Compilation of a pattern for Environmental Auditing of Roads in Islamic republic of Iran

Dr. Mahmood Ameri
School of civil Engineering
Iran University of science and technology, IUST
& president of transportation research institute, TRI
Tehran, Iran
Ameri@Iust.ac.ir

Fatemeh Zahed
Department of Economics and Sustainable Development
Transportation Research Institute, TRI
Tehran, Iran
Zahed@Rahiran.ir

Abstract— the whole desirable and undesirable, socioeconomic and environmental (short and long term) effects should be identified and considered for construction, maintenance, repair and operation of roads. Environmental auditing and monitoring of under operation projects can identify and quantify undesirable effects and resolve problems by offering rehabilitations and mitigation measures. Suitable physical (Air, climate, water, noise and soil) biological (fauna, flora and habitats) socio-economic and cultural indices and parameters for monitoring and measurement as well as required equipment for measurement and suitable methods for sampling and analysis have been identified to obtain a plan or a pattern for Environmental auditing. Eventually, a plan for environmental auditing is prepared for utilization of stakeholders via designation and compilation of environmental auditing checklists (précis and comprehensive) To determine environmental auditing level, some of possible methods were reviewed by experts and specialists, finally, "Roads" Weighting Methods" has been offered based on existence, numbers and significance of sensitive areas. Determination of environmental auditing schedule and limits, locations of monitoring, flowchart of environmental auditing reports, are the other achievements of the present investigation.

Keywords—Environmental Auditing; Roads; Precise Checklists; Comprehensive Checklists; Iran

I. INTRODUCTION

Roads are one of the main infrastructures in the modern living and an indispensable component in development of countries. The excessive population growth and the expansion of the urban communities in numerous countries have caused the development of various sectors including agriculture and industry. Naturally, roads are the linking component between the above-mentioned sectors. Thus, the short-term and long-term adverse consequences of road construction, repair, maintenance and operation on the economy, society and the environment are to be identified and dealt with.

The most significant characteristics of road transportation are as follows:
- Flexibility in selection of routes and loads
- Less loading frequency
- Continuous control of merchandise during the transportation
- Easy access to production centers
- Availability of transportation vehicles
- Short periods for reaching the destinations
- The expanded road networks in the country
- Lack of adequate railroad network in the country due to the mountainous terrains

Therefore, the environmental auditing and monitoring of operating projects for the identification and quantification of the adverse effects for preparation of subsequent mitigation measures by the pertinent authorities are highly important [1,2].

The environmental auditing of the national roads not only outlines the current environmental status of the roads, but also highlights their environmental benefits. Thus, this subject is of high priority. The major consequences of road environmental auditing are:
- Compliance with the environmental regulations
- Take into account the views of local people residing at the vicinity of the roads
- Improvement of health and safety along the roads
- Reduction of environmental pollutants
- Increase the environmental quality at the vicinity of the roads and protect the nearby biological environments
- Establish a databank in order to compare the changes in the concentration levels of pollutants (short, mid and long-term)
- Timely identification of non-compliance with the environmental standards
- Monitor the effectiveness of the environmental management plans indicated in the EIA
- Emergency response to the accidents causing the spillage of toxic materials into the environment.

II. LITERATURE REVIEW

There is no environmental auditing project conducted for the operating roads in the country. The only case study was on their environmental pollutions. This study indicated the following conclusion:

In some countries, the EMP has more emphasis on the measurement of carbon monoxide as the primary indicator of

air pollution. However, some studies have considered special role for the visual pollution. This type of pollution is studied along with the reduction of noise pollution through the erection of sidewalls along the roads. Moreover in some studies, the environmental auditing of roads is combined with the safety auditing.

The previously conducted studies reveal that the following cases are highlighted in the environmental auditing:

- Regions with endangered species
- National parks and other protected areas
- Habitats of the sensitive species
- Dry and semi-tropic forests
- Regions whose water quality and quantity are highly vital
- Air quality in human communities

Therefore, appropriate factors in the environmental auditing are provided below:

1- Concentration of endangered flora species in the national parks and other protected areas
2- Concentration of endangered fauna species in the national parks and other protected areas
3- Concentration of habitats whose presence is vital for the fauna species
4- Concentration of trees in the dry and semi-tropic forests
5- Measurement of Sox, Nox, CO and HC in populated areas
6- Measurement of pH and EC of soil, especially in the region where salt is used as a defrost
7- Measurement of vanadium or nickel in soil as indicators of fuel contamination
8- Measurement of TPH in surface and underground waters
9- Measurement of pH and Nacl in surface and underground waters in the regions where salt is used as a defrost
10- Measurement of sound level on both sides of the roads where the animal (endangered or sensitive) and/or human communities are present
11- Study land slide caused by the commute of heavy and light vehicles and the ensuing vibrations in the mountainous regions
12- Study the status of historical and religious sites along the roads whose pollution emission could damage them through wet and dry acidity. [3,4,5,6,7]

III. APPROPRIATE INDICATORS FOR THE ENVIRONMENTAL MONITORING OF THE ROADS

The major reasons for the selection of environmental monitoring indicators for the roads are:

1- Reduction of monitoring expenses
2- Linking the indicators with the project activities

3- Establish suitable indicators for the analysis of monitoring and auditing data

The monitoring indicators for the auditing plan in various environments are provided below:

1- Air quality monitoring indicators
   A) CO_2, SO_2, NO_2, O_3 gases
   B) Particulate matters
   C) Climatic parameters (speed and direction of wind, dominant winds, wind-rose, temperature, humidity, evaporation, precipitation, hail, snow, frost, storm, fog etc…, permeability, visibility [2,8].

2- Sound levels monitoring indicators
   A) SPL , Leq, Lmin, Lmax

3- Water quality monitoring indicators
   A) Surface Waters
- pH , Turbidity
- Electrical Conductivity (EC)
- Total Dissolved Solids (TDS)
- Total Suspended Solids (TSS)
- Total Volatile Solids (TVS)
- Dissolved Oxygen (DO)
- Biological Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- SO_4^{2-} , NO_3^- , PO_4^{3-}, Cl^-, Na ,TP ,TPH ,Ammonium , Total coliforms
- Heavy metals (Lead, Cadmium, Mercury, especially Nickel and Vanadium)

   B) Underground Waters
- pH, Electrical Conductivity (EC)
- Chemical Oxygen demand (COD)
- NO_3^- ,Phosphate ,TPH ,Heavy metals (Nickel, Vanadium)

4- Soil quality monitoring indicators
   A) Various types of metals caused by the activities during the operation of roads like nickel, vanadium, mercury, lead, cadmium etc…
   B) Various hydrocarbons caused by traffic and commute of vehicles

In addition to the above-mentioned items, other parameters for the quantitative and qualitative monitoring of soil and the vibration and slippage of land are to be taken into account.

   C) Analysis of chemical parameters like pH, CEC, SO_4^{-2}, organic substances, salinity, electrical conductivity of soil [9].

5- Natural environment monitoring indicators
- Vegetation coverage ,Fauna, wildlife Habitats
6- Socio-economic and cultural environment monitoring indicators

A) Population indicators: number of people, density, gender, migration patterns, family size, traditional model
B) Educational indicators: literacy level, higher education with respect to the population, number of educational centers
C) Settlements: location of the local communities' residence, relocation and resettlement
D) Housing: average size and price of housing
E) Health: health centers
F) Unintentional changes in land use and development
G) Impact on tourism in the region
H) Average rate of employment and unemployment
I) Average income per capita
J) Reconstruction or destruction of cultural heritage
K) Other means of transportation, expenses and the ease of transportation in the region

IV. WEIGHT OF THE MONITORING INDICATORS

For the weighting of the monitoring indicators, a set of questionnaire is used. In this questionnaire, various parameters in the physical, biological, socio-economic and cultural environments are summarized and categorized.
After the identification of the appropriate indicators for the environmental auditing of roads, the questionnaire was prepared based on the road type, climate, water, air etc… Subsequently, the aforesaid questionnaire is completed by experts and after that indicators are weighted with respect to table I.

The results of the questionnaires are presented in the tables indicating the physical, biological, socio-economic and cultural environments. Table I is prepared based on the overall conclusion of the table II.

TABLE I.   WEIGHT OF INDICATORS BASED ON IMPORTANCE

Number	Importance of the Indicator
1	Without Importance
2	Low Importance
3	Medium Importance
4	High Importance
5	Very High Importance

TABLE II.   Importance of Various Environments in Road Auditing

Environment	% of Importance
Physical	30.5
Biological	21.5
Socio-economic	29
Cultural	19

The aforesaid table reveals that the importance of cultural, biological, socio-economic and physical environments is 19%, 21.5%, 29% and 30.5%, respectively.

V. THE ENVIRONMENTAL AUDITING EXECUTIVE PLAN

- *DETERMINE THE LEVEL OF ENVIRONMENTAL AUDITING OF THE ROADS*

Some of the methods for the auditing of the roads were studied by the experts and it was concluded that the weighting system is the best recommended process. Thus, after the preliminary studies of the roads in the country, the road types and the sensitive spots on their paths were identified in order to determine which ones require a detailed environmental auditing.

In reference to the classification of the Ministry of Transportation, for the rural and access roads, a brief environmental auditing checklist is adequate. However, for the highways, expressways and the main roads based on the number of sensitive spots and their importance along the roads, a comprehensive environmental auditing checklist is to be completed.

The weighting method is the best tool to identify the roads that need brief or comprehensive environmental auditing checklists. Therefore, the 12 sensitive spots mentioned in the checklist of environmental monitoring stations on their level of traffic are scored. Then, the number of repeated sensitive spots is multiplied by the score in order to determine the weight of each sensitive spot (Table III). The total score of the sensitive spots is used as their weights in the auditing process.

The mentioned process is presented in the equation below:

$$S = \sum_{i=1}^{12} w_i n_i$$

S = Road score in auditing
w_i = Weight of each sensitive spot along the road (Constant number)
n_i = Number of repeated sensitive spot along the road

For example, if there are 3 permanent population centers, 2 historical sites and 2 protected areas along a highway, its scoring is as follows:

X = 10 (3) + 20 (2) + 20 (2) = 110

If a road contains one of the aforesaid sensitive spots and has the maximum traffic, its S value becomes 190.

Based on the score of 190 for a road with one of the 12 sensitive spots and maximum traffic, any road with the score of less than 50% (less than 95) needs a brief environmental auditing and if the score is more than 50% (more than 95), it required a comprehensive auditing.

TABLE III.   Sensitive spot scores

i	Sensitive Spot (n)	Score (w_i)
1	Stationary Population Spots	10
2	Temporary Population Spots	10
3	Sensitive Ecological Spots Flora/Fauna	20
4	Agricultural Lands	10
5	Historical, Archeological and Religious Sites	20
6	Water Resources	20
7	Bio-reserves	20
8*	Road-Construction and Operation Borrow Materials Depot	10
9	Fuel Stations	10
10	Industrial Complexes	10
11	Runoffs along the Road	10
12	The Protected Areas	20
13	Level of Traffic	20**

* This is important in areas, which are resulted in any type of pollution

** The score of 20 is for the roads with the heavy traffic. The lower scores would be given accordingly

Based on the expert views, the roads with the heaviest traffic would be given the score of 20 and the other roads according to the available statistical reports would be similarly scored.

Note: For the rural roads, access roads, highways and main roads, which require brief environmental auditing, it is important to point out that presence of international wetlands, protected areas and ecologically important areas imposes an especial condition. They have to conduct a comprehensive environmental auditing based on the result of the brief auditing checklists.

VI. THE SCOPE OF ENVIRONMENTAL AUDITING OF THE ROADS

Based on the road type, ambient conditions and the presence of sensitive areas along the road, different limitations would be imposed on the environmental auditing of the roads. Thus, the freeways and expressways should have a margin of 500 meters from each side for the water and soil pollutants and a margin of one kilometer for air and noise pollutants. For the main roads, these margins are 250 meters and 500 meters from each side, respectively. Also for the access roads and rural roads, a margin of 150 meters on each side would suffice.

The sensitive areas like the residential areas and industrial complexes, the protected areas and ecologically important spots within the 3-kilometer radius of the roads require an auditing plan.

Although some of the impacts like the emission of air pollutants and noise pollution could occur outside the mentioned limits, the probable impacts of traffic usually take place within the stated margins. Moreover, the studied roads are outside the city limits and the traffic within the municipal jurisdictions can not be included in the study.

The scheduled measurement of the various environmental parameters in road traffic has to provide accurate and adequate data and information for the identification of activities along the roads. Table IV presents the location of the monitoring measurements.

TABLE IV. Recommended Locations for the Environmental Auditing of Roads

#	Affected Environment	Recommended Measurement Sites
1	Surface Waters	- Shopping malls along the roads that are at the vicinity of a river - Cross-section of river with the road - The sites where the runoffs caused by rainfall along the roads are directed toward the rivers - Lakes and wetlands at the vicinity of the roads - Fuel stations with potential to contaminate surface waters
2	Underground Waters	- Near the lodging facilities along the road - Agricultural lands
3	Sewage	- Sewage of the lodging facilities along the roads - Sewage of industries and workshops along the roads
4	Noise	- Quartet of the protected areas - Residential areas at the vicinity of the roads - Lodging complexes along the roads - Habitats of fauna - Industrial complexes along the roads
5	Air Quality	- Agricultural lands along the roads - Industrial complexes along the roads - Lodging facilities along the roads - Fuel stations - Residential areas along the roads - Quartet of the protected areas - Habitats of fauna
6	Soil	- Residential areas along the roads - Industrial complexes along the roads - Quartet of the protected areas - Habitats of fauna - Agricultural lands along the roads
7	Socio-economic & Cultural Environment	- Inspection of roads for the identification of land use alterations - Residential areas along the roads
8	Vegetation Coverage	- Inspection of the roads for the destruction of the nearby vegetation coverage
9	Fauna Species	- Inspection roads for the sensitive spots used as the crossing of fauna and preparation of animal mortality data caused by accidents

VII. AUDITING CHECKLIST USED IN THIS STUDY

Based On figure 1 the checklists are prepared for two types of environmental auditing and the information required for each level of auditing differs from the other. So first and

foremost, the auditing group has to determine the environmental auditing level. The auditing level is identified based on the objective of auditing, road type, presence of sensitive spots and environmentally important areas. Then, the necessary parameters for environmental monitoring are selected. Subsequently, the proper equipment for the monitoring of the selected parameters is determined. It is preferable to have easy to use equipment with adequate precision. The approval of the pertinent authority for the implementation of the road environmental auditing is required. Afterwards, the auditing group and all the necessary equipment are to be prepared for dispatch. Based on the location of the protected areas managed by the Department of the Environment, the water resources, bio-reserves and the populated areas, the sites and time of sampling stations are determined.

Upon the sampling, monitoring and completion of the checklists, the forms are to be approved and signed by the environmental auditing group leader and to be sent to the highest pertinent authority.
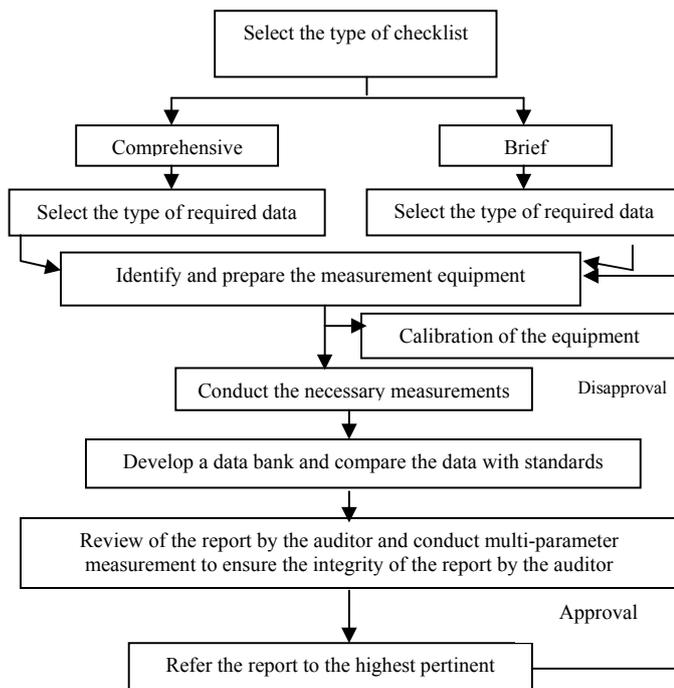

Figure 1. Flow Diagram of the Road Auditing Implementation Plan

VIII. RECOMMENDATIONS

In order to cover the financial expenses of auditing, the followings are recommended:
-   Conduct an expert review of the expenses, budgets and credits involved in road auditing plans and also determine the revenues from the road tolls. If the aforesaid budget is not adequate, the road tolls could be increased to provide the necessary credits for the auditing process
-   Allocate certain budget for road auditing by the organizations responsible for the control of polluting sources along the roads

After auditing and identification of non-compliance, a viable legal instrument is required to follow up and ensure pollution reduction. For example, the Department of the Environment has identified the polluting industries. It could apply legal means to force the polluter in conducting mitigation measures or face possible closure of the factory. Also, the expert committee supervising the environmental aspects of roads in the country could be given legal authority to act upon the auditing results and pressure the polluters to take steps in reducing their emissions and discharges.

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