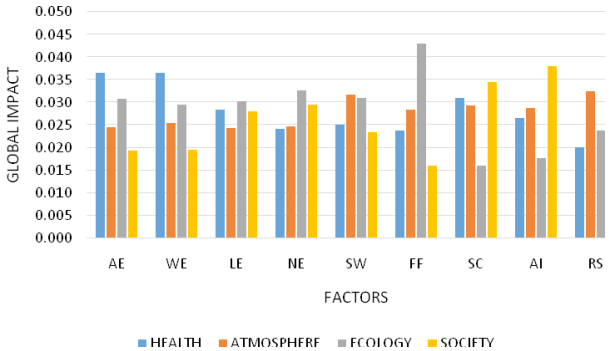

Fig. 8. Weighted Degree of Risk for Factor- Elements [FC(EL)]

probability, except for ecology, which follows reverse trend.

The ranking of weighted degree of risk (R) for factor-element are also calculated and shown in Figure 8. This figure shows the global impact of factor-element.

Conclusion

The degree of risks for the four elements of environment, i.e. HL, AP, EO and SO are obtained for all nine factors, through perceptions of various stake holders of building constructions. The ranking of factors is diversified for different elements, which is according to perception of human being. Interestingly, all the stakeholder showed moderate variation in their risk perceptions. Some of the risks are observed higher impacts with low probability. The health of the human being which is the prominent element of environment is worst affected by ill impact on AE, WE, LE, NE, and SW. The perception about the general atmosphere focus more on human fear psychosis about the depletion of construction material and thus RS is at the top of the ranking followed by AI, SC, SW, NE & LE which are apparent. The impact on ecology is impacted on higher side due to the NE followed by the FF, LE, AE, LE. The RS is leading in rank for the element society due to the reason as mentioned above for general atmosphere, followed by AI, SC, LE, SW, which seems to be logical also. In general it may be concluded that perception of stake holders is precise, about most of the environmental risks of building construction in terms of probabilities and impacts of risk occurrence. These perceived risk and higher cost for ecofriendly materials and equipment, most of the time act as a barrier to adoption of new techniques and technologies. The degree of risk may be considered as an index to rank the various factors affecting the environment due to construction activities, further may be used to find out the measures to reduce the impacts.

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Conflicts of Interest: The authors declare no conflicts of interest.

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