Initial Environmental Examination

May 2017

BAN: South Asia Subregional Economic Cooperation Dhaka – Northwest Corridor Road Project, Phase 2

Hatikamrul - Rangpur Road

Appendices A-G (Part 2 of 3)

Prepared by Roads and Highways Department, Government of Bangladesh for the Asian Development Bank.

APPENDIX A: TERMS OF REFERENCE FOR ENVIRONMENTAL IMPACT ASSESSMENT OF ROAD DEVELOPMENT PROJECTS UNDER SUBREGIONAL TRANSPORT PROJECT (SRTP)

A. Background

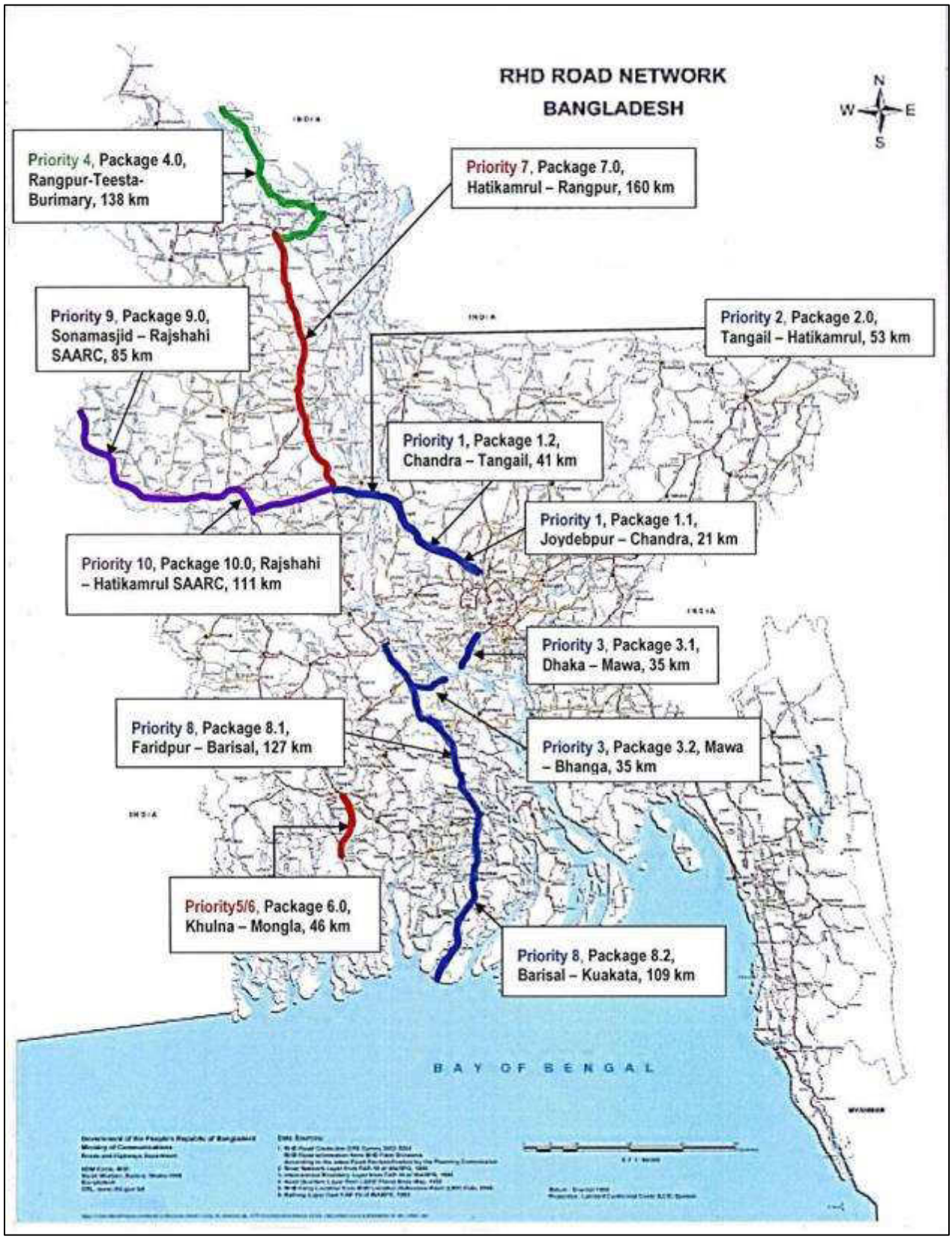
1. The Government of Bangladesh (GoB) has received a loan from Asian Development Bank (ADB) for the Subregional Transport Project Preparatory Facility under Technical Assistance for Subregional Road Transport Project Preparatory Facility (ADB Loan 2688-BAN). GoB has resolved to apply a portion of the loan to meet the expenditure for consultancy services to be rendered by international consultants to prepare (a) feasibility studies and (b) detailed engineering designs for upgrading selected national highways and zilla roads from 2-lanes to 4-lanes to promote subregional development. The Ministry of Communications (MOC) is the Executing Agency and Roads and Highways Department (RHD) is the Implementation Agency.

2. The environmental impact assessment (EIA) process will be based on current information, including an accurate project description, and appropriate environmental and social baseline data. In the environmental assessment, Roads and Highways Department (RHD) as the project proponent will consider all potential impacts and risks of the road development works on physical, biological, socioeconomic (occupational health and safety, community health and safety, vulnerable groups and gender issues, and impacts on livelihoods and physical cultural resources) in an integrated way. This TOR is prepared to carryout detailed EIA study for the 'Subregional Transport Project Preparatory Facility' in accordance with the relevant laws and regulations in Bangladesh and the Asian Development Bank's Safeguard Policy Statement, 2009. The study will be carried out by the design consultant during 2012-2014 and the EIA report will be submitted along with the EMP to DOE and ADB for approval.

3. As part of the EIA the project proponent will prepare an environmental management plan (EMP) that addresses the potential impacts and risks identified by the environmental assessment. The EMP will include the proposed mitigation measures, environmental monitoring and reporting requirements, emergency response procedures, related institutional or organizational arrangements, capacity development and training measures, implementation schedule, cost estimates, and performance indicators. Where impacts and risks cannot be avoided or prevented, mitigation measures and actions will be identified so that the project is designed, constructed, and operated in compliance with applicable laws and regulations and meets the requirements specified in this document.

B. Project Location

4. The road development project under SRTP covers a vast area of Bangladesh. The length of the roads of this project is 961km and located in South-central to Southern, South-Western, North-Western, and Northern parts of Bangladesh. The road alignment crosses a total of 21 districts and 2 major rivers, Jamuna and Padma. The districts it will cross are Khulna, Bagerhat, Borguna, Patuakhali, Jhalokathi, Barisal, Madaripur, Gopalganj, Faridpur, Munshiganj, Dhaka, Gazipur, Tangail, Sirajganj, Natore, Rajshahi, Nawabganj, Bogra, Gaibandha, Rangpur and Lalmonirhat. The project location Map with priority details is shown in Figure 1.


RHD ROAD NETWORK
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W
E
S
Priority 4, Package 4.0, Rangpur-Teesta-Burimary, 138 km
Priority 7, Package 7.0, Hatikamrul – Rangpur, 160 km
Priority 9, Package 9.0, Sonamasjid – Rajshahi SAARC, 85 km
Priority 2, Package 2.0, Tangail – Hatikamrul, 53 km
Priority 1, Package 1.2, Chandra – Tangail, 41 km
Priority 1, Package 1.1, Joydebpur – Chandra, 21 km
Priority 10, Package 10.0, Rajshahi – Hatikamrul SAARC, 111 km
Priority 3, Package 3.1, Dhaka – Mawa, 35 km
Priority 8, Package 8.1, Faridpur – Barisal, 127 km
Priority 3, Package 3.2, Mawa – Bhanga, 35 km
Priority5/6, Package 6.0, Khulna – Mongla, 46 km
Priority 8, Package 8.2, Barisal – Kuakata, 109 km
BAY OF BENGAL

C. Project Components

5. The SRTP consists of the following roads are being considered for upgrading:

(i) Design Package No. 1 – Joydevpur-Chandra-Tangail road section in N4 and N405 (70km)
(ii) Design Package No. 2 – Tangail-Hatikamrul (40km)
(iii) Design Package No. 3 – Dhaka-Mawa-Bhanga road section in N8 (70km)
(iv) Design Package No. 4 – Upgrading of Rangpur-Teesta-Burimari Road into 4-lane highway (138km)
(v) Design Package No. 5 – Construction of a bridge over the river Mongla at Mongla on Khulna-Mongla Road
(vi) Design Package No. 6 – Upgrading of Khulna-Mongla Road into 4-lane highway with link to Dhigraj to Mongla Ferry Ghat (46km)
(vii) Design Package No. 7 – Upgrading of Hatikamrul-Rangpur National Highway into 4-lane highway (160km)
(viii) Design Package No. 8 – Faridpur-Barisal-Kuakata road section in N8 (236km)
(ix) Design Package No. 9 – Upgrading of Sonamasjid-Rajshahi Road into 4 lane highway (Asian Highway, SAARC Corridor: Regional Corridors identified in SAARC Regional Multimodal Transport Study) (85km)
(x) Design Package No. 10 – Rajshahi-Hatikamrul Road into 4 lane highway (Asian Highway, SAARC Corridor: Regional Corridors identified in SAARC Regional Multimodal Transport Study) (111km)

6. As some of the packages consist of upgrading different sections of the same road, these sections would be considered together in a single EIA but with separate Environmental Management Plans for each package.

D. Objectives

7. The main objective of the EIA study is to assess both positive and negative environmental impacts due to each project activities. Assess the impacts and recommend appropriate mitigation measures during preconstruction, construction, and operation phases to minimize negative impacts of the project to acceptable levels. Prepare ten (10) EIA including EMP for SRTP in compliance with the Government and ADB requirements and obtain Environmental Clearance Certificate (ECC) from the Department of Environment, Bangladesh.

E. Scope of Work

1. Baseline Studies

a. Legal and Administrative Procedure

- Collection and review of relevant information regarding environmental legislation, statutory orders, by-laws, etc. connected to preparation and approval of the EIA report by the Department of Environment, and draft the memo. The memo will also consider the requirements of ADB Guidelines.
- Conduction of meetings with the Department of Environment, the Ministry of Environment and Forest (MoEF), and the Roads and Highways Department (RHD). During these meetings appropriate legal and administrative procedures

has been discussed. Review of other relevant environmental laws, regulations, Norms, and Standards on Air, Noise, Vibration, Water, Waste, and Wildlife.

- Conduction of discussion meeting with the Department of Environment particularly for "Environmental Clearance Certificate" in accordance with the Environment Conservation Act, 1995 and Bangladesh Environment Conservation Rules, 1997.

b. Stakeholder Consultation

8. Conduction of Stakeholder Group meetings to ensure relevance of the project to the interests of the people of the project area and hence sustainability of the project; and to seek views and suggestions toward identifying important environmental components (IECs) for environmental assessment and ascertain their degree and ranking. The proposed Stakeholder Group meeting will also help determine potential social, economic and cultural impacts due to the project. Targeted Stakeholder Group is to comprise members of the civil society, professional groups, etc. To provide local communities and socio-economic interest groups with the foundation for their role in detailed design project interventions and, hence, participation in project planning, implementation, operation and maintenance.

c. Preparation of Baseline Assessment

9. Review of reports and secondary data collected from the project's feasibility study. Feasibility study and the study conducted by the RHD as well as the studies on similar projects carried out under ADB funding.

10. Collection of general baseline information on existing environmental condition in the project influence area and environmental quality baseline monitoring along the project corridor and identification of the environmental components that need detailed study. Baseline assessment will be done based on the available secondary information, field visits, sampling and environmental monitoring including but not limited to the following:

(i) Physical Resources:

- Topography, climate, soils, geology, land use, aquatic resources, and surface and groundwater resources.

(ii) Environmental Risks:

- Cyclones, tornadoes, droughts, floods, earthquakes, road accidents, etc.

(iii) Ecological Resources:

- Landscape and natural ecosystem, flora and fauna, wildlife and wetland habitats, and protected areas.

(iv) Environmental Quality:

- Air (SPM, PM_{10}, CO, CO_2, NOx, SOx, O_3 etc.): Air samples should be collected from the existing road alignment to identify the baseline and air quality in the project area.
- Noise quality: Noise level should be measured along the highway roads during day and night times to identify the baseline and present noise level in the project area.
- Groundwater quality (pH, Mn, Fe, As, Total hardness as CaCO3, Coliforms, Chlorine as Cl-): Samples should be tested for baseline setup and identifying the present status of groundwater for drinking purpose.
- Surface Water Quality (pH, BOD, Chlorine as Cl-, COD, TDS, TSS, DO, EC, Fe): Samples should be tested for baseline setup and identifying the quality of the surface water.

- River-bed dredged materials: (Zn, Cu, Hg, Pb, Cd, and As): Samples should be collected from the dredged sites at a reasonable depth. Samples should be tested for identifying the baseline chemical properties of the dredged materials and the suitability of the material to be used for road embankment, and service area, etc.

(v) Cultural Resources Sites:

- Structures or sites those are of historical, religious, or architectural significance.

2. Detailed Field Investigation to Screen Environmental Impacts

a. Field Investigation and Analysis of Results

11. Collection of cadastral maps showing the project locations and descriptions of the surrounding activities. This is to ensure that the project is compatible with the national regulation specified for construction sites.

12. Initiation of necessary investigations and fieldwork for gathering of additional information on ecological and environmental baseline parameters of the Important Environmental Components (IECs) selected during the previous studies in the project area.

(i) Physical Environment
- Regional Hydrology and Flood Pattern,
- Drainage Congestion,
- River Erosion and Siltation, and
- Landuse

(ii) Ecological Environment
- Agriculture,
- Tree Plantation/Felling,
- Water bodies and Fisheries, and
- Wildlife

(iii) Environmental Pollution
- Surface and Ground Water Quality,
- Air Pollution,
- Noise and Vibration,
- Soil Contamination including dredged spoil, and
- Pollution due to Waste

(iv) Social Environment
- Land Acquisition,
- Homestead,
- Irrigation and Agricultural Production,
- Cultural Resources Loss,
- Navigation/Water Transport,
- Health and Safety,
- Employment Opportunities,
- Women Empowerment,
- Infrastructure and Industry,
- Split of Communities,
- Road Transport,
- Road Accident, and
- Tourism.

3. Anticipated Environmental Impacts and Mitigation Measures

13. This section will predict and assess the project's likely positive and negative direct and indirect impacts on physical, biological, socioeconomic (including occupational health and safety, community health and safety, vulnerable groups and gender issues, and impacts on livelihoods, and physical cultural resources) environment in the project's area of influence, in quantitative terms as far as possible; identify mitigation measures and any residual negative impacts that cannot be mitigated; explore opportunities for enhancement; identify and estimate the extent and quality of available data, key data gaps, and uncertainties associated with predictions and specifies topics; and examine transboundary, and cumulative impacts as appropriate.

4. Environmental Management Plan

14. In this section RHD will incorporate the set of mitigation and management measures to be adopted during project implementation to avoid, reduce, mitigate, or compensate for adverse environmental impacts (in that order of priority). It may include multiple management plans, sub plans and actions. It will include the following key components:

(i) Mitigation: Under mitigation the EMP will:
   (a) identify and summarize anticipated significant adverse environmental impacts and risks;
   (b) describe each mitigation measure with technical details, including the type of impact to which it relates and the conditions under which it is required (for instance, continuously or in the event of contingencies), together with designs, equipment descriptions, and operating procedures, as appropriate; and
   (c) provide links to any other mitigation plans (for example, for involuntary resettlement) required for the project.

(ii) Monitoring: Under monitoring the EMP will:
   (a) describe monitoring measures with technical details, including parameters to be measured, methods to be used, sampling locations frequency of measurements, detection limits and definition of thresholds that will signal the need for corrective actions; and
   (b) describe monitoring and reporting procedures to ensure early detection of conditions that necessitate particular mitigation measures and document the progress and results of mitigation.

(iii) Implementation arrangements: Under the implementation arrangements the EMP will:
   (a) specify the implementation schedule showing phasing and coordination with overall project implementation;
   (b) describe institutional or organizational arrangements, namely, who is responsible for carrying out the mitigation and monitoring measures, which may include one or more of the following additional topics to strengthen environmental management capability: technical assistance programs, training programs, procurement of equipment and supplies related to environmental management and monitoring, and organizational changes; and
   (c) estimate capital and recurrent costs and describe sources of funds for implementing the environmental management plan.

(iv) Performance indicators: Here the desired outcomes as measurable events will be described to the extent possible, such as performance indicators, targets, or acceptance criteria that can be tracked over defined time periods.

5. Institutional Arrangement, Capacity building and Grievance Redress Mechanism

15. Assessment of institutional capacity of the implementing agencies for effective implementation of environmental management and monitoring plan. Identification of responsible institutes for implementation and supervision of the Environmental management and monitoring plan (EMMP). Assess training needs of these agencies and propose capacity building measures and institutional arrangements to strengthen these agencies along with the cost estimates.

16. In this section RHD will describe the grievance redress framework (both informal and formal channels), prepared for the road development projects, setting out the time frame and mechanisms for resolving complaints about environmental performance.

6. Information Disclosure, Consultation, and Participation

17. This section will:

(i) describe the process undertaken during project design and preparation for engaging stakeholders, including information disclosure and consultation with affected people and other stakeholders;
(ii) summarize comments and concerns received from affected people and other stakeholders and how these comments have been addressed in project design and mitigation measures, with special attention paid to the needs and concerns of vulnerable groups, including women, the poor, and Indigenous Peoples; and
(iii) describe the planned information disclosure measures (including the type of information to be disseminated and the method of dissemination) and the process for carrying out consultation with affected people and facilitating their participation during project implementation.

7. Conclusion and Recommendation

18. This section will provide the conclusions drawn from the assessment and present the recommendations.

F. EIA Study Team

19. The EIA team has been included in the following team:

1. National Environmental Specailist-1	08 months
2. National Environmental Specailist-2	12 months
3. Junior Environmental Specialist-1	17 months
4. Junior Environmental Specialist-2	07 months

20. RHD will be responsible to coordinate with the Consultant to carry out the EIA study along with EMP in accordance with environmental guidelines of ADB and GOB within the project stipulated time schedule. The Environment and Social Circle of RHD will monitor the EIA and

EMP activities on a regular basis and review all environmental reports prepared by the Environmental Team of the Consultant.

G. Work Program and Personal Schedule

21. The duration of the preparation of the 10 EIA including EMP will be about 18 months. The work program and personnel schedule is provided in Annex-1.

H. EIA Report Structure

22. The EIA report will be prepared following the DOE guidelines and ADB safeguard policy statement 2009. The EIA reports prepared by RHD will contain the following Chapters:

Executive Summary
1. Introduction
2. Policy, Legal and Administrative Framework
3. Description of the Project
4. Description of the Environment (Baseline Data)
5. Anticipated Environmental Impacts and Mitigation Measures
6. Environmental Management Plan
7. Institutional Arrangement, Capacity Building and Grievance Redress Mechanism
8. Information Disclosure, Consultation and Participation
9. Conclusions and Recommendations

APPENDIX B: DOE APPROVAL OF THE TOR

Government of the People's Republic of Bangladesh
Department of Environment
www.doe-bd.org
Head Office, Paribesh Bhaban
E-16 Agargaon, Dhaka-1207

Memo No: DoE/Clearance/5195/2013/ 114 Date: 30 May, 2013

Subject: Approval of Terms of Reference for Environmental Impact Assessment (EIA) in favour of Sub-Regional Road Transport Project (Road Component Package-1).

Ref: Your application received on 04 March 2013.

With reference to your letter dated 04.03.2012 for the subject mentioned above, the Department of Environment hereby gives approval of TOR for Environmental Impact Assessment (EIA) in favour of Sub-Regional Road Transport Project (Road Component Package-1) subject to fulfilling the following terms and conditions.

1. Roads and Highways Department (RHD) shall conduct a comprehensive Environmental Impact Assessment (EIA) study considering the overall activity of each component under package-1 of the said Project in accordance with the TOR submitted to the DOE and additional suggestions provided herein.
2. The EIA report should be prepared in accordance with following indicative outlines:

   1. Executive summary
   2. Introduction: (Background, brief description, scope of study, methodology, limitation, EIA team, references)
   3. Legislative, regulation and policy consideration (covering the potential legal, administrative, planning and policy framework within which the EIA will be prepared)

   4a. Project activities: A list of the main project activities to be undertaken during site clearing, construction as well as operation.

   4b. Project schedule: The phase and timing for development of the PMBP

   4c. Resources and utilities demand: Resources required to develop the project, such as soil and construction material and demand for utilities (water, electricity, sewerage, waste disposal and others), as well as infrastructure (road, drains, and others) to support the project.

   4d. Map and survey information
   Location map, Cadastral map showing land plots (project and adjacent area), Geological map showing geological units, fault zone, and other natural features.

5. Baseline Environmental Condition should include, inter alia, following:
   - Physical Environment : Geology, Topology, Geomorphology, Soils, Meteorology, and Hydrology.
   - Biological Environment : Habitats, Aquatic life and fisheries, Terrestrial Habitats and Flora and Fauna
   - Environment Quality : Air, Water, Soil and Sediment Quality.
6. Socio-economic environment should include, inter alia, following:
   - Population: Demographic profile and ethnic composition
   - Settlement and housing
   - Traffic and transport
   - Public utilities: water supply, sanitation and solid waste
   - Economy and employment: employment structure and cultural issues in employment
   - Fisheries: fishing activities, fishing communities, commercial important species, fishing resources, commercial factors.

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7. Identification, Prediction and Evaluation of Potential Impacts (identification, prediction and assessment of positive and negative impacts likely to result from the proposed project).

   In identification and analysis of potential impacts'-the 'Analysis' part shall include the analysis of relevant spatial and non-spatial data. The outcome of the analysis shall be presented with the scenarios, maps, graphics etc. for the cases of anticipated impacts on baseline. Description of the impacts of the project on air, water, land, hydrology, vegetation-man maid or natural, wildlife, socio-economic aspect shall be incorporated in detail.

8. Management Plan/Procedures:

   For each significant major impact, proposed mitigation measures will be set out for incorporation into project design or procedures, impacts, which are not capable of mitigation, will be identified as residual impacts Both technical and financial plans shall be incorporated for proposed mitigation measures..
   An outline of the Environmental Management Plan shall be developed for the project.
   In Environmental Monitoring Plan, a detail technical and financial proposal shall be included for developing an in-house environmental monitoring system to be operated by the proponent's own resources (equipments and expertise).

9. Consultation with Stakeholders/Public Consultation (ensures that consultation with interested parties and the general public will take place and their views taken into account in the planning and execution of the project)

   Beneficial Impacts (summarize the benefits of the project to the Bangladesh nation, people and local community and the enhancement potentials)

10. Conclusion and Recommendations

3. Without approval of EIA report by the Department of Environment, Roads and Highways Department (RHD) shall not be able to open L/C in favor of importable machineries.
4. Without obtaining Environmental Clearance, Roads and Highways Department (RHD) shall not start operation of each component under package-1 of this project.
5. Roads and Highways Department (RHD) shall submit the EIA along with a filled-in application for Environmental Clearance in prescribed form, the applicable fee in a treasury chalan, the no objection certificates (NOCs) from the local authority, NOC from forest department (if it is required in case of cutting any forested plant/trees-private or public), NOC in favor of Cutting/Dressing (if it is required) of Hill/Hillock from the concerned authority and NOC from other relevant agencies for operational activity etc. for each component under package-1 of this project to the concerned Divisional office of DOE with a copy to the Head office of DOE in Dhaka.
6.

30.05.2013

(Syed Nazmul Ahsan)
Deputy Director (Environmental Clearance)
and
Member Secretary
Environmental Clearance Committee

Mr. Dilip Kumar Guha
Project Director & Additional Chief Engineer
Roads & Highways Department (RHD)
Technical Assistance for Subregional Road Transportation Project Preparatory Facility
132/4, New Baily Road, Dhaka.

Copy Forwarded to :

1) PS to Secretary, Ministry of Environment and Forest, Bangladesh Secretariat, Dhaka.
2) Director, Department of Environment, Khulna/Barisal Divisional Office, Khulna/Barisal.
3) Assistant Director, Office of the Director General, Department of Environment, Head Office, Dhaka.

APPENDIX C: RAPID ENVIRONMENTAL ASSESSMENT (REA) CHECKLIST

Instructions:

(i) The project team completes this checklist to support the environmental classification of a project. It is to be attached to the environmental categorization form and submitted to the Environment and Safeguards Division (RSES), for endorsement by Director, RSES and for approval by the Chief Compliance Officer.

(ii) This checklist focuses on environmental issues and concerns. To ensure that social dimensions are adequately considered, refer also to ADB's (a) checklists on involuntary resettlement and Indigenous Peoples; (b) poverty reduction handbook; (c) staff guide to consultation and participation; and (d) gender checklists.

(iii) Answer the questions assuming the "without mitigation" case. The purpose is to identify potential impacts. Use the "remarks" section to discuss any anticipated mitigation measures.

Country/Project Title: Bangladesh: SASEC-Dhaka Northwest Corridor Road Project, Phase 2

Sector Division: South Asia Transport and Communication Division

Screening Questions	Yes	No	Remarks
A. Project Siting Is the project area adjacent to or within any of the following environmentally sensitive areas?			
▪ Cultural heritage site		✓	The road passes through many villages and towns and few community resources like temple, mosque and graveyards are located near the roads. Some of these cultural sites will be directly affected because of the widening of the existing road.
▪ Protected Area		✓	There are no protected areas in or within 10km of the project area that might me directly affected because of the project.
▪ Wetland	✓		There are small ponds, beels and Khals link to certain rivers. However none of them are protected or rich in biodiversity.
▪ Mangrove		✓	None
▪ Estuarine		✓	None
▪ Buffer zone of protected area		✓	None
▪ Special area for protecting biodiversity		✓	None
B. Potential Environmental Impacts Will the Project cause…			

Screening Questions	Yes	No	Remarks
▪ Encroachment on historical/cultural areas; disfiguration of landscape by road embankments, cuts, fills, and quarries?	✓		No encroachment on historical but some cultural areas are envisaged. The topography of project road is mainly flat. However, minor impacts on landscape are unavoidable due to increase in elevation and widening of road embankment and side roads for slow moving vehicles.
▪ Encroachment on precious ecology (e.g. sensitive or protected areas)?		✓	The project road does not pass through any National Park/Wildlife Sanctuary.
▪ Alteration of surface water hydrology of waterways crossed by roads, resulting in increased sediment in streams affected by increased soil erosion at construction site?	✓		There are significant numbers of bridges with the existing road and those bridges will be reconstructed. The bridge construction may temporally increase the sedimentation level in the river around bridge construction site. However this would be temporary and short term in nature. All measures shall be taken during construction stage so that watercourses are not affected and temporary soil and rock stockpiles will be designed so that runoff will not induce sedimentation of waterways.
▪ Deterioration of surface water quality due to silt runoff and sanitary wastes from worker-based camps and chemicals used in construction?	✓		Suitable siltation prevention measures such as silt fencing is included in the EMP. Adequate measures for sanitary and construction related waste such as chemicals shall be taken to prevent contaminating local water resources.
▪ Increased local air pollution due to rock crushing, cutting and filling works, and chemicals from asphalt processing?	✓		Local air pollution level is likely to be increased for short duration during construction period particularly due to earth work. Appropriate distance from settlement area and wind direction will be taken into account to locate air polluting facility like stone crushing unit etc. if required.
▪ Risks and vulnerabilities related to occupational health and safety due to physical, chemical, biological, and radiological hazards during project construction and operation during project construction and operation?	✓		Construction activities could cause accidents and health risks to workers. Occupational health and safety measures will be mandatory for the contractor.

Screening Questions	Yes	No	Remarks
▪ Noise and vibration due to blasting and other civil works?	✓		Ambient noise level is expected to increase in the range of 80-90 dB(A) due to various construction activities, maintenance workshops, and earthmoving equipment for short durations. The impact due to noise during construction activities will be minimal to inhabitants since most of the built-up areas are located at safe distances from the road. However, there are few noise sensitive locations especially schools, mosque, shrine etc. close to the alignment that will be affected adversely. Impact due to noise to the workers and local community will be avoided/minimized through mitigation measures such as occupation health and safety gear, restriction of construction timing and others.
▪ Dislocation or involuntary resettlement of people?		✓	There will be minimal resettlement impacts. Further details are provided in the Resettlement Plan.
▪ Dislocation and compulsory resettlement of people living in right-of-way?		✓	
▪ Disproportionate impacts on the poor, women and children, Indigenous Peoples or other vulnerable groups?		✓	
▪ Other social concerns relating to inconveniences in living conditions in the project areas that may trigger cases of upper respiratory problems and stress?		✓	No major impacts anticipated. However, efforts will be made to minimize air pollution through appropriate measures such was wet spraying, covering of trucks, location of hot mix plants and other stationary equipment's away from settlement areas and others.
▪ Hazardous driving conditions where construction interferes with pre-existing roads?	✓		Proper safety measures such as barricades, flagman, sign boards etc. will be placed to prevent accidents.
▪ Poor sanitation and solid waste disposal in construction camps and work sites, and possible transmission of communicable diseases (such as STI's and HIV/AIDS) from workers to local populations?	✓		Appropriate waste management shall be adopted in construction camps. Worker health checks and awareness rising will be implemented to educate workers on communicable diseases.
▪ Creation of temporary breeding habitats for diseases such as those transmitted by mosquitoes and rodents?	✓		Breeding habitats maybe created in labour camps, garbage disposal sites borrow pits and material storage yards. Appropriate sanitation requirements in labour camps and avoidance of stagnant water included in the EMP.

Screening Questions	Yes	No	Remarks
▪ Accident risks associated with increased vehicular traffic, leading to accidental spills of toxic materials?	✓		Temporarily during construction Stage. Adequate measures will be provided to prevent them such as speed reduction, provision of crash barrier and proper traffic signage system at sensitive places will ensure smooth traffic flow which will reduce accidental risk
▪ Increased noise and air pollution resulting from traffic volume?	✓		Due to improvement in road riding conditions the net effect on noise and air pollution will be negligible. However, the number of traffic will increase and the pollution will also increase consistently.
▪ Increased risk of water pollution from oil, grease and fuel spills, and other materials from vehicles using the road?		✓	EMP recommendations are designed to mitigate water pollution due to construction related activities.
▪ Social conflicts if workers from other regions or countries are hired?		✓	EMP suggests to hire most workers from the local area and to ensure gender equality.
▪ Large population influx during project construction and operation that causes increased burden on social infrastructure and services (such as water supply and sanitation systems)?		✓	Most workers will be hired locally, hence this is not anticipated.
▪ Risks to community health and safety due to the transport, storage, and use and/or disposal of materials such as explosives, fuel and other chemicals during construction and operation?	✓		Transport, storage, use and disposal of fuel and chemicals will be required. Appropriate safety, storage and disposal measures recommended in the EMP.
▪ Community safety risks due to both accidental and natural causes, especially where the structural elements or components of the project are accessible to members of the affected community or where their failure could result in injury to the community throughout project construction, operation and decommissioning.	✓		Safety and injury related risks will arise from the presence of equipment's and construction activities. Clear demarcation of restricted areas and prevention of open access to construction areas is included in the EMP.

Climate Change and Disaster Risk Questions The following questions are not for environmental categorization. They are included in this checklist to help identify potential climate and disaster risks.	**Yes**	**No**	**REMARKS**
• Is the Project area subject to hazards such as earthquakes, floods, landslides, tropical cyclone winds, storm surges, tsunami or volcanic eruptions and climate changes	✓		As in most parts of Bangladesh, parts of the project road face problems of flooding. Required design measures for adapting to future flooding events the result of climate change have been recommended to this EIA as well.

▪ Could changes in temperature, precipitation, or extreme events patterns over the Project lifespan affect technical or financial sustainability (eg., increased erosion or landslides could increase maintenance costs, permafrost melting or increased soil moisture content could affect sub-grade).		✓	With the incorporation of recommendations from the climate change it is expected that the road will be able to withstand with future changes of various climatic parameters.
▪ Are there any demographic or socio-economic aspects of the Project area that are already vulnerable (eg., high incidence of marginalized populations, rural-urban migrants, illegal settlements, ethnic minorities, women or children)?		✓	There is no potential impact identified in the project area yet.
▪ Could the Project potentially increase the climate or disaster vulnerability of the surrounding area (e.g., by encouraging settlement in areas that will be more affected by floods in the future, or encouraging settlement in earthquake zones)?		✓	The project will significantly reduce the GHG emissions due to better road condition.

Note: Hazards are potentially damaging physical events.

APPENDIX D: SURFACE WATER QUALITY TEST RESULTS

জীবনের জন্য বিজ্ঞান "শেখ হাসিনার দর্শন, সব মানুষের উন্নয়ন"

বাংলাদেশ বিজ্ঞান ও শিল্প গবেষণা পরিষদ (বিসিএসআইআর)

BANGLADESH COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH (BCSIR)

Laboratories / Institute / Center: BCSIR Laboratories, Dhaka

ANALYSIS REPORT

ASC Ref No. : D-112, Date : 20-03-2017

Unit (Lab/Inst.) Ref. No. : 112, Date : 21-03-2017

Lab / Sample ID : SE - 535

Number of Sample : 17

Sample Description: Test of different parameters in supplied surface water samples (as supplied).

Test Commencement Date : 21/03/2017

Client's Details : Md. Shafiqul Islam, Jr. Environmental Specialist, Environment and Resource Analysis Center Ltd., 464/C (Ground Floor), Khilgaon, Dhaka-1219.

Test Completion Date : 05/04/2017

Details:

Lab Id	Sample ID (as mentioned)	Result				
		pH	Total Organic Content	Total Phosphate	Total Suspended Solids (TSS)	Dissolved Oxygen (DO)
SE 535-01	SW 01	7.22	3.16 ppm	4.95 ppm	58.21 mg/L	6.24 mg/L
SE 535-02	SW 02	6.88	6.42 ppm	7.35 ppm	141.53 mg/L	6.05 mg/L
SE 535-03	SW 03	6.93	6.35 ppm	4.58 ppm	148.50 mg/L	7.46 mg/L
SE 535-04	SW 04	6.86	3.16 ppm	4.52 ppm	50.21 mg/L	7.70 mg/L
SE 535-05	SW 05	7.45	6.29 ppm	3.48 ppm	62.34 mg/L	7.72 mg/L
SE 535-06	SW 06	7.30	6.39 ppm	4.22 ppm	195.21 mg/L	6.86 mg/L
SE 535-07	SW 07(50m Up Stream)	7.64	6.41 ppm	4.65 ppm	102.35 mg/L	7.73 mg/L
SE 535-08	SW 07(50m Down Stream)	6.92	6.28 ppm	6.06 ppm	130.63 mg/L	5.23 mg/L
SE 535-09	SW 08	7.21	12.63 ppm	5.81 ppm	183.02 mg/L	5.26 mg/L
SE 535-10	SW 09	6.84	6.37 ppm	7.83 ppm	198.51 mg/L	5.31 mg/L
SE 535-11	SW 10(50m Up Stream)	7.28	9.52 ppm	3.67 ppm	135.21 mg/L	7.64 mg/L
SE 535-12	SW 10(50m Down Stream)	7.72	9.48 ppm	4.03 ppm	112.41 mg/L	7.02 mg/L
SE 535-13	SW 11	7.22	15.84 ppm	6.79 ppm	212.59 mg/L	5.10 mg/L
SE 535-14	SW 12	7.32	32.12 ppm	63.50 ppm	316.35 mg/L	1.01 mg/L
SE 535-15	SW 13(50m Up Stream)	7.37	18.94 ppm	4.22 ppm	253.81 mg/L	1.47 mg/L
SE 535-16	SW 13(50m Down Stream)	7.22	12.61 ppm	5.26 ppm	222.79 mg/L	2.96 mg/L
SE 535-17	SW 16	7.49	12.69 ppm	6.12 ppm	192.70 mg/L	4.63 mg/L

Methodology / Instrument:

1. **pH:** pH measuring meter
2. **TSS:** Gravimetric method
3. **Phosphate:** Vanadomolybdophosphoric Yellow Color Method
4. **DO:** DO measuring meter
5. **TOC:** Wet Oxidation Method followed by Potentiometric Titration

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Notes:

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Form No. QSF-22 Revision No. 08 Revision Date: 24 June, 2016
ISO/IEC 17025:2005 Certified জীবনের জন্য বিজ্ঞান

Certificate No: T-1676

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BCSIR LABORATORIES, DHAKA
BANGLADESH COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH

ANALYSIS REPORT

Ref. No. : i) 401 of BCSIR Lab. Dhaka dt. 09/05/2016
: ii) D-401 of Analytical Service Cell, BCSIR. 08/05/2016
Lab ID : A-385 to A-388
Name and address of Customer : Md. Saiful Islam
Environmental Specialist
Environment and Resource Analysis Center Ltd.
464/C (Ground Floor), Khilgaon, Dhaka-1219, Bangladesh.
Work order details : **Application for testing of materials (Surface water and Ground water),** Date: 08/05/2016
Type of sample* : Water
Quantity of sample :1 Litre/bottle (7 bottles)
Packing and marking : Glass & Plastic bottle
Date of receipt : 09/05/2016
Period of analysis : 09/05/2016 to 25/05/2016
Visual observation/Remarks : Colourless

Lab ID	Particulars of supplied sample	Parameters	Concentration	Test Method (APHA)
A-385	Surface water (SW 01)	Total Organic Carbon (TOC)	4.01 mg/L	5310.B
		Total Phosphate (PO_4)	0.26 mg/L	4500-P C
		Total Suspended Solids (TSS)	Less than 5 mg/L	2540.D
		Oil and Grease	8.80 mg/L	5220.B
A-386	Surface water (SW 02)	Total Organic Carbon (TOC)	3.65 mg/L	5310.B
		Total Phosphate (PO_4)	0.71 mg/L	4500-P C
		Total Suspended Solids (TSS)	Less than 5 mg/L	2540.D
		Oil and Grease	Less than 5 mg/L	5220.B
A-387	Surface water (SW 03)	Total Organic Carbon (TOC)	2.42 mg/L	5310.B
		Total Phosphate (PO_4)	Less than 0.2 mg/L	4500-P C
		Total Suspended Solids (TSS)	Less than 5 mg/L	2540.D
		Oil and Grease	Less than 5 mg/L	5220.B

*The results relate only to the items tested..

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Laboratories/Institute/Center: Institute of National Analytical Research & Service (INARS)

ANALYSIS REPORT

ASC Ref No	: Mar2017001193	Unit (Lab/Inst.) Ref No	: INS-454
Lab/Sample ID	: A-217	Number of Sample	: 1
Sample Description	: Test of Surface water (Oil and Greese]-SW 01	Test Commencement date	: 21/03/2017
Client's Details	: Tahsin-Uz-Zaman ENRAC House#464/C (Ground Floor), Khilgaon, Dhaka-1219		

Details:

Lab ID	Particulars of supplied Sample	Parameters	Concentration	Test Method (APHA)
A-217	Surface water (SW-01)	Oil and Grease	18.2 mg/L	5520.B

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ANALYSIS REPORT

ASC Ref No	: Mar2017001194	Unit (Lab/Inst.) Ref No	: INS-455
Lab/Sample ID	: A-218	Number of Sample	: 1
Sample Description	: Test of Surface water (Oil and Greese)-SW 02	Test Commencement date	: 21/03/2017
Client's Details	: Tahsin-Uz-Zaman ENRAC House#464/C (Ground Floor), Khilgaon, Dhaka-1219	Test Completion date	: 04/04/2017

Details:

Lab ID	Particulars of supplied Sample	Parameters	Concentration	Test Method (APHA)
A-218	Surface water (SW-02)	Oil and Grease	5.20 mg/L	5520.B

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ANALYSIS REPORT

ASC Ref No	: Mar2017001195	Unit (Lab/Inst.) Ref No	: INS-456
Lab/Sample ID	: A-219	Number of Sample	: 1
Sample Description	: Test of Surface water (Oil and Greese)-SW 03	Test Commencement date	: 21/03/2017
Client's Details	: Tahsin-Uz-Zaman ENRAC House#464/C (Ground Floor), Khilgaon, Dhaka-1219		

Details:

Lab ID	Particulars of supplied Sample	Parameters	Concentration	Test Method (APHA)
A-219	Surface water (SW-03)	Oil and Grease	5.40 mg/L	5520.B

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ANALYSIS REPORT

ASC Ref No	: Mar2017001196	Unit (Lab/Inst.) Ref No	: INS-457
Lab/Sample ID	: A-220	Number of Sample	: 1
Sample Description	: Test of Surface water (Oil and Greese)-SW 04	Test Commencement date	: 21/03/2017
Client's Details	: Tahsin-Uz-Zaman ENRAC House#464/C (Ground Floor), Khilgaon, Dhaka-1219		

Details:

Lab ID	Particulars of supplied Sample	Parameters	Concentration	Test Method (APHA)
A-220	Surface water (SW-04)	Oil and Grease	7.60 mg/L	5520.B

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Laboratories/Institute/Center: Institute of National Analytical Research & Service (INARS)

ANALYSIS REPORT

ASC Ref No	: Mar2017001197	Unit (Lab/Inst.) Ref No	: INS-458
Lab/Sample ID	: A-221	Number of Sample	: 1
Sample Description	: Test of Surface water (Oil and Greese)-SW 05	Test Commencement date	: 21/03/2017
Client's Details	: Tahsin-Uz-Zaman ENRAC House#464/C (Ground Floor), Khilgaon, Dhaka-1219	Test Completion date	: 05/04/2017

Details:

Lab ID	Particulars of supplied Sample	Parameters	Concentration	Test Method (APHA)
A-221	Surface water (SW-05)	Oil and Grease	4.00 mg/L	5520.B

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Laboratories/Institute/Center: Institute of National Analytical Research & Service (INARS)

ANALYSIS REPORT

ASC Ref No	: Mar2017001198	Unit (Lab/Inst.) Ref No	: INS-459
Lab/Sample ID	: A-222	Number of Sample	: 1
Sample Description	: Test of Surface water (Oil and Greese)-SW 06	Test Commencement date	: 21/03/2017
Client's Details	: Tahsin-Uz-Zaman ENRAC House#464/C (Ground Floor), Khilgaon, Dhaka-1219	Test Completion date	: 06/04/2017

Details:

Lab ID	Particulars of supplied Sample	Parameters	Concentration	Test Method (APHA)
A-222	Surface water (SW-06)	Oil and Grease	3.40 mg/L	5520.B

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6th of April 2017 08:17 AM

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ANALYSIS REPORT

ASC Ref No	: Mar2017001199	Unit (Lab/Inst.) Ref No	: INS-460
Lab/Sample ID	: A-223	Number of Sample	: 1
Sample Description	: Test of Surface water (Oil and Greese)-SW 07 (50m Up Stream)	Test Commencement date	: 21/03/2017
Client's Details	: Tahsin-Uz-Zaman ENRAC House#464/C (Ground Floor), Khilgaon, Dhaka-1219	Test Completion date	: 06/04/2017

Details:

Lab ID	Particulars of supplied Sample	Parameters	Concentration	Test Method (APHA)
A-223	Surface water, SW-07 (Up Stream)	Oil and Grease	9.60 mg/L	5520.B

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Laboratories/Institute/Center: Institute of National Analytical Research & Service (INARS)

ANALYSIS REPORT

ASC Ref No	: Mar2017001201	Unit (Lab/Inst.) Ref No	: INS-462
Lab/Sample ID	: A-225	Number of Sample	: 1
Sample Description	: Test of Surface water (Oil and Greese)-SW 08	Test Commencement date	: 21/03/2017
Client's Details	: Tahsin-Uz-Zaman ENRAC House#464/C (Ground Floor), Khilgaon, Dhaka-1219		

Details:

Lab ID	Particulars of supplied Sample	Parameters	Concentration	Test Method (APHA)
A-225	Surface water (SW-08)	Oil and Grease	16.0 mg/L	5520.B

06/04/2017
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রিসার্চ এন্ড সার্ভিস (আইএনএআরএস)
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জীবনের জন্য বিজ্ঞান

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Laboratories/Institute/Center: Institute of National Analytical Research & Service (INARS)

ANALYSIS REPORT

ASC Ref No	: Mar2017001202	Unit (Lab/Inst.) Ref No	: INS-463
Lab/Sample ID	: A-226	Number of Sample	: 1
Sample Description	: Test of Surface water (Oil and Greese)-SW 09	Test Commencement date	: 21/03/2017
Client's Details	: Tahsin-Uz-Zaman ENRAC House#464/C (Ground Floor), Khilgaon, Dhaka-1219		

Details:

Lab ID	Particulars of supplied Sample	Parameters	Concentration	Test Method (APHA)
A-226	Surface water (SW-09)	Oil and Grease	16.0 mg/L	5520.B

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4th of April 2017 02:38 PM

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Laboratories/Institute/Center: Institute of National Analytical Research & Service (INARS)

ANALYSIS REPORT

ASC Ref No	: Mar2017001208	Unit (Lab/Inst.) Ref No	: INS-469
Lab/Sample ID	: A-232	Number of Sample	: 1
Sample Description	: Test of Surface water (Oil and Greese)-SW 10 (50m Up Stream)	Test Commencement date	: 21/03/2017
Client's Details	: Tahsin-Uz-Zaman ENRAC House#464/C (Ground Floor), Khilgaon, Dhaka-1219		

Details:

Lab ID	Particulars of supplied Sample	Parameters	Concentration	Test Method (APHA)
A-232	Surface water, SW-10 (Up Stream)	Oil and Grease	6.00 mg/L	5520.B

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Laboratories/Institute/Center: Institute of National Analytical Research & Service (INARS)

ANALYSIS REPORT

ASC Ref No	: Mar2017001204	Unit (Lab/Inst.) Ref No	: INS-465
Lab/Sample ID	: A-228	Number of Sample	: 1
Sample Description	: Test of Surface water (Oil and Greese)-SW 10 (50m Down Stream)	Test Commencement date	: 21/03/2017
Client's Details	: Tahsin-Uz-Zaman ENRAC House#464/C (Ground Floor), Khilgaon, Dhaka-1219		

Details:

Lab ID	Particulars of supplied Sample	Parameters	Concentration	Test Method (APHA)
A-228	Surface water, SW-10 (Down Stream)	Oil and Grease	10.0 mg/L	5520.B

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Laboratories/Institute/Center: Institute of National Analytical Research & Service (INARS)

ANALYSIS REPORT

ASC Ref No	: Mar2017001205	Unit (Lab/Inst.) Ref No	: INS-466
Lab/Sample ID	: A-229	Number of Sample	: 1
Sample Description	: Test of Surface water (Oil and Greese)-SW 11	Test Commencement date	: 21/03/2017
Client's Details	: Tahsin-Uz-Zaman ENRAC House#464/C (Ground Floor), Khilgaon, Dhaka-1219		

Details:

Lab ID	Particulars of supplied Sample	Parameters	Concentration	Test Method (APHA)
A-229	Surface water (SW-11)	Oil and Grease	9.60 mg/L	5520.B

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Laboratories/Institute/Center: Institute of National Analytical Research & Service (INARS)

ANALYSIS REPORT

ASC Ref No	: Mar2017001206	Unit (Lab/Inst.) Ref No	: INS-467
Lab/Sample ID	: A-230	Number of Sample	: 1
Sample Description	: Test of Surface water (Oil and Greese)-SW 12	Test Commencement date	: 21/03/2017
Client's Details	: Tahsin-Uz-Zaman ENRAC House#464/C (Ground Floor), Khilgaon, Dhaka-1219		

Details:

Lab ID	Particulars of supplied Sample	Parameters	Concentration	Test Method (APHA)
A-230	Surface water (SW-12)	Oil and Grease	6.80 mg/L	5520.B

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5th of April 2017 07:39 AM

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ANALYSIS REPORT

ASC Ref No	: Mar2017001203	Unit (Lab/Inst.) Ref No	: INS-464
Lab/Sample ID	: A-227	Number of Sample	: 1
Sample Description	: Test of Surface water (Oil and Greese)-SW 10 (50m Up Stream)	Test Commencement date	: 21/03/2017
Client's Details	: Tahsin-Uz-Zaman ENRAC House#464/C (Ground Floor), Khilgaon, Dhaka-1219	Test Completion date	: 05/04/2017

Details:

Lab ID	Particulars of supplied Sample	Parameters	Concentration	Test Method (APHA)
A-227	Surface water, SW-13 (Up Stream)	Oil and Grease	7.40 mg/L	5520.B

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4th of April 2017 02:48 PM

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Laboratories/Institute/Center: Institute of National Analytical Research & Service (INARS)

ANALYSIS REPORT

ASC Ref No	:	Mar2017001207	Unit (Lab/Inst.) Ref No	:	INS-468
Lab/Sample ID	:	A-231	Number of Sample	:	1
Sample Description	:	Test of Surface water (Oil and Greese)-SW 13 (50m Down Stream)	Test Commencement date	:	21/03/2017
Client's Details	:	Tahsin-Uz-Zaman ENRAC House#464/C (Ground Floor), Khilgaon, Dhaka-1219	Test Completion date	:	05/04/2017

Details:

Lab ID	Particulars of supplied Sample	Parameters	Concentration	Test Method (APHA)
A-231	Surface water, SW-13 (Down Stream)	Oil and Grease	11.4 mg/L	5520.B

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Laboratories/Institute/Center: Institute of National Analytical Research & Service (INARS)

ANALYSIS REPORT

ASC Ref No	: Mar2017001209	Unit (Lab/Inst.) Ref No	: INS-470
Lab/Sample ID	: A-233	Number of Sample	: 1
Sample Description	: Test of Surface water (Oil and Greese)-SW 16	Test Commencement date	: 21/03/2017
Client's Details	: Tahsin-Uz-Zaman ENRAC House#464/C (Ground Floor), Khilgaon, Dhaka-1219		

Details:

Lab ID	Particulars of supplied Sample	Parameters	Concentration	Test Method (APHA)
A-233	Surface water (SW-16)	Oil and Grease	2.40 mg/L	5520.B

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5th of April 2017 08:00 AM

APPENDIX E: GROUNDWATER QUALITY TEST RESULTS

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Fax : +880-2-9827062
Web : http://www.icddrb.org

Environmental Microbiology Laboratory

Test Report

Lab. ID No.2017031011
Receipt No: MAR1708298

Date of Reporting: 20.03.2017
Date of Sample Tested: 15.03.2017
Date of Sample Received: 15.03.2017

Particular of Sample: Drinking Water

Client Address: ENRAC GW 02, Hatikumurul.

Sl. No.	Water Quality Parameters	Unit	Results	Bangladesh Standard for Drinking Water (ECR'97)	WHO Guideline for Drinking Water, 2004	Method
1	Total coliforms	CFU /100mL	0	0	0	Membrane Filtration
2	Faecal coliforms	CFU /100mL	0	0	0	Membrane Filtration

N.B: This report is valid only for particular sample tested and cannot be used for publicity.

Dr. Zahid Hayat Mahmud
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Tested By (Code No.): 7, 8
EM.FM.007.01 Effective Date 30/03/2016

Checked By (Code No.): 2
End of the Report

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Environmental Microbiology Laboratory

Test Report

Lab. ID No.2017031010
Receipt No: MAR1708299

Date of Reporting: 20.03.2017
Date of Sample Tested: 15.03.2017
Date of Sample Received: 15.03.2017

Particular of Sample: Drinking Water

Client Address: ENRAC GW 03, Sherpur Bazar.

Sl. No.	Water Quality Parameters	Unit	Results	Bangladesh Standard for Drinking Water (ECR'97)	WHO Guideline for Drinking Water, 2004	Method
1	Total coliforms	CFU /100mL	0	0	0	Membrane Filtration
2	Faecal coliforms	CFU /100mL	0	0	0	Membrane Filtration

N.B: This report is valid only for particular sample tested and cannot be used for publicity.

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Tested By (Code No.): 7, 8
EM.FM.007.01 Effective Date 30/03/2016

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Environmental Microbiology Laboratory

Test Report
Receipt No: MAR1708300

Lab. ID No.2017031002

Particular of Sample: Drinking Water

Client Address: ENRAC GW 04, Ariabazar.

Date of Reporting: 20.03.2017
Date of Sample Tested: 15.03.2017
Date of Sample Received: 15.03.2017

Sl. No.	Water Quality Parameters	Unit	Results	Bangladesh Standard for Drinking Water (ECR'97)	WHO Guideline for Drinking Water, 2004	Method
1	Total coliforms	CFU /100mL	0	0	0	Membrane Filtration
2	Faecal coliforms	CFU /100mL	0	0	0	Membrane Filtration

N.B: This report is valid only for particular sample tested and cannot be used for publicity.

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EM.FM.007.01 Effective Date 30/03/2016

Checked By (Code No.): 2

End of the Report

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Environmental Microbiology Laboratory

Test Report

Lab. ID No.2017031003

Receipt No: MAR1708301

Date of Reporting: 20.03.2017
Date of Sample Tested: 15.03.2017
Date of Sample Received: 15.03.2017

Particular of Sample: Drinking Water

Client Address: ENRAC GW 05, Bogra Rail.

Sl. No.	Water Quality Parameters	Unit	Results	Bangladesh Standard for Drinking Water (ECR'97)	WHO Guideline for Drinking Water, 2004	Method
1	Total coliforms	CFU /100mL	24	0	0	Membrane Filtration
2	Faecal coliforms	CFU /100mL	16	0	0	Membrane Filtration

Comment: The supplied water sample is contaminated with total coliforms and faecal coliforms.

N.B: This report is valid only for particular sample tested and cannot be used for publicity.

Dr. Zahid Hayat Mahmud
Associate Scientist and Head
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Tested By (Code No.): 7, 8
EM.FM.007.01 Effective Date 30/03/2016

Checked By (Code No.): 2

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Web : http://www.icddrb.org

Environmental Microbiology Laboratory

Test Report

Lab. ID No.2017031004

Receipt No: MAR1708302

Date of Reporting: 20.03.2017
Date of Sample Tested: 15.03.2017
Date of Sample Received: 15.03.2017

Particular of Sample: Drinking Water

Client Address: ENRAC GW 06, Matidhali, Biman Mor.

Sl. No.	Water Quality Parameters	Unit	Results	Bangladesh Standard for Drinking Water (ECR'97)	WHO Guideline for Drinking Water, 2004	Method
1	Total coliforms	CFU /100mL	0	0	0	Membrane Filtration
2	Faecal coliforms	CFU /100mL	0	0	0	Membrane Filtration

N.B: This report is valid only for particular sample tested and cannot be used for publicity.

Dr. Zahid Hayat Mahmud
Associate Scientist and Head
Environmental Microbiology Lab, LSSD, icddr,b

Tested By (Code No.): 7, 8
EM.FM.007.01 Effective Date 30/03/2016

Checked By (Code No.): 2
End of the Report

icddr,b
Centre for Food and Waterborne Diseases
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Environmental Microbiology Laboratory

Test Report

Lab. ID No.2017031005
Receipt No: MAR1708303

Date of Reporting: 20.03.2017
Date of Sample Tested: 15.03.2017
Date of Sample Received: 15.03.2017

Particular of Sample: Drinking Water

Client Address: ENRAC GW 07, Polashbari Chowmatha.

Sl. No.	Water Quality Parameters	Unit	Results	Bangladesh Standard for Drinking Water (ECR'97)	WHO Guideline for Drinking Water, 2004	Method
1	Total coliforms	CFU /100mL	0	0	0	Membrane Filtration
2	Faecal coliforms	CFU /100mL	0	0	0	Membrane Filtration

N.B: This report is valid only for particular sample tested and cannot be used for publicity.

Dr. Zahid Hayat Mahmud
Associate Scientist and Head
Environmental Microbiology Lab, LSSD, icddr,b

Tested By (Code No.): 7, 8
EM.FM.007.01 Effective Date 30/03/2016

Checked By (Code No.): 2
End of the Report

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Environmental Microbiology Laboratory

Test Report

Lab. ID No.2017031009
Receipt No: MAR1708305

Date of Reporting: 20.03.2017
Date of Sample Tested: 15.03.2017
Date of Sample Received: 15.03.2017

Particular of Sample: Drinking Water

Client Address: ENRAC GW 08, Mithipur Union Pourashava.

Sl. No.	Water Quality Parameters	Unit	Results	Bangladesh Standard for Drinking Water (ECR'97)	WHO Guideline for Drinking Water, 2004	Method
1	Total coliforms	CFU /100mL	15	0	0	Membrane Filtration
2	Faecal coliforms	CFU /100mL	5	0	0	Membrane Filtration

Comment: The supplied water sample is contaminated with total coliforms and faecal coliforms.

N.B: This report is valid only for particular sample tested and cannot be used for publicity.

Dr. Zahid Hayat Mahmud
Associate Scientist and Head
Environmental Microbiology Lab, LSSD, icddr,b

Tested By (Code No.): 7, 8
EM.FM.007.01 Effective Date 30/03/2016

Checked By (Code No.): 2

End of the Report

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Environmental Microbiology Laboratory

Test Report

Lab. ID No.2017031008
Receipt No: MAR1708306

Date of Reporting: 20.03.2017
Date of Sample Tested: 15.03.2017
Date of Sample Received: 15.03.2017

Particular of Sample: Drinking Water

Client Address: ENRAC GW 09, Mithapukur.

Sl. No.	Water Quality Parameters	Unit	Results	Bangladesh Standard for Drinking Water (ECR'97)	WHO Guideline for Drinking Water, 2004	Method
1	Total coliforms	CFU /100mL	0	0	0	Membrane Filtration
2	Faecal coliforms	CFU /100mL	0	0	0	Membrane Filtration

N.B: This report is valid only for particular sample tested and cannot be used for publicity.

Dr. Zahid Hayat Mahmud
Associate Scientist and Head
Environmental Microbiology Lab, LSSD, icddr,b

Tested By (Code No.): 7, 8
EM.FM.007.01 Effective Date 30/03/2016

Checked By (Code No.): 2
End of the Report

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Environmental Microbiology Laboratory

Test Report

Lab. ID No.2017031006

Receipt No: MAR1708307

Date of Reporting: 20.03.2017
Date of Sample Tested: 15.03.2017
Date of Sample Received: 15.03.2017

Particular of Sample: Drinking Water

Client Address: ENRAC GW 10, Asshotpur, Parker Mor, Rangpur.

Sl. No.	Water Quality Parameters	Unit	Results	Bangladesh Standard for Drinking Water (ECR'97)	WHO Guideline for Drinking Water, 2004	Method
1	Total coliforms	CFU /100mL	0	0	0	Membrane Filtration
2	Faecal coliforms	CFU /100mL	0	0	0	Membrane Filtration

N.B: This report is valid only for particular sample tested and cannot be used for publicity.

Dr. Zahid Hayat Mahmud
Associate Scientist and Head
Environmental Microbiology Lab, LSSD, icddr,b

Tested By (Code No.): 7, 8
EM.FM.007.01 Effective Date 30/03/2016

Checked By (Code No.): 2

End of the Report

Form No. QSF-22 Revision No. 08 Revision Date: 24 June, 2016
ISO/IEC 17025:2005 Certified
জীবনের জন্য বিজ্ঞান

Certificate No: T-1676

Institute of National Analytical Research and Service (INARS)
ইনস্টিটিউট অব ন্যাশনাল এনালাইটিক্যাল রিসার্চ এন্ড সার্ভিস
BCSIR LABORATORIES, DHAKA
BANGLADESH COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH

Lab ID	Particulars of supplied sample	Parameters	Concentration	Test Method (APHA)
A-388	Ground water (GW 01)	Manganese (Mn)	0.67 mg/L	3110.B
		Arsenic (As)	0.022 mg/L	3114.C
		Iron (Fe)	12.7 mg/L	3111.B
		Chloride (Cl)	2.66 mg/L	4110.B
		Total Hardness as $CaCO_3$	172 mg/L	2340.C

25-05-2016

Sig and Name of the Validator
Md. Aminul Ahsan
Principal Scientific Officer
Institute of National Analytical Research & Service (INARS)

*The results relate only to the items tested.

Dr. Qudrat-I-Khuda Road, Dhanmondi, Dhaka-1205, Tel.: 88-02-8621741, 9664959, Fax: 880-2-8613022;
PABX: 8611057-61, 8625038-9, 8626034-5, 8626032, Ext/325; E-mail: directordi@yahoo.com, bcsir@bangla.net

জীবনের জন্য বিজ্ঞান "শেখ হাসিনার দর্শন, সব মানুষের উন্নয়ন"

বাংলাদেশ বিজ্ঞান ও শিল্প গবেষণা পরিষদ (বিসিএসআইআর)

BANGLADESH COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH (BCSIR)

Laboratories / Institute / Center: BCSIR Laboratories, Dhaka.

ANALYSIS REPORT

ASC Ref No. : D-113, Date : 20-03-2017

Unit (Lab/Inst.) Ref. No. : 113, Date : 21-03-2017

Lab / Sample ID : SE - 536

Number of Sample : 08

Sample Description: Test of different parameters in supplied samples (as supplied).

Test Commencement Date : 21/03/2017

Client's Details : Md. Shafiqul Islam, Jr. Environmental Specialist, Environment and Resource Analysis Center Ltd., 464/C (Ground Floor), Khilgaon, Dhaka-1219.

Test Completion Date : 05/04/2017

Details:

Lab Id	Sample ID (as mentioned)	Result					
		pH	Manganese (Mn)	Arsenic (As)	Iron (Fe)	Chloride (Cl)	Total Hardness (as $CaCO_3$)
SE 536-01	GW 01	7.32	0.056 ppm	5.11 ppb	0.027 ppm	20.83 ppm	83.9 ppm
SE 536-02	GW 03	6.02	0.144 ppm	4.64 ppb	0.025 ppm	40.05 ppm	85.2 ppm
SE 536-03	GW 04	6.84	0.017 ppm	6.28 ppb	0.026 ppm	27.41 ppm	68.5 ppm
SE 536-04	GW 05	6.95	0.363 ppm	6.64 ppb	0.059 ppm	26.79 ppm	86.8 ppm
SE 536-05	GW 06	6.66	0.584 ppm	2.93 ppb	0.021 ppm	81.19 ppm	152 ppm
SE 536-06	GW 07	6.56	0.522 ppm	3.09 ppb	0.022 ppm	73.43 ppm	133.2 ppm
SE 536-07	GW 08	5.99	0.031 ppm	4.83 ppb	0.020 ppm	50.38 ppm	75.9 ppm
SE 536-08	GW 09	6.47	0.191 ppm	5.05 ppb	0.022 ppm	47.43 ppm	137.3 ppm
SE 536-09	GW 10	6.76	0.026 ppm	4.10 ppb	0.040 ppm	10.73 ppm	38.3 ppm

Methodology / Instrument:

1. **pH:** pH measuring meter
2. **Iron & Manganese:** Atomic Absorption Spectrophotometer.
3. **Chloride:** Ion Chromatography
4. **Hardness:** Potentiometric Titration
5. **Arsenic:** Atomic Absorption Spectrophotometer with Hydride Vapor Generator (HVG) Unit.

6.4.17

Analyst

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6.4.17

Director / Officer-In-Charge

Dr. Md. Sarwar Jahan
Director (Addl-Charge)
BCSIR Laboratories, Dhaka
Dr. Qudrat-e-Khuda Road
Dhaka-1205

Notes:

1. The results reported here are based only on the supplied samples in this laboratory.
2. Any complain about the test result will not be acceptable after one month from the date of issuing of the said report.
3. This report/result shall not be reproduced / published without prior approval of the authority.

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APPENDIX F: AIR QUALITY IMPACTS ASSESSMENT OF PROPOSED HIGHWAY CORRIDOR OF HATIKAMRUL-RANGPUR

A. Introduction

1. The major impact on the air quality during the operation stage will be due to plying of vehicles on the proposed Highway corridor. The impact on air quality depends upon traffic volume, traffic fleet including fuel type and prevailing atmospheric conditions. An unstable atmospheric condition disperses pollutants more and results in to low pollutant concentrations while stable atmospheric conditions buildup the pollution level. To assess the likely impacts on the ambient air quality due to the proposed highway corridor project, the prediction of the carbon monoxide (CO) and particulate matter (PM) concentrations have been carried out using line source dispersion modelling approach, based on Gaussian equation. CO is an indicator pollutant for vehicular exhaust pollution. So, prediction of CO concentration is representative of the impacts of air pollution due to traffic movement on the road. Both $PM_{2.5}$ and PM_{10} concentration emitted from vehicles exhaust and re-suspension of road dust are predicted along the high corridor. The modeling for this project has been carried out using CALINE-4, line source model developed by the California Transport Department. The model has been setup and run by using CO emission factors (Department of Environment, Bangladesh Govt., 2012), for $PM_{2.5}$ (ARAI, 2007, Indian standards) and for PM_{10} due to re-suspension of road dust (AP-42, USEPA) and hourly traffic volumes as predicted for the project. Only CO emission factor are available in full-fledged for all vehicles categories in Bangladesh. The study is conducted to predict hourly increment in CO, $PM_{2.5}$ and PM_{10}.

B. Model descriptions

2. CALINE-4 is the fourth generation simple line source Gaussian plume dispersion model (Benson, 1984). It employs a mixing zone concept to characterize pollutant dispersion over the roadway. The main purpose of the model is to assess air quality impacts near transportation facilities. The input parameters are emission source strength, meteorology and road geometry. It can predict the pollutant concentrations at selected receptors locations for 1 hour and 8-hour average up to 500 meters of the roadway. For most applications, optional inputs can be bypassed and many other inputs can be assigned assuming worst-case values. More complex approaches to dispersion modeling are unnecessary for most of the applications because of the uncertainties in the estimation of emission factors and traffic volumes for the future years. CALINE- 4's accuracy is well balanced with the accuracy of state-of-art predictive models for vehicular pollution.

C. Source information

1. Traffic data

3. The fleet wise traffic volumes for the present study have been taken from the detailed project report of the project. The annual average daily traffic (AADT) data is available for the proposed highway corridor through traffic survey for year 2016 (Base year) and future years (2020, 2025, 2030, 2035 and 2040). CALINE 4 model needs hourly average traffic volume. However, model has been setup for peak traffic hours assuming 2 times of average hourly traffic volume. The total hourly traffic volume is further categorized in to two wheeler, three wheeler, four wheeler, light commercial vehicles (LCVs), high commercial vehicles (HCVs) and Bus based on the traffic survey at existing highway corridor (Figure 1). It is found that heavy duty vehicles is the dominating vehicles category (33%) along the road corridors.

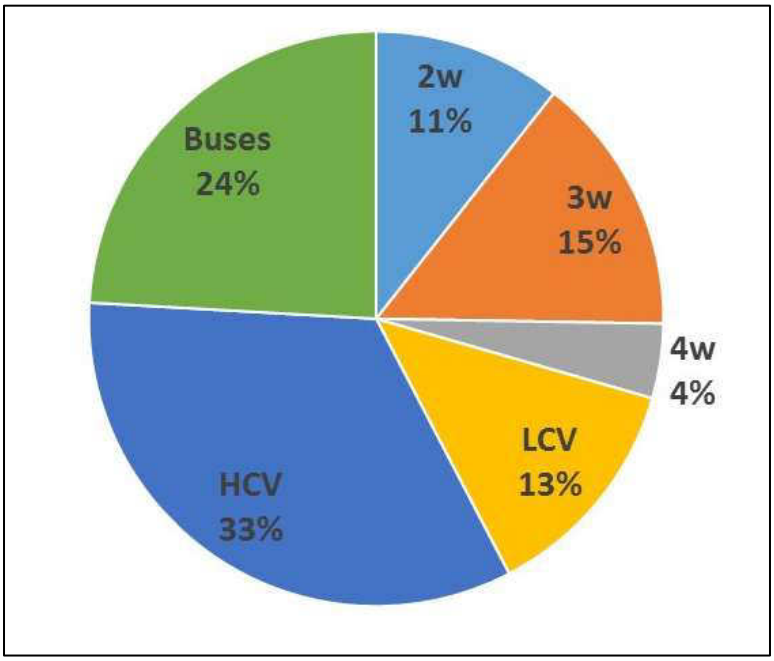


Figure F-1: Traffic Fleet on the proposed Highway Corridor

4. The annual average daily motorized traffic data are given in table 1 of proposed highway.

Table F-1: Annual average daily motorized traffic data

Road Section	Years	Motor Cycles (2W)	Auto Rickshaw (3W)	Car (4W)	Light Commercial Vehicles (LCV)	HCV	Bus	Total
Hatikamrul-Bhuyangati	2016	396	389	417	1147	7172	4479	14000
	2020	518	509	546	1545	12843	5871	21832
	2025	694	681	731	2069	17186	8406	29767
	2030	928	912	978	2767	23000	11248	39833
	2035	1242	1220	1309	3704	30779	15053	53307
	2040	1663	1633	1751	4956	41190	20144	71337
Sherpur-Sherpur	2016	2281	3474	698	3366	6129	4562	20510
	2020	2989	4554	916	4520	11196	5981	30156
	2025	4000	6094	1225	6048	14983	8563	40913
	2030	5353	8155	1640	8093	20051	11460	54752
	2035	7164	10914	2194	10831	26832	15336	73271
	2040	9587	14605	2936	14494	35907	20523	98052
Bogra 2nd By pass-Sultanganj, Banani,	2016	2814	8321	1638	2879	6297	5271	27220
	2020	3688	10908	2147	3900	11472	6909	39024
	2025	4935	14597	2874	5220	15352	9893	52871
	2030	6605	19534	3846	6985	20544	13239	70753
	2035	8838	26141	5146	9348	27492	17717	94682
	2040	11828	34982	6887	12510	36791	23709	126707
Kashi pur(M okamt ola)-Gabin	2016	1175	1154	414	1989	4645	3331	12708
	2020	1541	1513	542	2688	8788	4365	19437
	2025	2062	2025	726	3597	11759	6250	26419

Road Section	Years	Motor Cycles (2W)	Auto Rickshaw (3W)	Car (4W)	Light Commercial Vehicles (LCV)	HCV	Bus	Total
	2030	2759	2710	971	4813	15737	8363	35353
	2035	3692	3626	1300	6441	21059	11191	47309
	2040	4941	4853	1739	8620	28182	14977	63312
Palashbari-Pirganj, Ekberpur	2016	626	216	223	987	2679	1719	6450
	2020	820	283	292	1325	5183	2254	10157
	2025	1097	379	391	1774	6935	3227	13803
	2030	1468	507	523	2373	9280	4319	18470
	2035	1965	679	701	3176	12419	5780	24720
	2040	2630	908	937	4250	16621	7735	33081
Pirganj-Mithapukur	2016	583	73	227	741	2753	1668	6045
	2020	765	96	298	1002	5301	2186	9648
	2025	1023	128	399	1341	7094	3130	13115
	2030	1370	171	533	1794	9493	4188	17549
	2035	1833	229	714	2401	12703	5605	23485
	2040	2453	307	955	3213	16999	7501	31428
Mithapukur-Rangpur Modern More, Pairabond	2016	2607	812	518	1591	3409	2743	11680
	2020	3418	1064	678	2148	6325	3597	17230
	2025	4574	1424	908	2875	8464	5149	23394
	2030	6121	1906	1215	3848	11327	6891	31308
	2035	8191	2551	1626	5149	15158	9222	41897
	2040	10961	3414	2176	6890	20285	12340	56066

2. Road geometry

5. In the CALINE-4 model the entire length of the selected road section is divided into various road links. The division of sections into links has been done in such way, so that the link can be fairly considered as straight stretch of road having homogenous geometry with uniform road width, height and alignment. The coordinates of end points of links specify the location of the links in the model. The maximum numbers of link in each road section can be 20. The mixing zone width calculated for selected highway corridor is 14.2 m (1.2 m+ 3 m + 3 m + 7 m) as per guideline provided in CALINE4 model.

3. Emission factors

6. Emission factor is one of the important input parameter in Caline-4 model. In the present study, the emission factors specified by Department of Environment, Bangladesh Govt., 2012 (for CO), ARAI, 2007, Indian standards (for $PM_{2.5}$) and AP-42 for PM_{10} due to re-suspension of road dust are used. Only CO emission factor are available in full-fledged for all vehicles categories in Bangladesh. The weighted emission factors (WEF in g/mile) have been calculated using these emission factors (g/km) for CO, $PM_{2.5}$ and PM_{10} for corresponding year. The emission factor for CO and $PM_{2.5}$ used in the present study for different vehicles type are given in table 2. These emission factors have been expressed in terms of type of vehicles and type of fuel used (for petrol and diesel driven passenger cars). Since, there is only one input requirement for total no. of vehicles in the CALINE 4 model, whereas, there are different categories of vehicles (viz., Two wheelers, Cars, Bus and trucks) with different fuel used, it is essential that a single value representing the equivalent or weighted emission factors for all the vehicles is input into the model.

The emission factor used to estimate WEF are given below in table 3. The traffic data are not available for fuel types, therefore average emission factor for different fuels vehicle are used in this study. Thus, WEF expressed in g/mile (converted from gm/km) has been calculated for the present study using methodology given by Sharma et al., 2013. For PM_{10}, emission from re-suspension of road dust of paved road have been estimated using following empirical equation (USEPA 2011).

$$E = k\,(sL)^{0.91} \times (W)^{1.02}$$

Where:
E= particulate emission factor (g/VKT)
K =particle size multiplier (g/VKT), default value of "k" for PM_{10} is 0.3 g/VKT
sL = road surface silt loading (g/m^2) = 0.531 g/m^2 (Sahu et al., 2011)
W = Average weight of vehicles (in tons) on road = 1.41 Ton (Sahu et al., 2011)

7. The calculated WEF for CO, $PM_{2.5}$ and PM_{10} for peak traffic hours is given in table 3. It is estimated that WEF is almost same for all future years for all three pollutants. This is because of similar traffic fleet characteristics in all years. The WEF is representative of dominated vehicles types.

Table F-2: Emission factors for different types of Vehicle

Vehicle type	CO Emission factor (gm/km)*	$PM_{2.5}$ Emission factor (gm/km)#
Two wheeler	5.5	0.20
Three Wheeler	4.5	0.24
Cars/Jeep	2.68	0.06
LCV	6.5	0.49
BUS$	4.5	1.08
HCV	4.5	1.60

*Department of Environment, Bangladesh Govt., 2012 (CASE Project); #ARAI, 2007; $ Emission factor for bus is not available, so HCV is used.

Table F-3: Weighted Emission Factor for proposed traffic

Year	Weighted Emission factor for CO (g/mile)	Weighted Emission factor for $PM_{2.5}$ (g/mile)	Weighted Emission factor for PM_{10} (g/mile)
2016	7.72	1.48	3.21
2020	7.68	1.61	3.34
2025	7.67	1.61	3.35
2030	7.67	1.61	3.35
2035	7.67	1.61	3.35
2040	7.67	1.61	3.35

4. Meteorological data

8. The study was conducted to predict pollutant concentration for given meteorological conditions. The meteorological parameters such as wind speed, wind direction, temperature, mixing height and stability condition are used in model as given in table 4. It is found that dominated wind direction is South East in the study area with average wind speed of 0.24 km/hr. The minimum threshold wind speed essential for the model run is 0.5 m/s. The same has been used in the present study. The model has been run with standard case, in which models predicted maximum pollutant concentration w.r.t down wind direction.

TableF-4: Meteorological Parameters in the study area

Parameter	Unit	Location of Sampling Point								
		Koddar Mor	Hatikamrul	Chandaikona Bazar	Nandigram - Sherpur	Noymail Bus Stand	Bir Shrestho Square	Elenga – Gaibandha Rangpur	Pirganj Bus Stand	Rangpur Parker Mor
Temp	^{0}C	25	26.15	23.55	25.95	28.39	25.83	25.47	22.76	23.82
Humidity	%	79.97	79.84	81.87	82.64	76.10	85.43	86.72	92.01	88.36
Wind Speed	Km/hr	0.43	0.14	0.09	0.34	0.62	0.11	0.09	0.20	0.17
Wind Direction	Degree	238.37^0 South-West	194.57^0 South-West	148.58^0 South-East	95.98^0 South-East	183.61^0 South-West	237.53^0 South-West	229.23^0 South-West	280.40^0 North-West	165.06^0 South-East

5. Receptors

9. A set of link receptors were taken at various receptor locations within each section at a distance of 5 m, 10 m, 20 m, 40 m, 70 m, 100m and 200 m both sides (in perpendicular direction along the road alignment) from edge of the carriageway to know the dispersion of pollutant from the road. The monitoring station are marked as receptor points to compare the monitoring and predicted pollutant concentrations. Further, model also run for grid receptor locations to evaluate the spatial dispersion of the pollutant along whole road section (Figure 2).

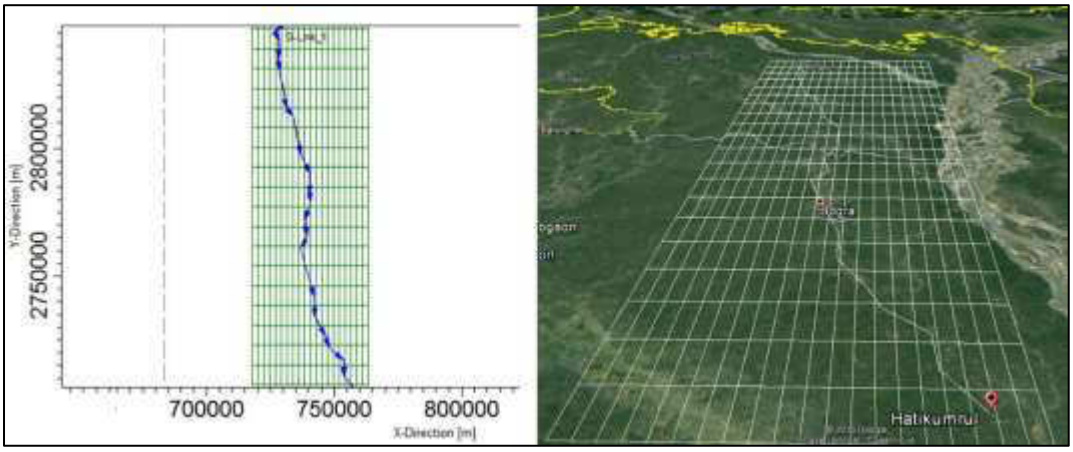


Figure F-2: Road alignment and receptor grid representation in Model and Google Earth view

D. Results

10. The model has been setup and run to predict hourly average CO, $PM_{2.5}$ and PM_{10} concentrations generated from traffic movement on proposed highway. The kerb side locations are selected to compare the model prediction with monitored locations and same has been described in table 5. It seems the monitored concentration are higher than predicted concentrations of each pollutant which might be due contribution of other sources such as natural dust, other fossil fuels etc. The contribution of vehicles movement is almost 50-60% of total concentration at receptor locations.

Table F-5: Monitored and Predicted Concentration at selected location (kerb) along the road

Parameter	Concentrations					
	Monitored			Predicted		
	$PM_{2.5}$ ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)	CO (ppm)	$PM_{2.5}$ ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)	CO (ppm)
Hatikamrul	27.77	65.78	0	18	29	0.1
Elenga – Gaibandha Rangpur Intersection	30.88	70.07	0	13	26	0
Pirganj Bus Stand	40.32	93.75	0	18	29	0
Rangpur Parker Mor	37.63	66.66	0	15	28.6	0

11. The predicted hourly average concentration of CO, $PM_{2.5}$ and PM_{10} during peak traffic hour are shown in table 6. The graphical representation of hourly average pollutant concentrations on both side of the road sections shown in figures 3 – 5 at different locations.

Table F-6: Pollutant predicted concentrations along the proposed highway corridor for peak traffic hour

Pollutant	Distance from the edge of the road, m. (Left side)								Distance from the edge of the road, m. (Right side)						
	-200	-100	-70	-40	-20	-10	-5		5	10	20	40	70	100	200
CO (ppm)	0	0	0	0	0.1	0.1	0.1		0.1	0	0	0	0	0	0
$PM_{2.5}$ ($\mu g/m^3$)	0.00	1.80	3.60	7.20	12.60	16.56	18.00		13.00	9.10	7.80	3.90	2.60	0.00	0.00
PM_{10} ($\mu g/m^3$)	1.11	2.90	5.80	11.60	20.30	26.68	29.00		22.00	15.40	14.30	6.60	6.60	2.20	1.12

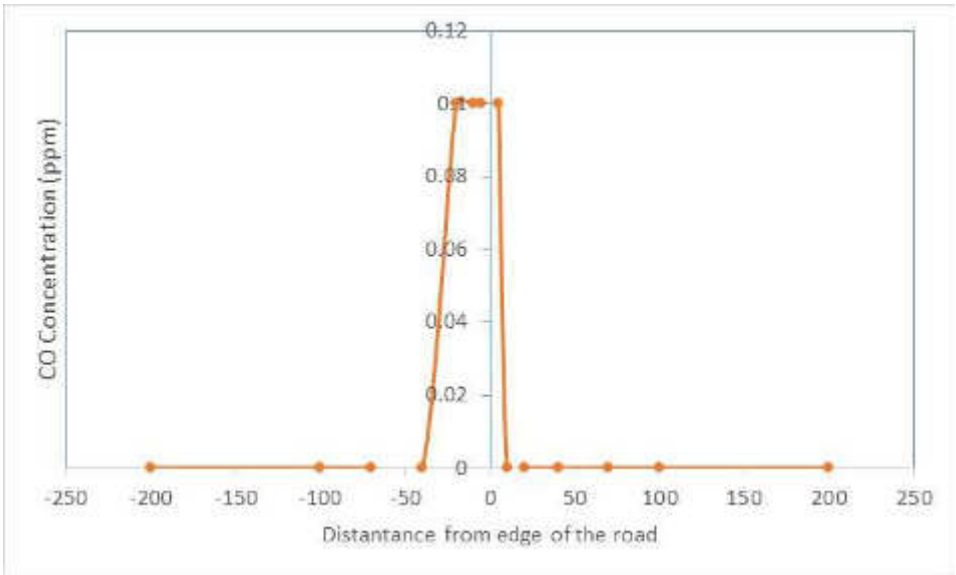


Figure F-3: CO predicted concentrations (ppm) along the proposed highway corridor (Left Side is of graph represent downwind side)

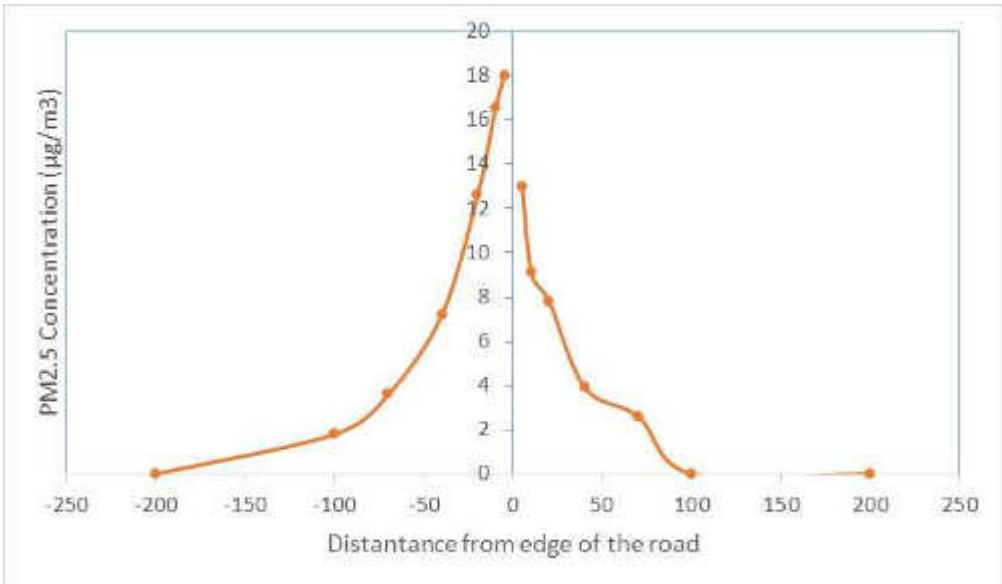


Figure F-4: $PM_{2.5}$ predicted concentrations (µg/m^3) along the proposed highway corridor (Left Side is of graph represent downwind side)

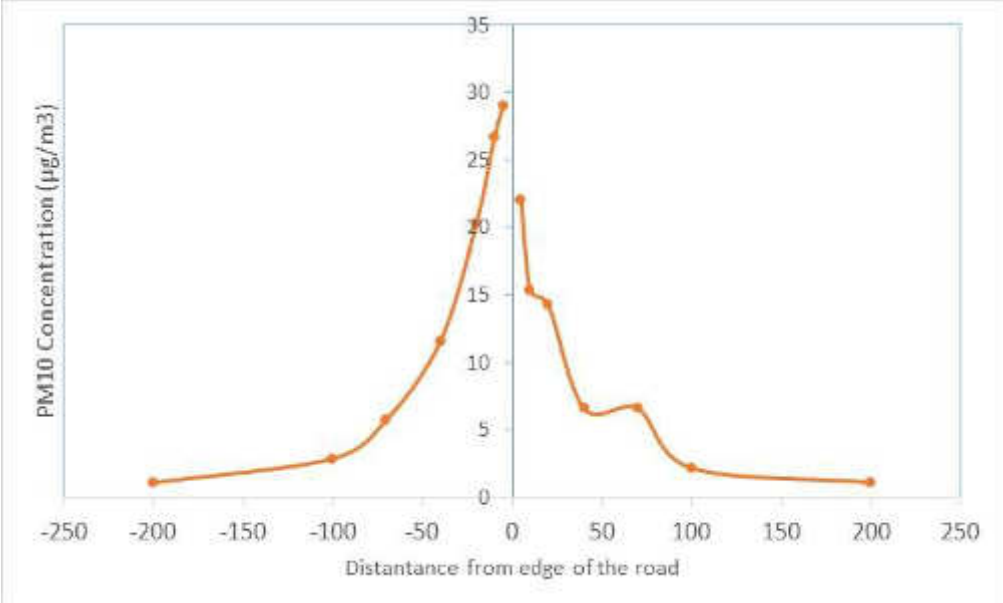
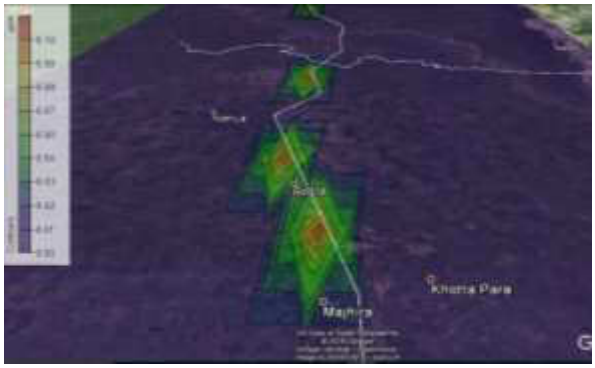


Figure F-5: PM_{10} predicted concentrations (µg/m^3) along the proposed highway corridor (Left Side is of graph represent downwind side)

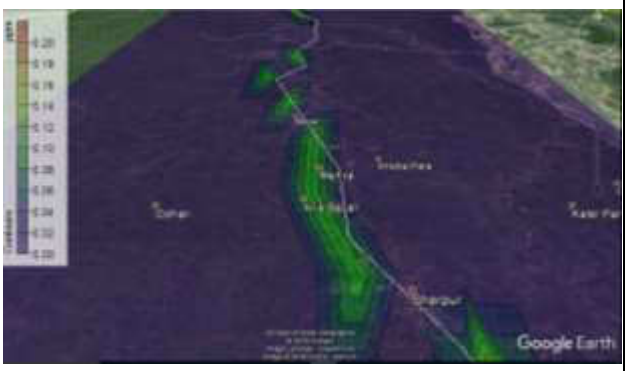
12. In addition, the spatial distribution of hourly average predicted CO, $PM_{2.5}$ and PM_{10}, concentrations have been plotted in figures 6-9, respectively for peak traffic hour which shows that pollutant concentrations is decreasing when goes away from the highway corridor. Therefore, the impacts of traffic movement at proposed highway project will not impact the surrounding atmosphere.

Figure F-6: Spatial distribution of CO concentrations

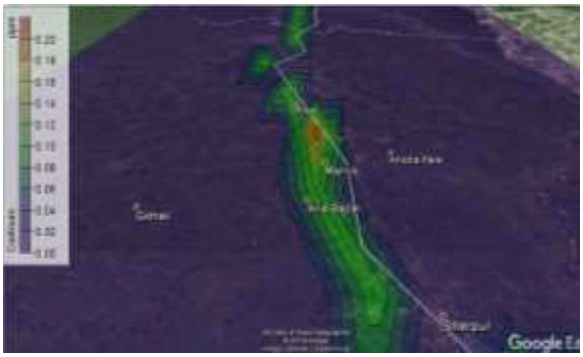


Year 2016

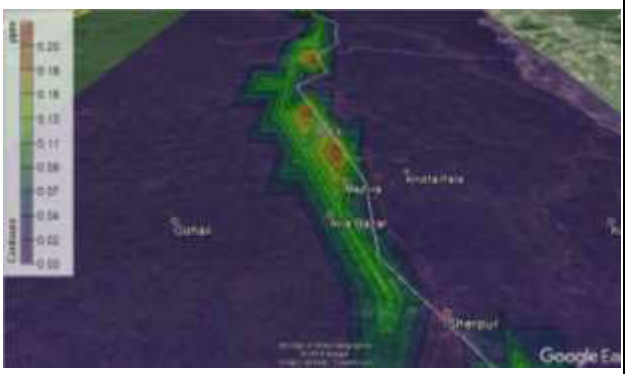
Year 2020



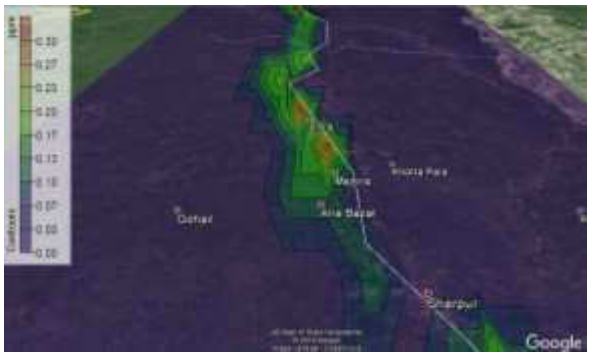
Year 2025



Year 2030

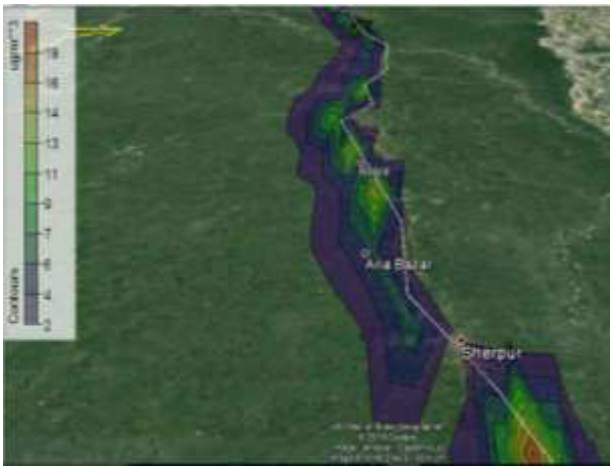


Year 2035



Year 2040

Figure F-7: Spatial distribution of $PM_{2.5}$ concentrations



Year 2016

Year 2020

Year 2025

Year 2030

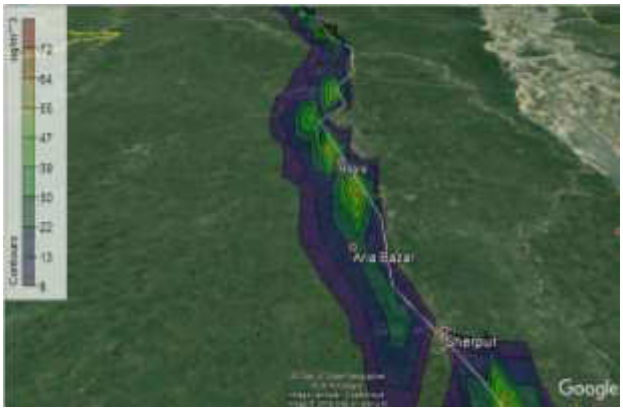
Year 2035

Year 2040

Figure F-8: Spatial distribution of PM_{10} concentrations

Year 2016

Year 2020



Year 2025

Year 2030

Year 2035

Year 2040

13. The summary of maximum GLC of CO, $PM_{2.5}$ and PM_{10} at kerb side of road in downwind side are described in Table 7.

Table F-7: Maximum GLC of CO, $PM_{2.5}$ and PM_{10} at kerb side of road in downwind side

Year	CO	$PM_{2.5}$	PM_{10}
2016	0.1	18	29
2020	0.1	25	54
2025	0.2	32	72
2030	0.2	40	94
2035	0.2	52	123
2040	0.3	75	164

Reference:

- Department of Environment (2012). Revisions of Vehicular Emission Standards For Bangladesh (Bdesh-2 And Bdesh-3) Draft Final Report - Part 1, Clean Air and Sustainable Environment (CASE) Project, Department of Environment, Government of The People's Republic of Bangladesh.
- ARAI (Automotive Research Association of India), 2007. Emission factor development for Indian vehicles. Project report no. AEF/2006-07/IOCL/Emission Factor Project. Automotive Research Association of India, Pune, India, 94 pages.
- USEPA (U.S. Environment Protection Agency), 2011d. Compilation of air pollutant EFs: miscellaneous sources: paved roads final section. AP 42, Fifth Ed. 1.

APPENDIX G: NOISE MODELING FOR THE PROJECT CORRIDOR
Noise Emission Modeling of the proposed Elenga-Hatikamrul-Rangpur Roadway traffic

1. Under the proposed project the existing 2-lane roadways will be upgraded to a four lane road with safety features that include the addition of a separate SMVT lane, flyovers at the busiest junctions, overpasses, Bus stops, pedestrian bridges and additional lanes at intersections. This will generate additional traffic and consequently alter the noise environment along the route of the roadway. We used Canarina CUSTIC 3.2 software for noise pollution modeling for the assessment of the noise pollution propagation generated from traffic. The CUSTIC Software allows us to create robust and useful numeric simulations that fully makes use of the graphical user interface. The methodology and governing equations for noise modelling under the graphic user interface of CUSTIC 3.2 is described in Annex A.

A. Basic Data and Assumptions for Noise Impact Modeling

2. Noise emission from vehicles along the route is modelled as steady-state line source. We use the traffic projections (primarily motorized traffic) from the "STPPF (Road Component - Package 1) –Traffic Forecast Report – Feb 2014" to estimate the source emissions according to different scenarios. In the report, traffic projections are made considering 2011 RHD traffic data as the baseline traffic and increasing it by the annual growth rates. For the Rangpur-Hatikamrul route, there is no diverted traffic from any internal road but affected by SAARC traffic. More specifically, for 2011-16, traffic on all seven sections is increased annually by the normal traffic growth rates. In 2016 the additional traffic on all seven sections generated from the SAARC traffic (367 veh./day from Nepal and Bhutan) is added. In 2018 additional SAARC traffic of 1259 veh./day is added up to Gobindaganj and 856 veh./day from Gobindaganj to end point which will be diverted from India. During the period 2018-2040, traffic on all seven sections is increased annually by the normal traffic growth rates.

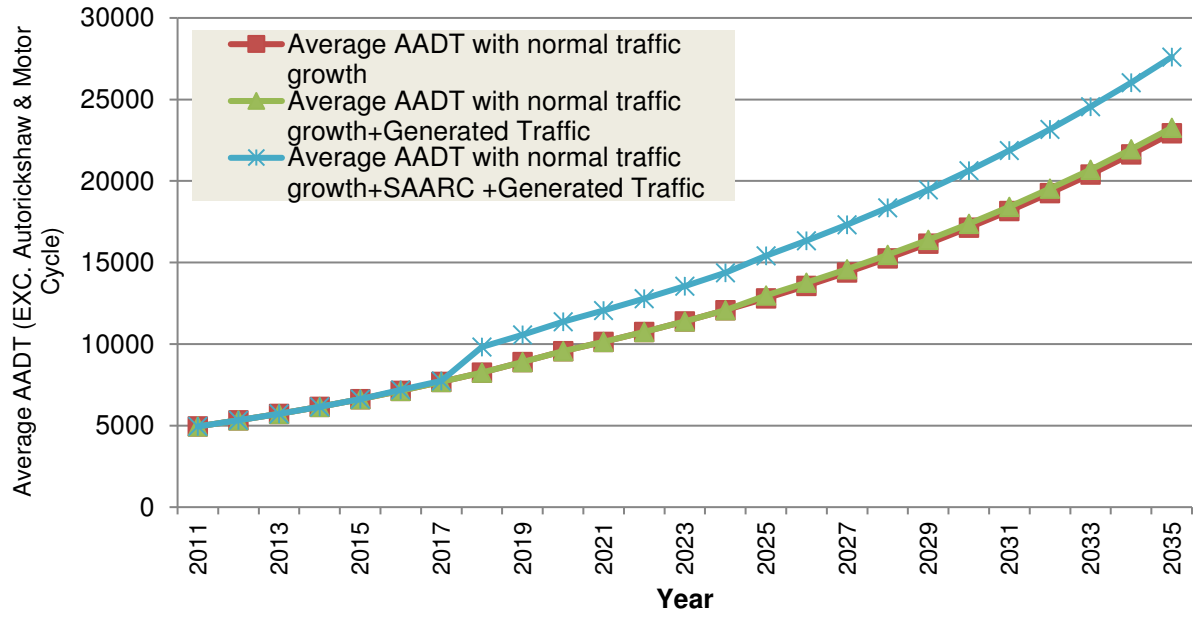


Figure G-1: Traffic Forecast of Rangpur-Hatikamrul Road
(Source: STPPF (Road Component - Package 1) –Traffic Forecast Report – Feb 2014)

3. For noise emission modeling, we considered three scenarios: (i) baseline emission for the current year (i.e. projected estimate of 2016); (ii) projected noise emission for the design year 2033 and (ii) projected noise emission for the year 2040. Estimations of Motorized traffic of different sections of the road for these scenarios (as stated in the STPPF report) are used as input which is summarized in Table 1. Figure 2 shows the different road sections in which noise emission modeling has been performed. The design speed has been assumed to be 80 km/hr for noise emission modeling. The posted speed is 70 km/hr, therefore 80 km/hr will give a conservative estimate of noise emissions.

Table G-1: Baseline traffic data of different sections which were used for noise modeling

Segment name	Box Designation in Figure 2	Baseline traffic for year 2016 (veh/hr)	Projected traffic for 2033 (veh/hr)	Projected traffic for 2040 (veh/hr)
N5-51, between Mithapukur-Rangpur Modern More, Pairabond, km 316.022	1	486	1553	2336
N5-50, between Pirganj-Mithapukur, km 292.502	2	252	871	1309
N5-48, between Palashbari-Pirganj, Ekberpur, km 275.511	3	269	917	1378
N5-45, between Kashipur (Mokamtola)-Gabindaganj, Pakurtala, km 243.512	4	530	1754	2638
N5-33, between Int. with Bogra2nd By pass-Sultanganj, Banani, km 203.568	5	1134	3511	5279
N5-31, Sherpur(Int. withZ-5049)-Sherpur(Int. with Z-5401)	6	854	2717	4085
N5-28,Hatikamrul-Bhuyangati	7	583	1977	2972
N405-1, between Elenga-Jamuna Bridge,11km west of Elenga	8,9,10	775	2123	3802

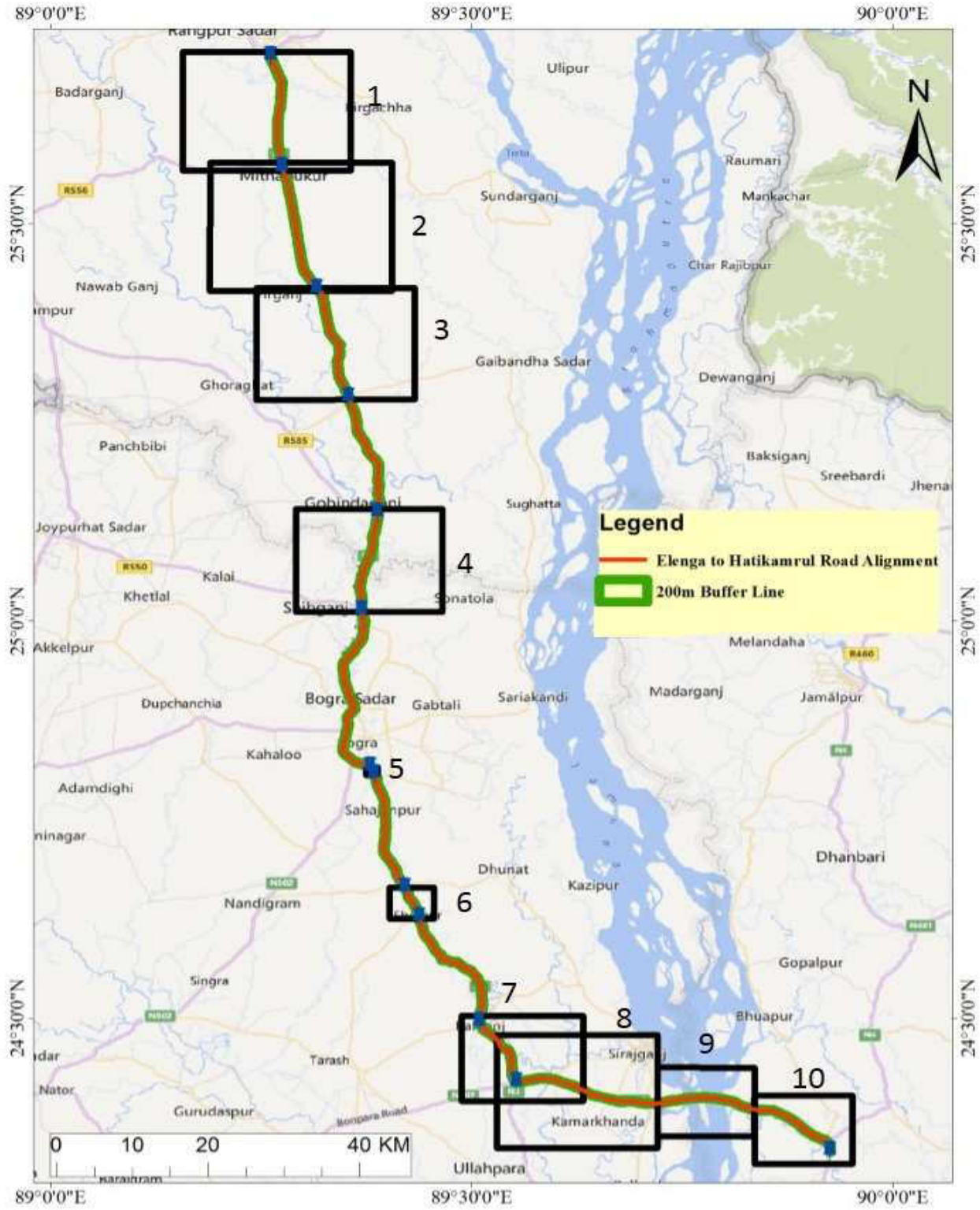


Figure G-2: The different road sections in which noise emission modeling has been performed. Boxes 1 – 10 are delineated in the figure to highlight the road sections (see Table 1 for details) in which noise simulations were made.

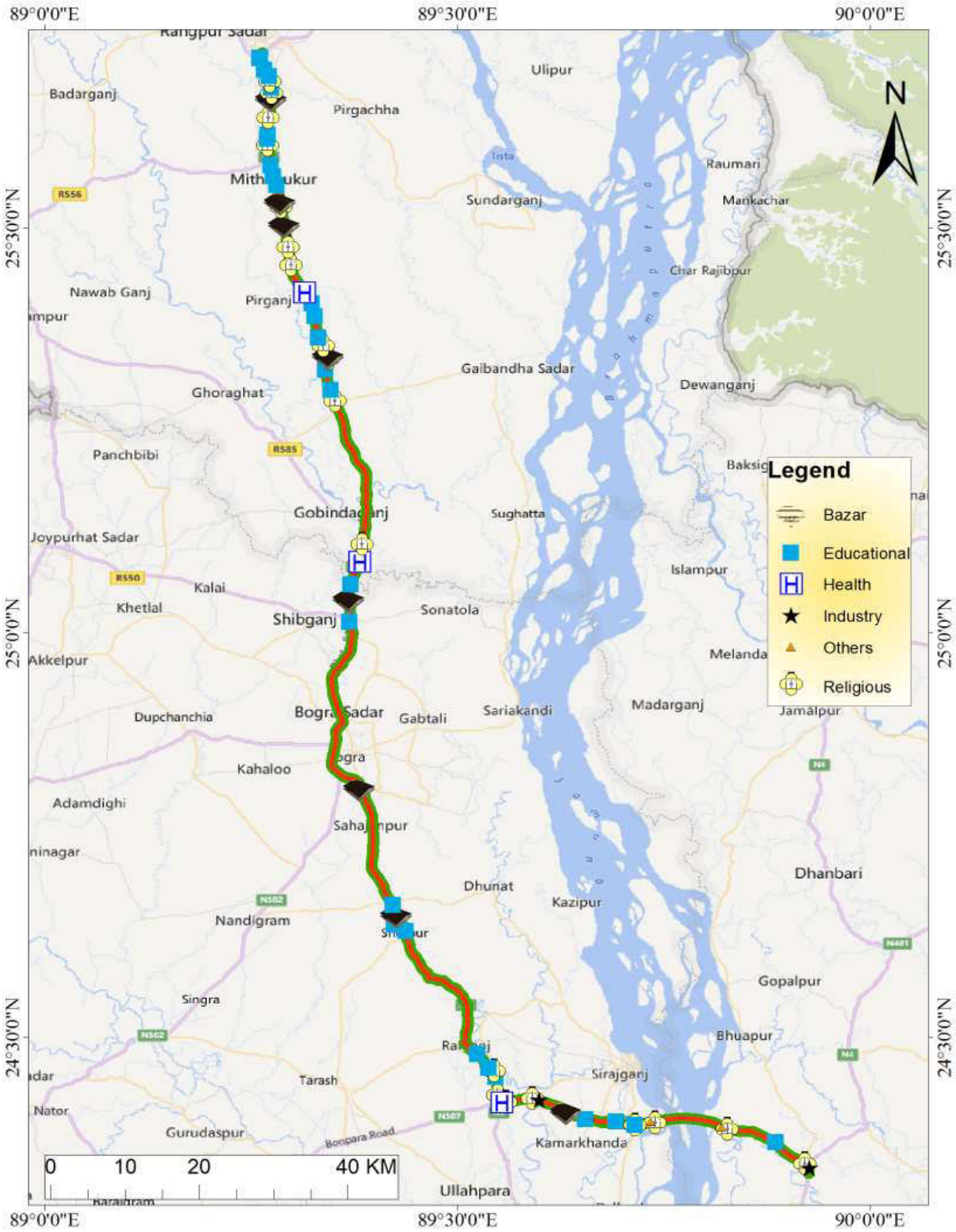


Figure G-3: Location of sensitive noise receptors where baseline noise measurements were carried out along the Elenga- Hatikamrul-Rangpur route

B. Identification of Sensitive Noise Receptors in the Road Network

4. As a part of the baseline study, noise level measurements were made at different locations along the Rangpur-Hatikamrul route. These noise receptors are chosen based on the assumption that these locations may be sensitive to noise increase due to traffic because of the specific nature of the establishment: educational institution, health complexes or religious centres. Baseline noise measurements were performed during daytime with a calibrated noise level meter. 5-minute continuous noise level measurements were carried out at the selected locations in 'A' Weighting and slow Response mode, and the equivalent noise levels (Leq)[24] was determined. Figure 3 shows the locations of these receptors. The noise prediction from CUSTIC 3.2 is compared to the baseline noise to assess the impact of the proposed road development project. Applicable Noise guidelines and standards are provided in Annex B.

C. Noise Impact on Roadside Environment

5. As mentioned earlier, noise impact on roadside environment has been assessed on several sensitive receptors (educational, religious institutions, health facilities) located beside the road. The Hatikamrul-Rangpur route has been divided into 8 road segments, the predicted noise under different scenarios and impact on the receptors are described below:

1. N5-28, Hatikamrul-Bhuyangati

6. The noise simulation under different scenarios for the Hatikamrul-Bhuyangati segment (Box 7 in figure 2) is shown in Figure 4(a). Figure 4(b) provides a spatial noise intensity map of the segment. Table 2 provides the baseline and predicted noise (for the year 2040) at different sensitive receptors identified along the route. It can be seen that

- The baseline noise at these receptors exceed standards for residential areas and are comparable to standards of mixed/commercial/industrial areas.
- There will be slight increment of ambient noise at the educational institutions probably because of their close proximity to the main road.

[24] The equivalent level is the level (L_{eq}) of a hypothetical steady sound that would have the same energy (i.e., the same time-averaged mean square sound pressure) as the actual fluctuating sound observed. The equivalent level represents the time average of the fluctuating sound pressure and is close to the maximum level observed during the measurement period. For the fluctuating noise scenario the equivalent noise level (L_{eq}) is generally used for more complete noise sample and is calculated as follows:

$$L_{eq} = 10\log_{10}\left[\sum_{i=1}^{n} P_i 10^{L_i/10}\right]$$

where P_i is the probability of the noise level lying in the i-the measurement interval and L_i is the mid-point of that interval

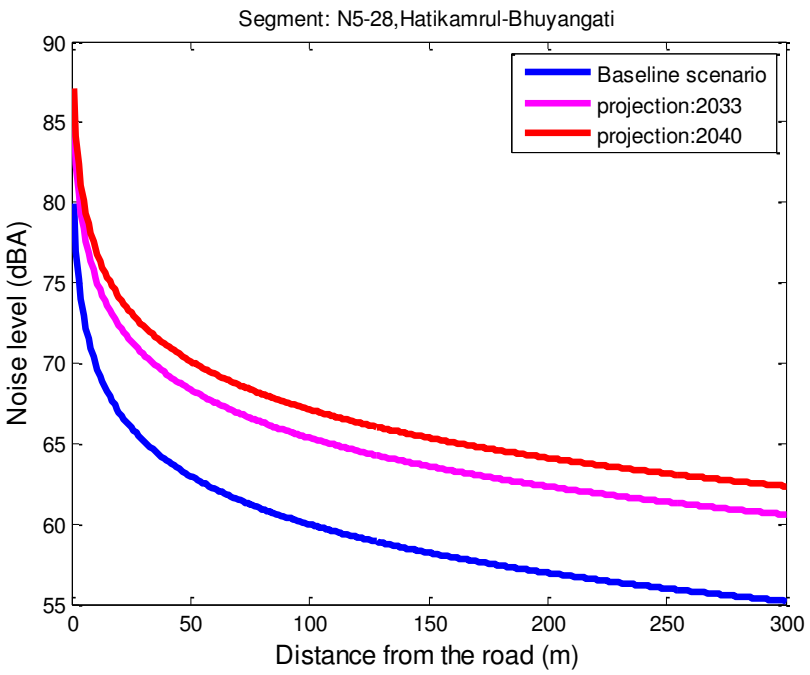


Figure G-4 (a): Noise Prediction under different scenarios as a function of the distance from the road in the Hatikamrul-Bhuyangati segment

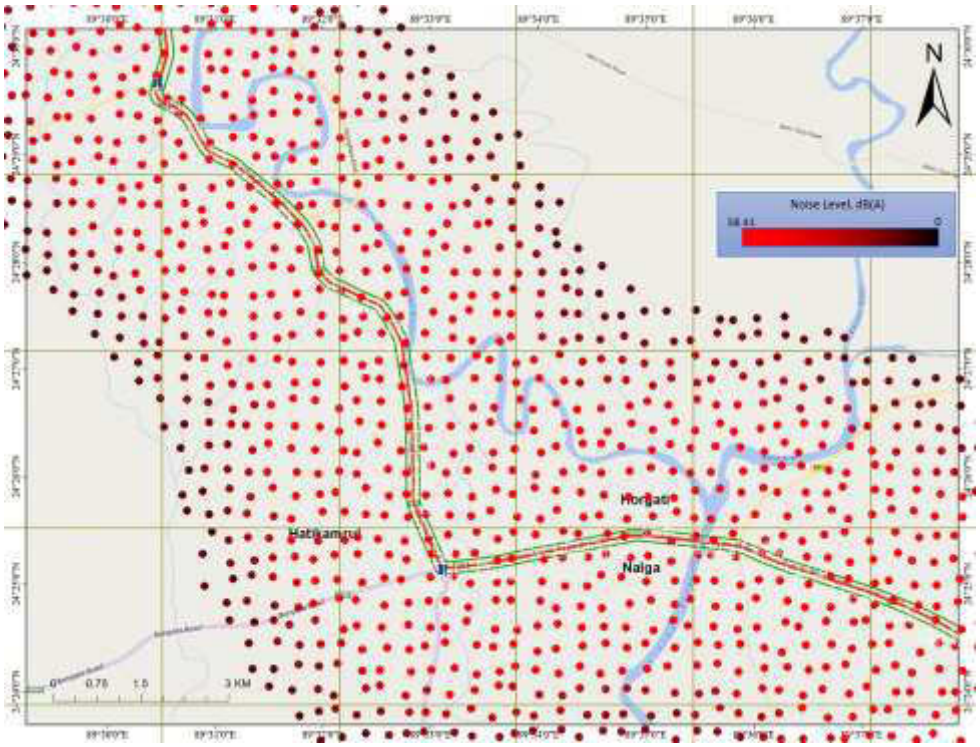


Figure G-4 (b): Spatial noise intensity map of the Hatikamrul-Bhuyangati segment (Box 7)

Table G-2: Baseline and predicted noise (for the year 2040) at different sensitive receptors identified along the Hatikamrul-Bhuyangati route segment

Segment name	Name of sensitive receptor	Type of establishment	Latitude	Longitude	Baseline noise (Leq) under current traffic conditions	Predicted noise (Leq) for the year 2040	Comments (No change/ net increase in noise)
N5-28, Hatikamrul-Bhuyangati	Hatikamrul Puraton Mosque	Religious	24.42852	89.54746	82.5	74.2	No change
	Dadupur Sahebgonj Govt. High School	Educational	24.45099	89.5454	68.6	69.9	**Marginal increase**
	Daudpur Raypara Mosque	Religious	24.45828	89.54364	74.2	72.5	No change
	National Skill Development Institute	Educational	24.46188	89.5375	71.0	73.7	**Net increase**
	Royhati Madrasa Mor	Educational	24.47895	89.52355	70.1	73.4	**Net increase**

2. N5-31, Sherpur Int. with Z-5049)-Sherpur (Int. with Z-5401)

7. The noise simulation under different scenarios for the N5-31, Sherpur (Int. with Z-5049)-Sherpur (Int. with Z-5401) segment (Box 6 in figure 2) is shown in Figure 5(a). Figure 5(b) provides a spatial noise intensity map of the segment. Table 3 provides the baseline and predicted noise (for the year 2040) at different sensitive receptors identified along the route. It can be seen that

- The baseline noise at some of these receptors (except the educational institutions) exceed standards for residential areas
- There will be an increase in ambient noise at the educational institutions probably because of their close proximity to the main road. It may be suggested in the mitigation plan that regular noise monitoring should be conducted in these locations in future and proper mitigation measures should be devised (green-belt development) if required.

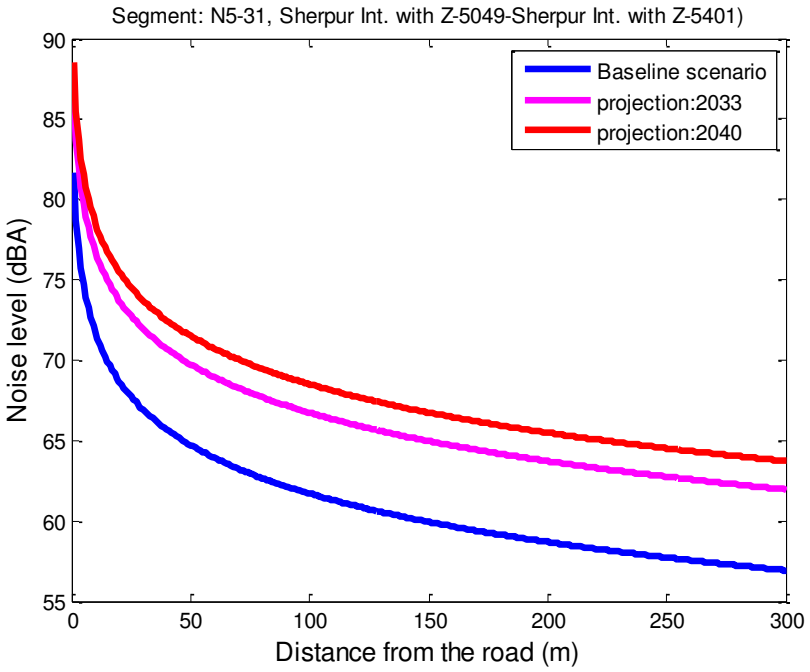


Figure G-5 (a): Noise Prediction under different scenarios as a function of the distance from the road in the N5-31, Sherpur Int. with Z-5049)-Sherpur (Int. with Z-5401)

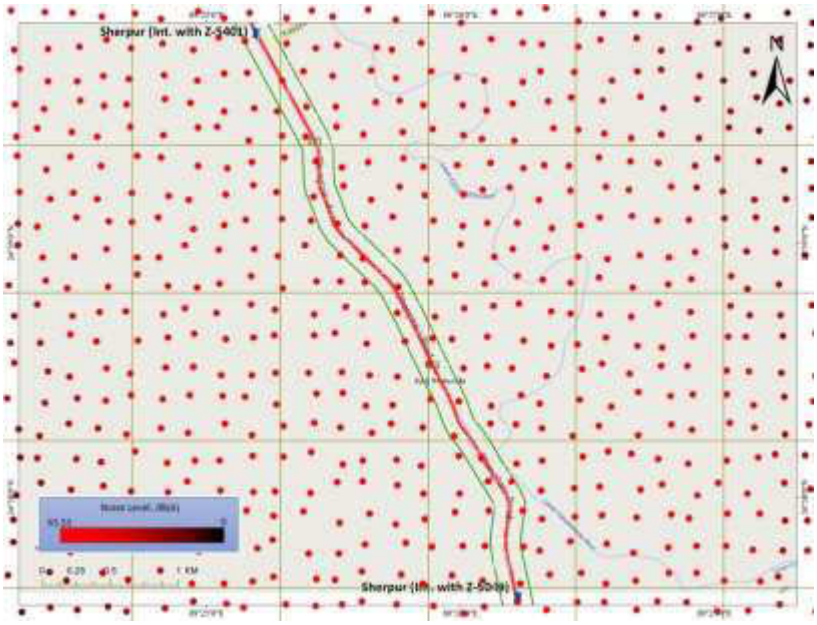


Figure G-5 (b): Spatial noise intensity map of the N5-31, Sherpur Int. with Z-5049)-Sherpur (Int. with Z-5401) (Box 6)

Table G-3: Baseline and predicted noise (for the year 2040) at different sensitive receptors identified along the N5-31 route segment

Segment name	Name of sensitive receptor	Type of establishment	Latitude	Longitude	Baseline noise (Leq) under current traffic conditions	Predicted noise (Leq) for the year 2040	Comments (No change/ net increase in noise)
N5-31, Sherpur Int. with Z-5049)-Sherpur (Int. with Z-5401)	Holi Child School	Educational	24.63166	89.43683	73.2	72.4	No change
	Krishnapur Govt. Primart School	Educational	24.63901	89.43226	57.6	70.6	**Net increase**
	Sherua Bottola Bazar	Bazar	24.65272	89.42429	80.6	75.5	No change
	Jameya Hafizia Madrasha	Educational	24.66334	89.42091	61.8	70.4	**Net increase**

3. N5-33, between Int. with Bogra 2nd By pass-Sultanganj, Banani

8. The noise simulation under different scenarios for the N5-31, Sherpur (Int. with Z-5049)-Sherpur (Int. with Z-5401) segment (Box 5 in figure 2) is shown in Figure 6(a). Figure 6(b) provides a spatial noise intensity map of the segment. Table 4 provides the baseline and predicted noise (for the year 2040) the sensitive receptor identified along the route. It can be seen that the baseline noise at some of the receptors exceed standards for residential areas and there will be no net change of noise due to added traffic in the route.

Table G-4: Baseline and predicted noise (for the year 2040) at different sensitive receptors identified along the N5-33 route segment

Segment name	Name of sensitive receptor	Type of establishment	Latitude	Longitude	Baseline noise (Leq) under current traffic conditions	Predicted noise (Leq) for the year 2040	Comments (No change/ net increase in noise)
N5-33, between Int. with Bogra 2nd By pass-Sultanganj, Banani, km 203.568	Banani Bazar	Bazar	24.81253	89.3807	82.5	74.2	No change

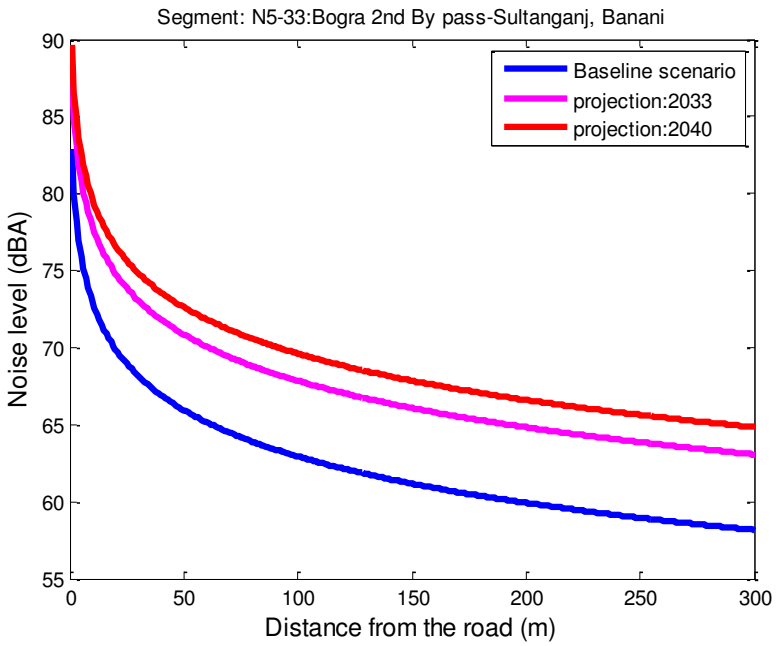


Figure G-6 (a): Noise Prediction under different scenarios as a function of the distance from the road in the N5-33, between Int. with Bogra 2nd By pass-Sultanganj, Banani

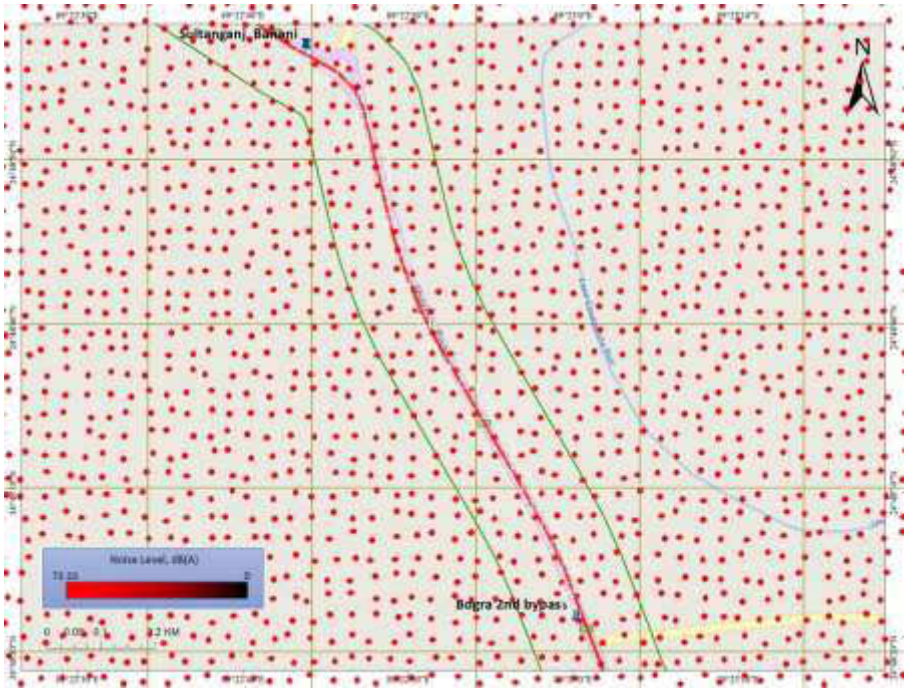


Figure G-6 (b): Spatial noise intensity map of the N5-33, between Int. with Bogra 2nd Bypass-Sultanganj, Banani (Box 5)

4. N5-45, between Kashipur (Mokamtola)-Gabindaganj, Pakurtala

9. The noise simulation under different scenarios for the N5-45, between Kashipur (Mokamtola)-Gabindaganj, Pakurtala (Box 4 in figure 2) is shown in Figure 7(a). Figure 7(b)

provides a spatial noise intensity map of the segment. Table 5 provides the baseline and predicted noise (for the year 2040) at different sensitive receptors identified along the route. It can be seen that

- The baseline noise at some of these receptors exceed standards for residential areas
- There will be an increase in ambient noise at the educational institution and health facility probably because of their close proximity to the main road. It may be suggested in the mitigation plan that regular noise monitoring should be conducted in these locations in future and proper mitigation measures should be devised (green-belt development) if required.

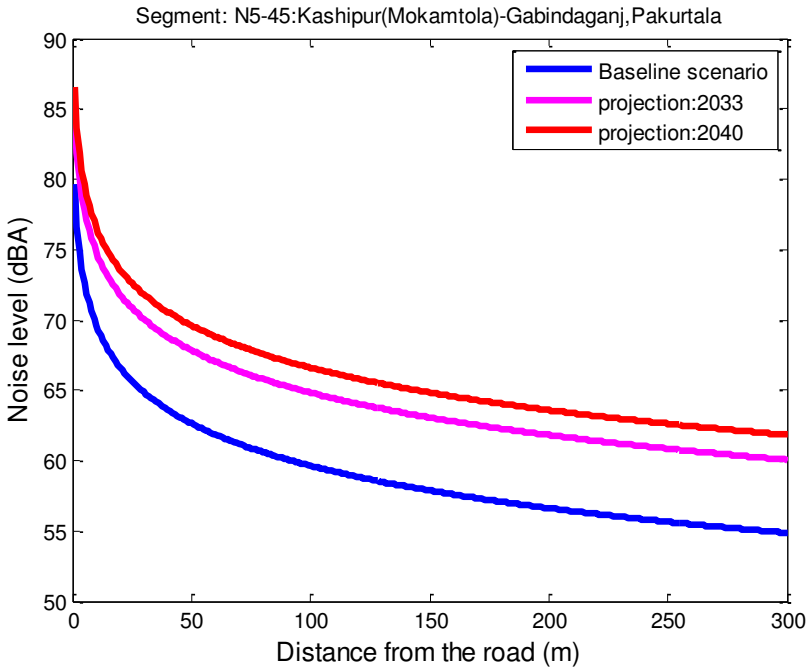


Figure G-7(a): Noise Prediction under different scenarios as a function of the distance from the road in the N5-45, between Kashipur (Mokamtola)-Gabindaganj, Pakurtala

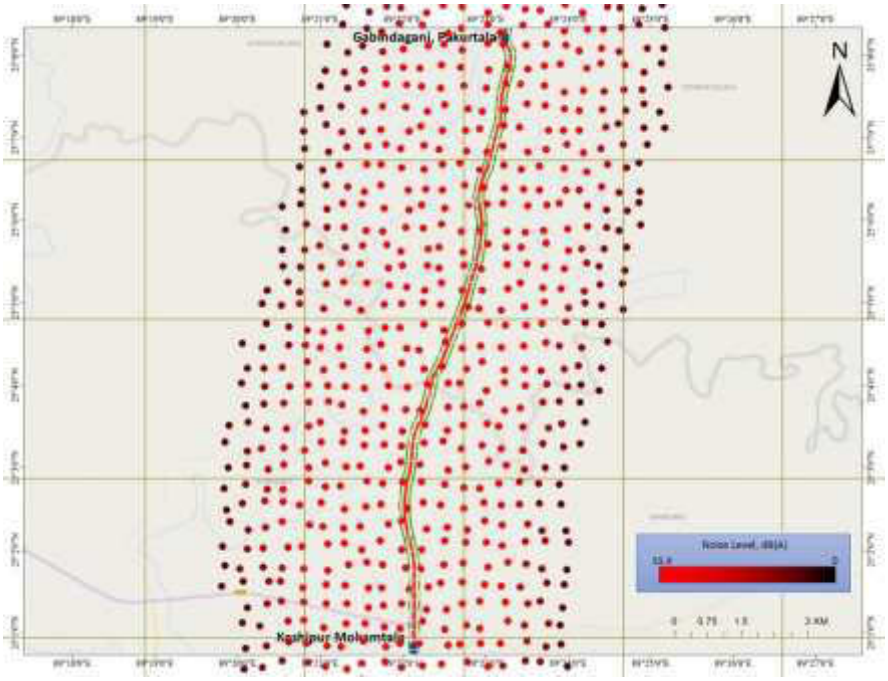


Figure G-7(b): Spatial noise intensity map of the N5-45, between Kashipur (Mokamtola)-Gabindaganj, Pakurtala (Box 4)

Table G-5: baseline and predicted noise (for the year 2040) at different sensitive receptors identified along the N5-45 route segment

Segment name	Name of sensitive receptor	Type of establishment	Latitude	Longitude	Baseline noise (Leq) under current traffic conditions	Predicted noise (Leq) for the year 2040	Comments (No change/ net increase in noise)
N5-45, between Kashipur (Mokamtola)-Gabindaganj, Pakurtala, km 243.512	Makamtola Mohila Degree College	Educational	25.01357	89.36747	63.8	65.0	Marginal increase
	Pakurtola Bazar	Bazar	25.04359	89.36677	75.1	72.1	No change
	Rahbol Girls High School	Educational	25.05966	89.36947	63.4	68.3	Increase
	TMSS Health Complex	Health	25.08785	89.3807	61.8	73.3	Increase
	Boxer Mondolpara Jame Mosque	Religious	25.10972	89.38301	73.8	71.6	No change

5. N5-48, between Palashbari-Pirganj, Ekberpur

10. The noise simulation under different scenarios for the N5-48, between Palashbari-Pirganj, Ekberpur (Box 3 in figure 2) is shown in Figure 8(a). Figure 8(b) provides a spatial noise intensity map of the segment. Table 6 provides the baseline and predicted noise (for the year 2040) at different sensitive receptors identified along the route. It can be seen that

- The baseline noise at most of these receptors exceed standards for residential areas mainly due to high level of human activities during daytime
- There will be a marginal increase in ambient noise at few of these receptors and overall the generated noise will not alter the existing noise environment significantly.

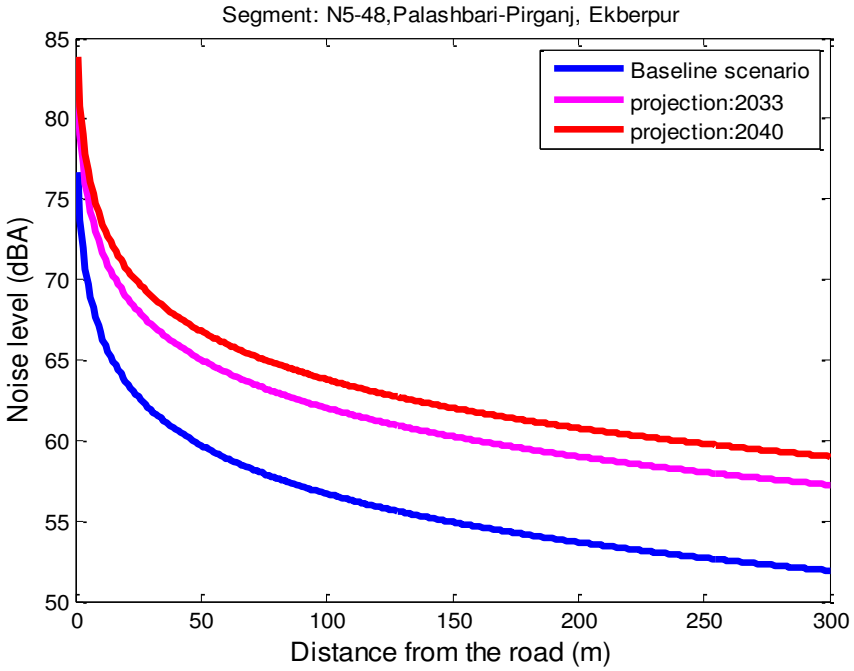


Figure G-8 (a): Noise Prediction under different scenarios as a function of the distance from the road in the N5-48, between Palashbari-Pirganj, Ekberpur

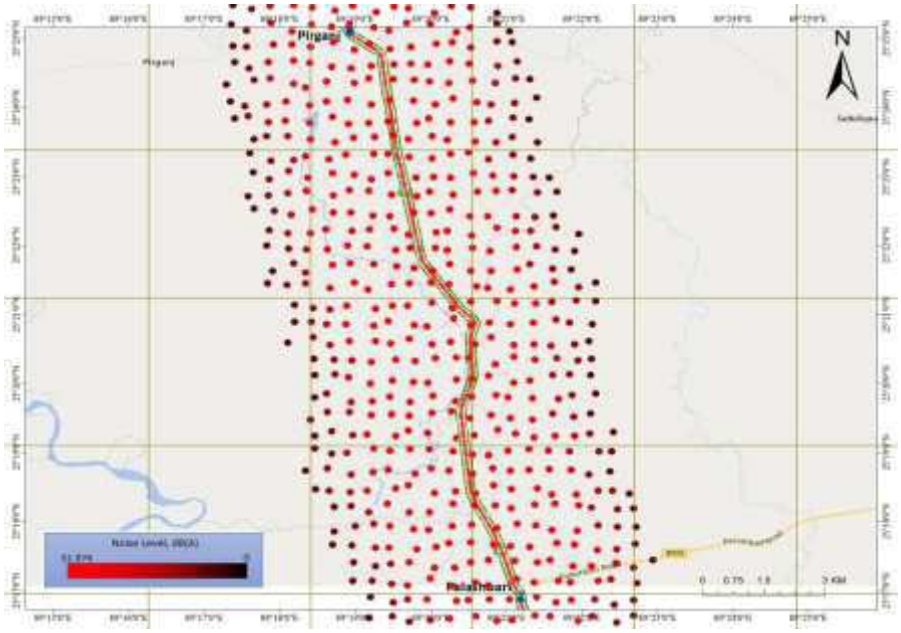


Figure G-8 (b): Spatial noise intensity map of the N5-48, between Palashbari-Pirganj, Ekberpur (Box 3)

Table G-6: baseline and predicted noise (for the year 2040) at different sensitive receptors identified along the N5-48 route segment

Segment name	Name of sensitive receptor	Type of establishment	Latitude	Longitude	Baseline noise (Leq) under current traffic conditions	Predicted noise (Leq) for the year 2040	Comments (No change/ net increase in noise)
N5-48, between Palashbari-Pirganj, Ekberpur, km 275.511	Mosque	Religious	25.28686	89.35039	74.7	66.7	No change
	Mosheshpur Govt. Primary School	Educational	25.30028	89.34622	73.7	66.3	No change
	Akbarpur Govt. Primary School	Educational	25.32521	89.33933	65.3	65.2	No change
	R. V. Cold Storage Mosque	Religious	25.33883	89.34263	66.8	69.3	**Increase**
	Dhaperhat Bazar	Bazar	25.3441	89.3419	70.6	72.9	**Increase**
	Mosque	Religious	25.35539	89.33632	71.3	66.9	No change
	Madarpur Govt. Primary School	Educational	25.36537	89.33066	73.9	70.8	No change
	Lillah Boarding Madrasha	Educational	25.39123	89.32641	61.5	64.4	**Increase**
	PirganjMohila Technical and BM College	Educational	25.40738	89.32244	69.3	65.3	No change

6. N5-48, between Pirganj, Ekberpur -Mithapukur

11. The noise simulation under different scenarios for the N5-50, between Pirganj-Mithapukur (Box 2 in figure 2) is shown in Figure 9(a). Figure 9(b) provides a spatial noise intensity map of the segment. Table 7 provides the baseline and predicted noise (for the year 2040) at different sensitive receptors identified along the route. It can be seen that

- The baseline noise at most of these receptors exceed standards for residential areas mainly due to high level of human activities during daytime.
- There will be a marginal increase in ambient noise at only one of the receptors (a mosque) and overall the generated noise will not alter the existing noise environment significantly

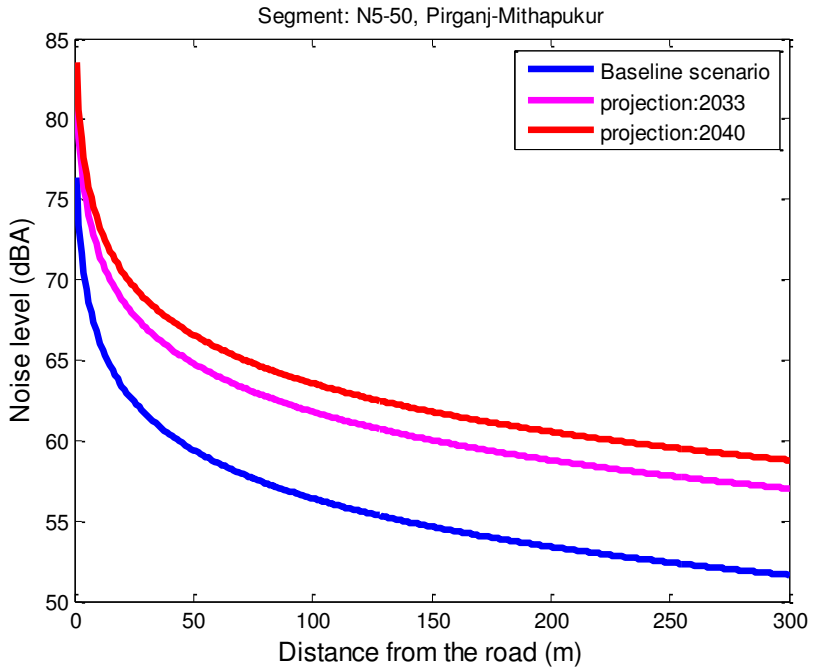


Figure G-9 (a): Noise Prediction under different scenarios as a function of the distance from the road in the N5-50, between Pirganj-Mithapukur

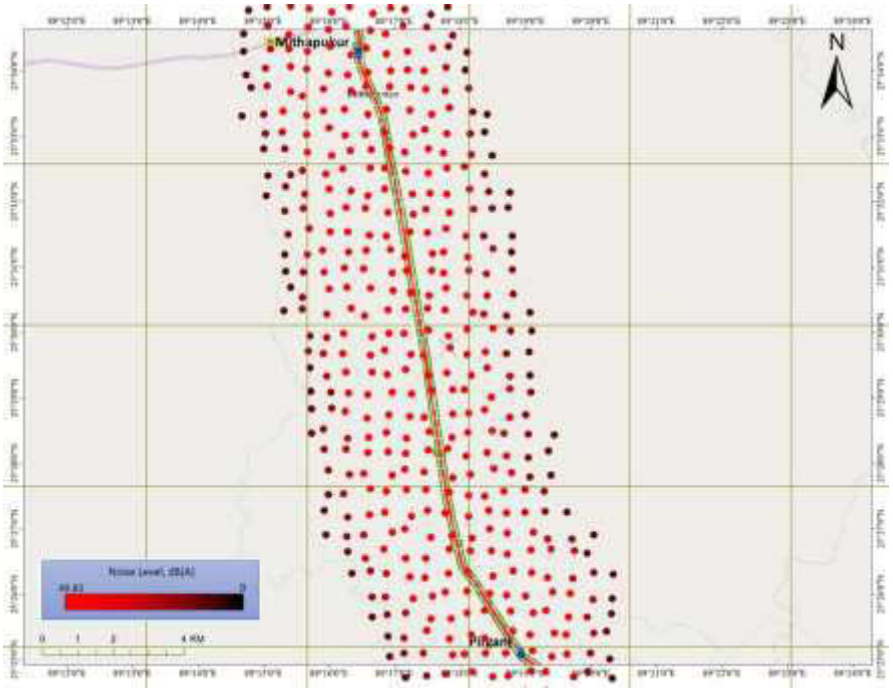


Figure G-9 (b): Spatial noise intensity map of the N5-50, between Pirganj-Mithapukur (Box 2)

Table G-7: baseline and predicted noise (for the year 2040) at different sensitive receptors identified along the N5-50 route segment

Segment name	Name of sensitive receptor	Type of establishment	Latitude	Longitude	Baseline noise (Leq) under current traffic conditions	Predicted noise (Leq) for the year 2040	Comments (No change/ net increase in noise)
N5-50, between Pirganj-Mithapukur, km 292.502	Pirganj Community Eye Hospital	Health	25.42076	89.31395	69.3	70.5	No change
	Mosque	Religious	25.45452	89.29762	65.4	69.9	**Increase**
	Bishmail Jame Mosque	Religious	25.47706	89.29352	69.5	69.7	No change
	Borodorga Bazar	Bazar	25.50597	89.2894	71.9	69.4	No change
	ShotibariJame Mosque	Religious	25.52649	89.28544	74.2	70.9	No change
	Sathibari Bazar	Bazar	25.53495	89.28418	79.7	72.0	No change
	Al Farukh High School	Educational	25.5536	89.27981	75.2	65.2	No change
	Hera Memorial Mohila Mohabiddaloy	Educational	25.56396	89.27596	72.6	68.0	No change

7. N5-51, between Mithapukur-Rangpur Modern More, Pairabond

12. The noise simulation under different scenarios for the N5-51, between Mithapukur-Rangpur Modern More, Pairabond (Box 1 in figure 2) is shown in Figure 10(a). Figure 10(b) provides a spatial noise intensity map of the segment. Table 8 provides the baseline and predicted noise (for the year 2040) at different sensitive receptors identified along the route. It can be seen that

- The baseline noise at most of these receptors exceeds standards for residential areas mainly due to high level of human activities during daytime.
- There will be an increase in ambient noise at the educational institutions probably because of their close proximity to the main road. It may be suggested in the mitigation plan that regular noise monitoring should be conducted in these locations in future and proper mitigation measures should be devised (green-belt development) if required.

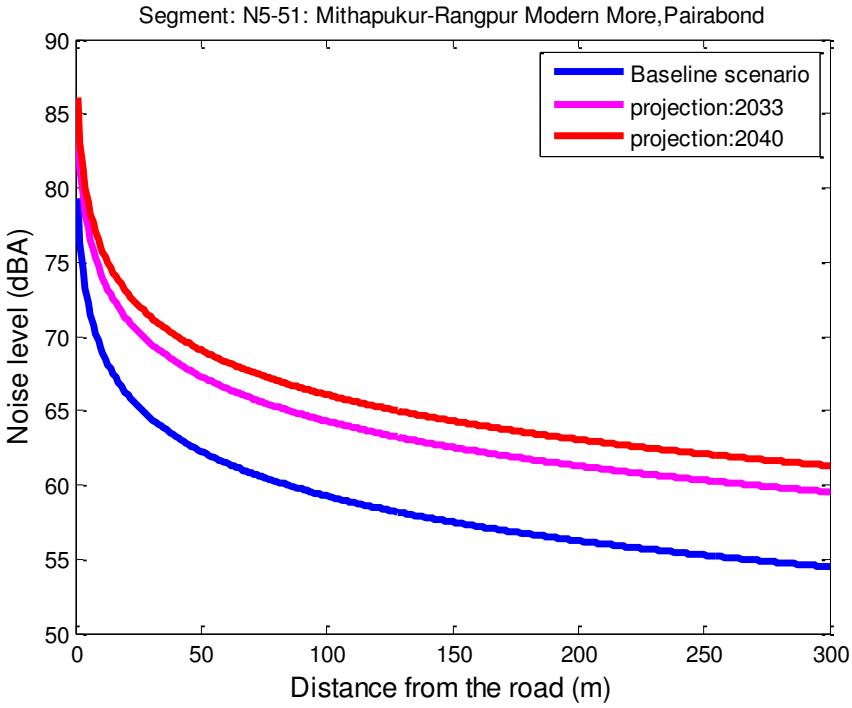


Figure G-10(a): Noise Prediction under different scenarios as a function of the distance from the road in the N5-51, between Mithapukur-Rangpur Modern More, Pairabond

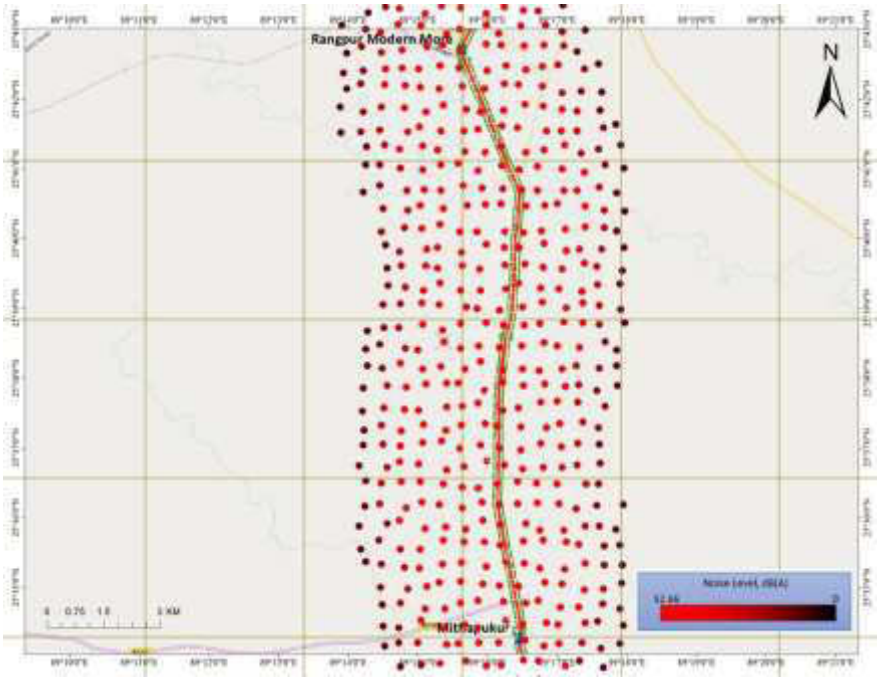


Figure G-10(b): Spatial noise intensity map of the N5-51, between Mithapukur-Rangpur Modern More, Pairabond (Box 1)

Table G-8: baseline and predicted noise (for the year 2040) at different sensitive receptors identified along the N5-50 route segment

Segment name	Name of sensitive receptor	Type of establishment	Latitude	Longitude	Baseline noise (Leq) under current traffic conditions	Predicted noise (Leq) for the year 2040	Comments (No change/ net increase in noise)
N5-51, between Mithapukur -Rangpur Modern More, Pairabond, km 316.022	Mithapukur Autistic School	Educational	25.57818	89.27351	67.2	70.1	**Increase**
	Batason Fathehfur Jame Mosque	Religious	25.60268	89.26888	74.4	72.6	No change
	Genbikash Sishukanon	Educational	25.61124	89.26881	73.4	71.7	No change
	Adorsho High School	Educational	25.61546	89.26982	70.8	67.8	No change
	Mosque	Religious	25.63672	89.2699	74.3	71.9	No change
	Boiriganj Bazar	Bazar	25.66192	89.27274	80.6	68.8	No change
	Islampur Mondon Para Mosque	Religious	25.6672	89.27393	67.5	68.9	**Increase**
	Payrabondo Salehkiya Madrasa	Educational	25.6738	89.27351	61.6	69.1	**Increase**
	Hazipara Jame Mosque	Religious	25.68171	89.27203	69.0	68.6	No change
	Drishtiprotibondhi School	Educational	25.68816	89.27077	61.2	67.0	**Increase**
	Popular Model School	Educational	25.69598	89.26561	77.3	66.1	No change
	Muslim Aid Institute of Technology	Educational	25.71022	89.25935	72.5	64.8	No change
	North Bengal University	Educational	25.71091	89.26022	69.7	72.3	**Increase**

8. Tangail (Elenga)-Hatikamrul Road

13. The noise simulation under different scenarios for the Tangail (Elenga)-Hatikamrul Road (Box 8-10 in figure 2) is shown in Figure 11(a). Figure 11(b) provides a spatial noise intensity map of the segment. Table 9 provides the baseline and predicted noise (for the year 2040) at different sensitive receptors identified along the route. It can be seen that

- The baseline noise at most of these receptors exceeds standards for residential areas mainly due to high level of human activities during daytime.
- There will be an increase in ambient noise at most of the receptors identified along the route. It may be suggested in the mitigation plan that regular noise monitoring should be conducted in these locations in future and proper mitigation measures should be devised (green-belt development) if required.

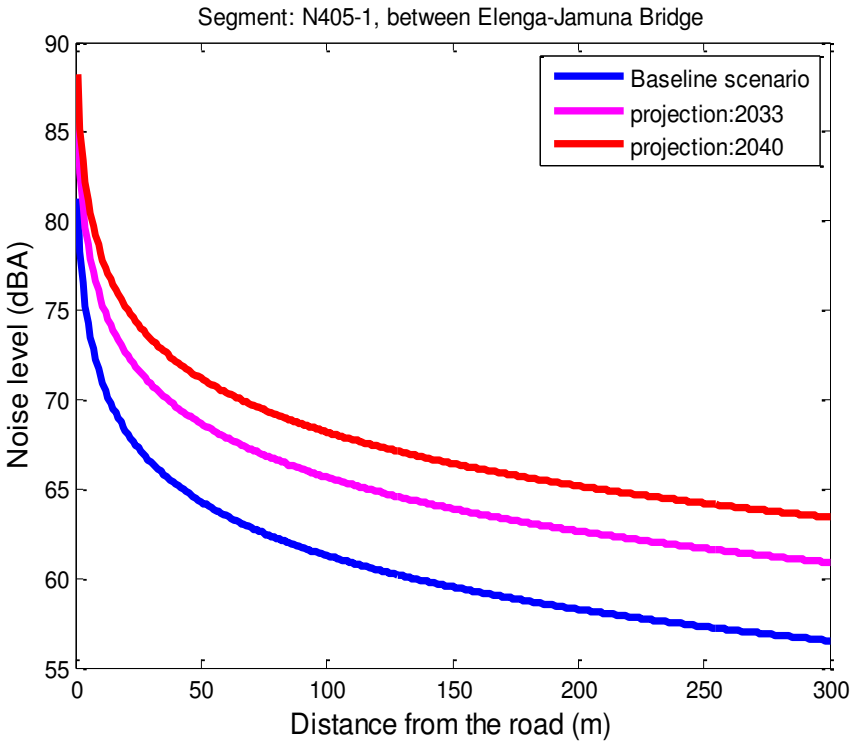


Figure G-11(a): Noise Prediction under different scenarios as a function of the distance from the road in Tangail (Elenga)-Hatikamrul Road segment

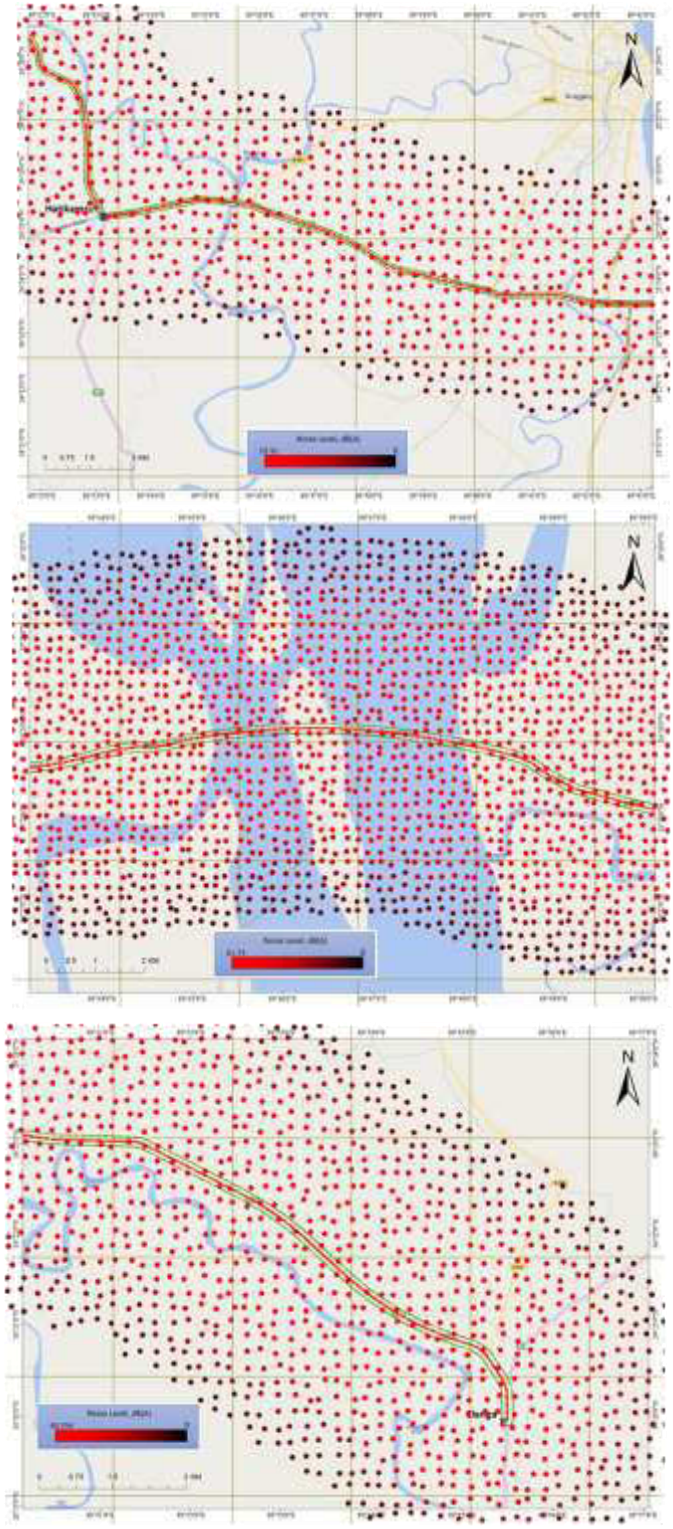


Figure G-11(b): Spatial noise intensity map of the Tangail (Elenga)-Hatikamrul Road (Box 8, 9 and 10)

Table G-9: baseline and predicted noise (for the year 2040) at different sensitive receptors identified along the Tangail (Elenga)-Hatikamrul Road segment

Segment name	Name of sensitive receptor	Type of establishment	Latitude	Longitude	Baseline noise (Leq) under current traffic conditions	Predicted noise (Leq) for the year 2040	Comments (No change/ net increase in noise)
Tangail (Elenga)-Hatikamrul Road	Bytunnur Jame Mosque	Religious	24.34407	89.91985	62.0	67.4	**Increase**
	An-Noor Mosque	Religious	24.38649	89.8258	62.0	68.5	**Increase**
	Mosque	Religious	24.39461	89.73837	48.9	65.6	**Increase**
	Sayadabad Mosque	Religious	24.39177	89.71413	61.0	69.9	**Increase**
	Dhopakanti Mosque	Religious	24.42	89.5575	72.3	74.8	**Increase**
	Fuljor Degree College Mosque	Religious	24.42454	89.58956	65.7	68.0	**Increase**
	Bangabandhu Setu Purbo Station	Others	24.38945	89.81992	66.3	72.4	**Increase**
	Bangabandhu Setu Poschim Station	Others	24.39579	89.73359	59.7	71.8	**Increase**
	Hatikomrul Highway Thana	Others	24.41885	89.55367	76.0	70.7	No change
	Gas Transmission Company Ltd	Industry	24.3384	89.92561	73.5	68.9	No change
	Poschimanchol Gas Company Limited	Industry	24.42158	89.59808	74.6	68.6	No change
	Shakhawat Memorial Hospital	Health	24.41961	89.55268	80.0	72.3	No change
	Analiabari High School	Educational	24.37013	89.88501	60.3	66.1	**Increase**
	Talimul Islam Madrasha	Educational	24.39169	89.7142	66.0	69.3	**Increase**
	Jamuna Polytechnic Institute	Educational	24.39612	89.69189	64.6	67.6	**Increase**
	Shohidul Bulbul Karigori College	Educational	24.39864	89.65486	63.4	66.9	**Increase**
	Simanto Bazar	Bazar	24.41015	89.63028	67.0	73.6	**Increase**

Annex A: Methodology for Noise Modeling

A. Noise Model

1. Noise emission from the proposed road network will be modeled using CUSTIC 3.2 (Canarina Environmental Software, Spain). CUSTIC 3.2 noise modeling is based on estimates for dispersion of noise in free field by means of numerical simulations which provides approximate values for the noise levels, regardless of source type (point, line or area). The program calculates the noise level discrete points in space considering different kind of sources and the conditions of the atmosphere. Figure 1 presents the input and output data of the CUSTIC 3.2 software. As shown on the Figure 1, input data include: type of source (point, line ore area), ambient (climate) data, grid size and scale. Based on data entered the software calculates noise levels and presents those levels in form of iso-lines, numerical grid or color gradient.

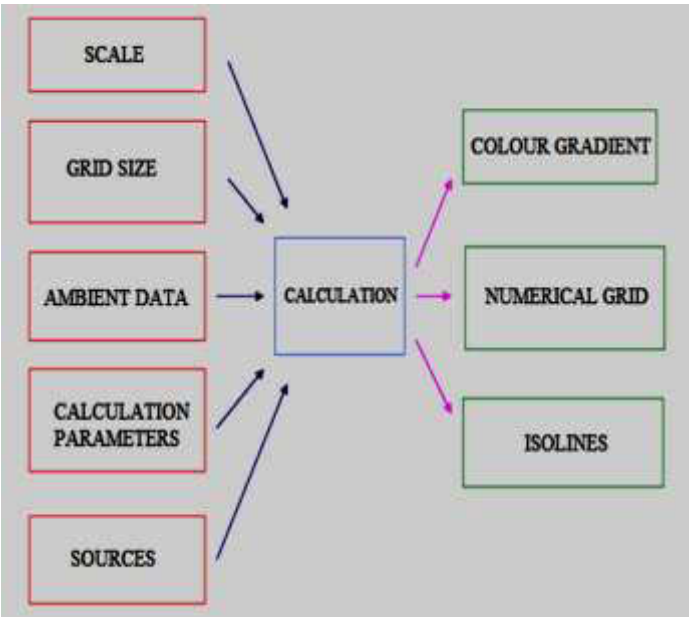


Figure 1: Input and output data arrangements in CUSTIC 3.2

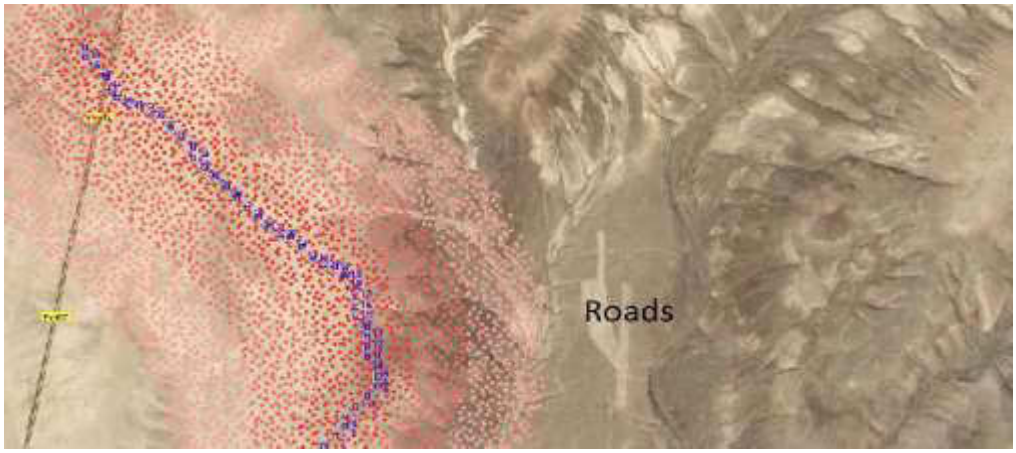


Figure 2: A typical noise intensity output in CUSTIC 3.2 for a typical road using line noise source.

Mathematical Construct of Noise Dispersion Model

2. The mathematical model that the software uses provides options to model noise emissions from a wide range of sources that might be present at industrial areas and urban areas. The basis of the model is the linear sound propagation equation, which is used to model simple point source emissions from vehicles, industries, aircrafts etc. Emission sources are categorized into two basic types of sources: point sources and line sources. The algorithms used to model each of these source types are described in the following:

3. The CUSTIC software accepts meteorological data records to define the conditions for sound propagation. The model estimates the noise level for each source and receptor combination and calculates user-selected averages. For an external source, the noise level equation is

$$\boldsymbol{L_{eq} = LW - 20\times \log(r) - 11\times dB(A)}$$

Where **r** is the distance and LW the source power.

4. However, for an industrial complex, the following equation will be used:

$$\boldsymbol{L_{eq} = L_i + 10\times \log(S) - 20\times \log(r) - 14\times dB(A)}$$

Where $\boldsymbol{S}$ is the external surface and $\boldsymbol{L_i}$ is the internal noise power.

5. In a road case, we shall consider several points. We shall consider a minimum number of 1000 vehicles per hour N with a 50km/h minimum velocity (100km/h is the maximum velocity). Then we have a 68 dB(A) noise level at 10m from a lineal road (infinity length). The noise level in the linear (infinite) road case will be,

$$\boldsymbol{L_{eq} = 68\times dB(A) + 30\log(v/50) + 10\times \log(N/1000) - 10\times \log(r/10)}$$

6. In the curved road case, the program considers a finite element method of calculation. Each small size of road contributes to the total noise level. Each contribution will be given by

$$\boldsymbol{L_i = 10\times \log(a/180)}$$

Where **a** is the angle of the small road size (degrees).

7. To obtain the total noise level, we add the different $\mathbf{L_i}$ values following the equation

$$\boldsymbol{L_{eq} = 10\times \log[\sum_i 10^{(L_i/10)}]}$$

This model performs satisfactorily for simple sound propagations with no ground interaction or attachment. The application will not consider sound reflections in the ground surface.

Data and Assumptions in the Noise model

8. The noise model will consider the following:

- Current noise emissions will be predicted based on current vehicle density in the proposed road sections. The estimated projected traffic will be used to predict the noise in future times.
- Flat topographic features (no undulations) will be assumed in the noise model. Meteorological information of the respective area will be used as input parameters.
- Contour diagrams of noise isolines will be generated along the proposed road route
- Several potential sensitive receptors will be located along the route of the road network (educational institutions, hospitals, religious institutions) and the incremental increase in noise will be calculated based on measured baseline noise in those locations and predicted noise from CUSTIC 3.2

Reference:

CUSTIC 3.2 Noise Pollution Modeling Software, Manuel, 2004.CanarinaAlgorithosNumericos, S.L.

Annex B: Ambient Noise Standards and Guidelines

Table B-1: Bangladesh standards for sound level (GoB, 2006)

Locations	Noise level (dBA) at day	Noise level (dBA) at night
Silent zone	50	40
Residential area	55	45
Mixed area	60	50
Commercial area	70	60
Industrial area	75	70

(Ref: Noise Pollution Control Rules, 2006)

Table B-2: Noise Level Guidelines Measure Out of Doors. (Guidelines for Community Noise, WHO, 1999)

Receptor	One Hour L_{Aeq} (dBA)	
	Daytime 07:00 – 22:00	Night-time 22:00 – 7:00
Residential, institutional, educational	55	45
Industrial, commercial	70	70

Note: For acceptable indoor noise levels for residential, institutional, and education settings refer to WHO (1999).

Table B-3: Noise Limits for Various Working Environments.

Location/ activity	Equivalent Level L_{Aeq}, 8h	Maximum L_{Amax}, fast
Heavy Industry (no demand for oral communication)	85 dB(A)	110 dB(A)
Light Industry (decreasing demand for oral communication)	50 – 65 dB(A)	110 dB(A)
Open offices, control rooms, service counters or similar	45 – 50 dB(A)	--
Individual offices (no disturbing noises)	40 – 45 dB(A)	--
Classrooms, lecture halls	35 – 40 dB(A)	--
Hospitals	30 – 35 dB(A)	40 dB(A)

Note: For acceptable indoor noise levels for residential, institutional, and education settings refer to WHO (1999).