RIGA TECHNICAL UNIVERSITY

Līga LIEPLAPA

METHODOLOGY OF ROAD ENVIRONMENTAL IMPACT ASSESSMENT

Summary of doctoral thesis

Riga, 2013

RIGA TECHNICAL UNIVERSITY
Faculty of Power and Electrical Engineering
Institute of Environmental Protection and
Heating Systems

Līga LIEPLAPA
Environmental science doctoral program

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Summary of doctoral thesis

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Riga 2013

UDK 502.175 (043.2)
Li 266 m

Lieplapa L. Methodology of Road Environmental Impact Assessment. Summary of doctoral thesis. - Riga: RTU, 2013. - 42 pp.

Published in accordance with the resolution of RTU, Institute of Environmental Protection and Heating Systems protocol No. 31, December 17, 2012.

ISBN 978-9934-8302-7-3

DISSERTATION PROPOSED FOR DOCTOR DEGREE IN ENVIRONMENTAL MANAGEMENT AT RIGA TECHNICAL UNIVERSITY

This doctoral thesis is proposed for attaining doctor degree in environmental science and will be defended on July the 8th, 2013 at 10:00 at the RTU, Faculty of Power and Electrical Engineering, 1 Kronvalda Boulevard, room No. 21.

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CONFIRMATION STATEMENT

I, the undersigning, hereby confirm that I have developed this dissertation, which is submitted for consideration at Riga Technical University for attaining doctoral degree of environmental science. This study has not been submitted to any other university or institution for the purpose of attaining scientific degrees.

Līga Lieplapa …………………………….
Date: ………………………

The dissertation is written in Latvian and contains: introduction, 4 chapters, conclusions, bibliography, 45 figures, 20 tables and 100 pages. The bibliography contains 133 titles.

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TOPICALITY OF RESEARCH

Joining common economical space, developing awareness of environment on the public and state level, political and economical significance of environmental solutions is increasing in Latvia. Since the law „On Environmental Impact Assessment" (1998) came into force more than 100 environmental impact assessments are performed for projects of different branches of economics.

Environmental impact assessment (EIA) is the first and the most important step to forecast a possible environmental load of planned economical activities and implement preventive environmental protection measures. It is a ground for decision making on acceptance or rejection of planned economical activity. Therefore a quality of environmental impact assessment is becoming more important and more urgent during last year's. At the moment quality of EIA and the main conclusions often depend on knowledge, experience and even opinion of involved experts, rarely based on objective data interpretation and/or retrospective, mutually comparable quantitative evaluation of EIA of similar objects.

EIA should give a reasonable answer to the questions how and how much planned project will impact the environment, what changes are anticipated if technological or environmental parameters will change. This answer can be given only using measurable, verifiable numbers – environmental indicators, and not using general environmental description and assessment based on assumptions. During the last years critical attitude of society against credibility of EIA results is appears more and more often, formal nature and uncertainty of results of EIA reports can be noticed, but with implementation of method of environmental indicators the cooperation among project developer, society and decision makers would be facilitated to support the best possible alternative of project development.

When economics develops and purchasing capacities improves the number of vehicles and traffic intensity are increasing promoting an improvement and development of infrastructure of motor roads. Through the increase of carrying capacity of vehicles, many traditional types of railway cargo transportation are shifted to motor roads more and more often. The distances of waste transportation also are increased. These and many other trends increase significantly environmental load and also potential risks, raise quality requirements for roads and building technologies. Insufficiently assessed environmental risks can cause irreversible damage to the environment and worsen quality of life of significant part of society. Eco-effective, qualitative and strategically well-positioned development of traffic infrastructure is the basis of economical development in every region and in whole Latvia. Previously mentioned conditions increase an importance, complexity and quality requirements of EIA a number of times – it should be based on the newest scientific conclusions and should synergistically include national strategies and regional spatial development planning.

Since the results of environmental impact assessments and road infrastructure developed according to these results influence society wellness and long-term social and economic development of Latvia, the indicator approach developed as a result of this doctoral thesis and use of benchmarking method in the process of EIA can significantly improve efficiency of financial investment of road building during the next 20 years as well as life quality of society. Implementation of benchmarking method in EIA is economically profitable, it does not need significant financial investments and the credibility of results is high. The method is based on actual measurement results of environmental parameters.

As a result of this research the methodology of road project environmental impact assessment is developed. Thereby the risk of possible speculations based on information and interpretations is reduced giving to society and decision makers numerical and verifiable data. The methodology is approbated in this research and it can be used in practice.

OBJECTIVES AND TASKS

The main objective of the thesis is to develop a methodology of road environmental impact assessment based on system of environmental parameters and environmental indicators.

In order to achieve the objective the following tasks are established:

1) To analyze the use of environmental parameters and indicators in environmental impact assessments of road projects, to develop methodology of indicator validation and approbate it.
2) To perform measurements after building of new road to evaluate changes of freely chosen environmental parameters, to develop environmental indicator as characteristic for further environmental impact assessment.
3) To find empirical equation mathematically describing connection between changes of values of chosen environmental indicator depending on independent variables.
4) To develop algorithm of environmental indicator benchmarking method taking into account engineering and environmental aspects.
5) To develop environmental indicator benchmarking methodology using data from environmental impact assessments of 14 road

projects in Latvia and comparing them with measurement results of freely chosen environmental indicators.

6) To develop recommendations for quality improvement of environmental impact assessments.

Based on those results the common matrix of indicator system for EIA of road projects is prepared in order to make information enclosed in assessment controllable, verifiable and objective. The use of indicator method can give a huge methodological and informative support to EIA developers, society and decision makers.

METHODS OF RESEARCH

During the research generally adopted quantitative and qualitative methods on data analyses were used including statistical data processing, grouping of data, regression analyses of data, inductive – deductive methods of data analyses. Comparative, analytical and graphical methods are used to compare and analyze facts and evaluate solutions for specific questions. In order to make data visualization the author of this doctoral thesis used tables and figures.

In this doctoral thesis methodology of road project environmental impact assessment is described, characteristics influencing emissions into air are defined; benchmarking method is described and modified to use it for EIA – to assess environmental impact. In this case the methodology is approbated on evaluation of NO_x, PM, CO emissions into air and noise. An analysis of use of indicators for underground water quality and hydro geological conditions and indicators are chosen to approbate benchmarking method.

SCIENTIFIC NOVELTY OF THESIS

During the research a methodology of environmental impact assessment is developed containing modules of determination of environmental impact indicators for roads.

Elaboration of doctoral thesis was started with development of system for validation of environmental indicators and parameters for road project environmental impact assessment. Proposed indicator validation system allows quantitatively determine current environment situation and to perform objective, comparable and verifiable environmental impact assessment.

In this doctoral thesis research methodology is presented covering regression analysis of obtained data and determination of empirical environmental indicators obtained with the help of computer program STATGRAPHICS Plus. Performing mathematical analysis of data obtained from road project environmental impact assessment empirical equation is obtained and adequacy of it is verified. Empirical models for indicators of harmful emissions into air and noise are obtained depending on number of road transport. Therefore based on establishment of freely chosen environmental indicators and determination of values possibility of development of environmental indicator empirical models is approbated. The methodology is possible to use for determination of empirical models of other environmental indicator component. It allows forecasting a level of environment pollution after project implementation and it can be used to verify results of other calculation methods.

In this doctoral thesis methodology of environmental indicator verification system is developed and this methodology can be used to model environmental impact assessment for every object.

PRACTICAL SIGNIFICANCE

Developed model of road environmental impact assessment is an important step towards more objective environmental impact assessment and allows diminishing subjectivism in this process performing every environmental impact assessment in Latvia, the Baltic States and Europe.

The doctoral thesis has high practical value on the state level (on the level of the Ministry of Environmental Protection and Regional Development and Environment State Bureau) as well as on the regional and municipal level evaluating building of new objects. It shows that persons preparing reports on environmental impact assessment can create environmental indicators and look for values of them. Comparing environmental indicator values obtained for specific object with benchmark values it is possible to describe situation which would develop after the object will be built.

The results of doctoral thesis are important also for further scientific researches and implementation of results. The methodology can be used by Ministry of Environmental Protection and Regional Development and Environment State Bureau, planners and scientists, as well as students of engineering sciences.

APPROBATION

The results of the thesis were reported and discussed in 5 local and international conferences. They are described and analyzed in 9 publications 4 of which are internationally quotable.

The author has taken part in conferences:

1. 53th RTU international scientific conference with paper „Analysis of indicators of environmental impact assessment for roads”, 11-12 October, 2012, Riga.

2. United 3rd World Congress of Latvian Scientists and 4th Letonica Congress, section „Environmental quality in Latvia: current situation, challenges, solution" with paper „Methods of indicator validation of environmental impact assessment", 25 October, 2011, Riga.
3. 52nd RTU international conference, section „Environmental and Climate Technologies" with paper „Air Pollution Indicators for Motor Road EIA", 11-12 October, 2011, Riga.
4. Rezekne University VIII International scientific and practical conference „Environment. Technology. Resources." with paper „Using of Indicators for Environmental Impact Assessment in Latvia and Necessity for Indicators Validation", 20-22 June, Rezekne.
5. 50th RTU international scientific conference with paper „The Analysis of Noise Level on Saulkrasti Bypass, Latvia", 12-16 October, 2009, Riga.
6. 51st international scientific conference of Daugavpils University with paper „Indikatoru pielietošana ietekmes uz vidi novērtējumā Latvijā un to apstiprināšanas nepieciešamība", 13-15 April, 2011, Daugavpils.
7. 51st international scientific conference of Daugavpils university with paper „Sabiedrības iesaistīšana ietekmes uz vidi novērtējuma (IVN) procesā un tās loma lēmumu pieņemšanā", 15-18 April, 2009, Daugavpils.

PUBLICATIONS

1. Lieplapa L., Veidenbergs I., Blumberga D. An empirical study of analysis of indicators for roads impact assessment// Ecological Indicators: An International Journal, ISSN: 1470-160X – raksts pieņemts recenzēšanai 19.03.2013.
2. Lieplapa L., Blumberga D. Assessing methods of PM10 and NOx emission for EIA of roads// Management of Environmental Quality: An International Journal, Volume 23, Number 2, 2012. - pp. 163-172.
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4. Lieplapa L., Blumberga D. Indikatoru apstiprināšanas metodes ietekmes uz vidi novērtējumam// Apvienotā Pasaules latviešu

zinātnieku 3.kongresa un letonikas 4 kongresa sekcijas „Vides kvalitāte Latvijā: Esošais stāvoklis, izaicinājumi, risinājumi" referātu kopsavilkumu krājums – Rīga: RTU, 2011. – lpp. 60-61.

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6. Lieplapa L., Blumberga D. Using of Indicators for Environmental Impact Assessment in Latvia and Necessity for Indicators Validation// Environment. Technology. Resources: Proceedings of the 8th International Scientific and Practical Conference June 20-22, 2011. Volume I – Rezekne: Rezekne Higher Education Institution, 2011, - pp. 139-145.
7. Lieplapa L., Blumberga D. Indikatoru pielietošana ietekmes uz vidi novērtējumā Latvijā un to apstiprināšanas nepieciešamība// Daugavpils Universitātes 53.starptautiskās zinātniskās konferences tēzes - Daugavpils Universitāte, 2011.- lpp.49.
8. Zandberga A., Lieplapa L., Blumberga D. The Analysis of Noise Level on Saulkrasti Bypass, Latvia// 50th International Scientific Conference Environmental and Climate Technologies. - Riga: Scientific Journal of Riga Technical University, 2009. – pp. 135-141.
9. Lieplapa L., Blumberga D. Sabiedrības iesaistīšana ietekmes uz vidi novērtējuma (IVN) procesā un tās loma lēmumu pieņemšanā// Daugavpils Universitātes 51.starptautiskās zinātniskās konferences tēzes – Daugavpils Universitāte, 2009. – lp.43.

STRUCTURE AND AMOUNT OF THESIS

The thesis is written in Latvian and consists of an introduction, 4 chapters, conclusions and bibliography. It contains 100 pages, including 45 figures, 20 tables. Bibliography contains 133 sources. The literature review is not included in this summary.

1. DEVELOPMENT OF INDICATOR METHOD FOR ENVIRONMENTAL IMPACT ASSESSMENT

If environmental impact assessment can be considered as a sieve sorting relevance of different fields and factors of environment then indicators play the role of knots of the sieve. The literature review testifies that environmental impact assessment of intended actions can be performed based on 3 different approaches:

1. Based on expert evaluation.
2. Using environmental indicators.
3. Combining both approaches.

In the proposed EIA methodology following important terms determining characteristics of environmental impact assessment are used:

- *environmental factors*: air, soil, water, geological environment, biotic environment, relief etc.;
- values of environmental quality:
  - *environmental parameters*: emissions into air, water and soil, noise level etc. (can be obtained by direct measurements or calculations);
  - *environmental indicators* or criteria: specific emissions into air, water and soil, specific noise level etc. (can be obtained as mathematical connection between environmental parameter value and variable).

Methodology of environmental impact assessment described in doctoral thesis develops gradual and flexible summarization of actions within 6 stages illustrated in Figure 1.1. Stages reflect the process of methodology development and succession of obtained results on which every next stage is based. The methodology is based on previous traditions and experience on environment impact assessment, analysis of use of environmental aspects and environmental parameters and indicators evaluated in EIA. As a result a system of indicators is elaborated and developed using processing of numerical value of data obtained (collected, calculated and measured) and determination of benchmarks.

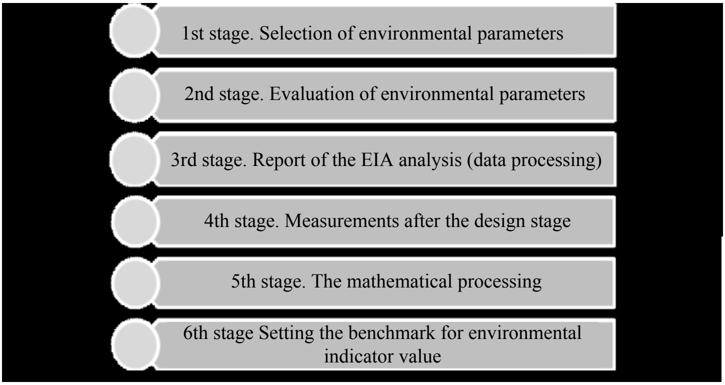

Fig. 1.1 Stages of development of methodology of environmental impact assessment

Stage 1

The first step in indicator system development is determination of parameters. In the research the expert method is used to performing parameter selection based on experience, considerations and representative values of the environmental changes described in literature. For each environmental factor the parameters previously used for environmental impact assessment are gathered as well as the most characteristic values mentioned in literature. Environmental parameters and indicators are chosen for specific group of objects – motor roads.

The use of parameter for environment impact assessment usually is chosen by experts performing EIA. There are 2 types of parameters:

1) parameters with benchmarks established by legislation of the Republic of Latvia;
2) parameters which are universally recognized and supported by experts.

Stage 2

An evaluation of significance and importance of all chosen parameters is performed. The significance expresses the relevance of parameter for characterization of exact influences and it is generally known, scientifically and practically reasoned by exact data. The significance of parameter is evaluated in the scale from 0 till 5.

The importance of parameter expresses a practical use of parameter to evaluated impact. It is determined using expert method evaluating parameters within a scale of values:

- important or is used (+2)

- unimportant or is not used (-2).

In quantitative environmental impact assessment and choosing environmental parameters two types of data play the main role:

- measurement data obtained during pre- study assessment or as a result of monitoring.
- data obtained from environmental impact assessment of similar existing objects or sector;

Stage 3

Processing of existing EIA reports. The analysis of data from 14 motor road project environmental impact assessment reports (from year 2000 till 2010) was performed:

- processed data from EIA reports;
- it is analyzed and gathered what kind of indicators are assessed, level of detailed elaboration (quantitative and qualitative evaluation);
- gathered data on the most relevant environmental indicators: current and forecasted traffic flow, current and forecasted noise level and emissions into air.

Stage 4

Measurements performed after-project phase or as a result of monitoring open a wide range of possibilities to get not only confirmation of fact that EIA report corresponds with real situation and what is data connection with independent variables examined in environmental impact assessment during pre-study phase. At this time environmental impact assessment for motor roads is chosen connected with emission measurements in air, water and soil, as well as noise, biological diversity and changes of animal behaviour.

Stage 5

Based on gathered and mathematically processed data a mathematical analysis is performed using method of mathematical statistics – regression analysis. The changes of an amount of motor road emissions are performed depending on changes of number of vehicles and other parameters. Verification of conditions of proper use of regression analysis is performed examining dependent variable distribution law. Obtained mathematical connection is used for optimization of indicator system during environmental impact assessment of designed object.

Stage 6

Determination of benchmarks for environmental indicator values. Data were analyzed and used for approbation of benchmarking method. For this approbation indicators characterizing air quality changes, noise indicators and it relation with number of vehicles were used.

For the development of benchmarking method data on current environmental situation and traffic intensity are used. The method shows sufficiently high possible credibility. It is a mathematical statistical method for data analysis and comparison based on regression analysis of data. The objective of method development is used during EIA to determine and forecast environment changes as well as weakest links of object (see Figure 1.2).

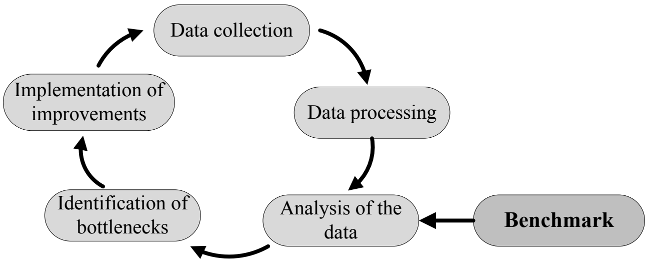

Fig. 1.2 A principal scheme of use of benchmarking method

Benchmarking method can be improved using indicators which can more precisely describe concentration of emissions of polluting substances in air in the case of motor road building evaluating environmental impact.

In order to determine changes of air quality building new roads and reconstruction existing roads in the context of environmental impact assessment noise and the three main air quality indicators are inspected within this research:

- solid particle concentration in air PM, related with number of cars;
- nitrogen oxide concentration in air NO_x, related with number of cars;
- Carbon monoxide concentration in air CO, related with number of cars.

Air quality characteristic or changes of this environmental parameter as a result of motor road impact is characterized, considering connection (1.1):

$$C = Cf + Ca, \tag{1.1}$$

where

C – air quality characteristic;

Cf – background quality (before the start of economic activity);

Ca – impact of motor road.

Approbation of benchmarking method was performed by analysis of data of two kinds about CO, NO_x and PM emissions and noise caused by motor transport:

a) Measured or calculated data about current environmental condition;
b) Calculated (forecasted with the help of computer programme "EnviMan") for environmental condition after implementation of planned activity (road building or reconstruction).

General algorithm of method of indicators proposed for environmental impact assessment is given in Figure 1.3 where sub-methods, horizontal methodology – benchmarking method are enclosed.

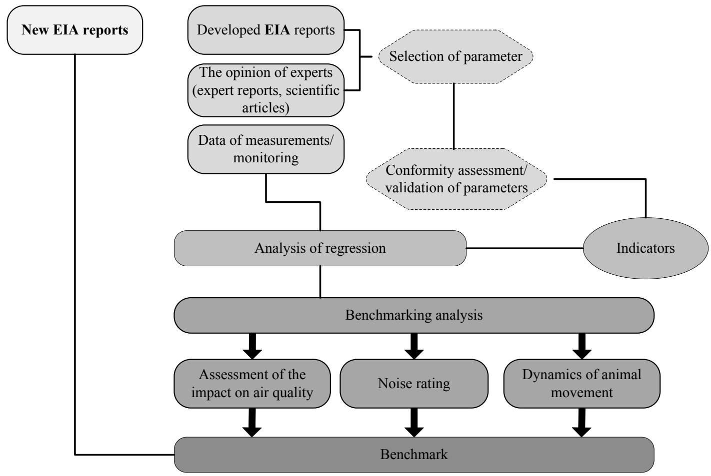

Fig. 1.3 Algorithm of work methodology

Use of indicators within environmental impact assessment helps decision makers, project developers, supervising institutions also whole society to gain unequivocal concept of possible impacts of project. As a result clear conditions of EIA are obtained which can be fulfilled evaluating environmental impacts of similar projects i.e. if it is possible all indicators included into confirmed system of indicators should be assessed using quantitative methods. It could assure comparability of data, development of database in order to introduce benchmarking method in practice and to improve it. Benchmarking method based on reliable data correlation allows forecasting possible impacts easier, quicker and economically profitable specifying prognosis of impact using other mathematical methods

2. TESTING OF METHOD

In this work, the EIA group is motor road projects. The study consists of several parts that include the choice of a parameter, the validation of the system of environmental indicators and benchmark methods for establishing in the context of Latvia, with the ability to use the results to extend the borders of the Baltic States and Europe. The results serve as a basis for further research in the selection and validation of indicators for practical application of the methods. The subsequent use and development of the work must be seen in both the vertical and horizontal dimension. This study illustrates the vertical plane as the environmental impact assessment for a single environmental indicator system that improves the quality of the EIA report and reduces their subjectivity. Horizontal dimension is expressed by certain groups of objects (motor road project) the choice of environmental indicators system, and the results of transmission options for a similar business projects

Dissertation literature review provides a wealth of information on road environmental impacts, the significance of impacts and the characteristic values and relationships (see Section 1).

2.1. Establishment of Environmental Indicators and Parameters

The first step in the establishment of a system of indicators is the determination of environmental parameters and their transformation into environmental indicators.

The expert method is used in this work, the parameter choice selected through the experiences and observations described in the literature research. First the environmental factors affected by motor roads are determined, based on the practical experience of environmental impact assessments for 14 road projects. For each environmental factor the characteristic environmental parameters are summarized.

For all selected parameters the importance and significance rating have been established, the relevance of which varies in practical EIA reports. The significance shows the scientific and practically proven value of their role in the characterization of the impacts, but importance shows the practical use of the parameter. Importance and significance comparison allows us to assess weaknesses in EIA practice that needs to evolve to the EIA the end result would be informal, objective and understandable to all parties.

The importance analysis of the selected environmental parameters, which in this case is comparable to the practical application of parameter for EIA of highway project, was carried out according to the numerical scale from -2 to +2.

The analysis shows that only 58% (32 parameters) out of 55 initially selected parameters are essential for the environmental impact assessments analysis in Latvia.

The comparison of environmental parameter assessment results is represented in Figure 2.1. It shows that many parameters (13 out of 39 parameters), which have been assessed with high significance value (4 and 5 points) not used in the assessment of impacts - they have been found to be minor. For example, the parameter "their natural transition" (unit - number) a large part of the EIA report is mentioned, but in fact there is no specific data where and how the migration (movement) space in the planned highway route is and what animals they use. Therefore, it recognized the importance of the underestimated or negligible (-2) EIA practice (Latvian), although internationally recognized the significance of this parameter.

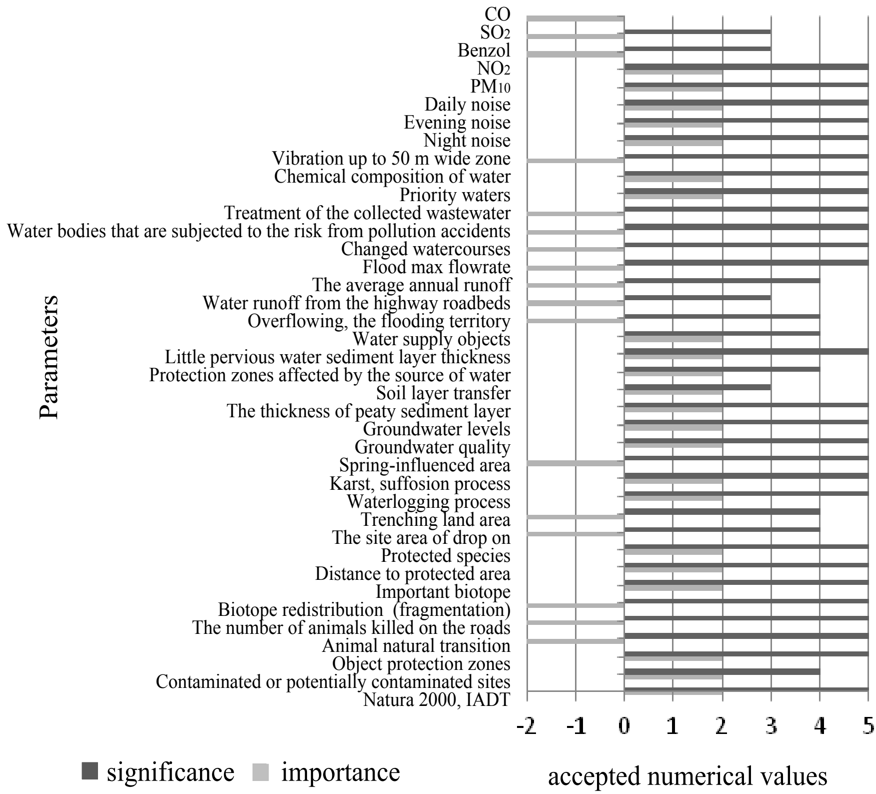

Fig. 2.1 Rating of environmental parameters by using expert methods

The outlined problems are more evident in a recent EIA reports. Therefore, this study considers that the parameter is used in the case where it has a score (numeric or descriptive). Application analysis (Figure 2.2) reflects the verity of the hypothesis that a joint parameter, and a system of indicators established on its basis for similar economic activities in the project (such as roads) of the environmental impact assessment will improve the quality of the EIA report and will avoid subjective assumptions. As shown in Figure 2.2, 36%, or 14 out of 39 of the study analyzes the environmental parameters have been used just half (7 of 14) EIA report. Even more so - in some EIA reports a number of environmental factors, the evaluation is based on analysis of the parameters. It can be concluded that the EIA reports are more descriptive and does not provide an unambiguous picture of the potential impacts of the project, and do not make the decision.

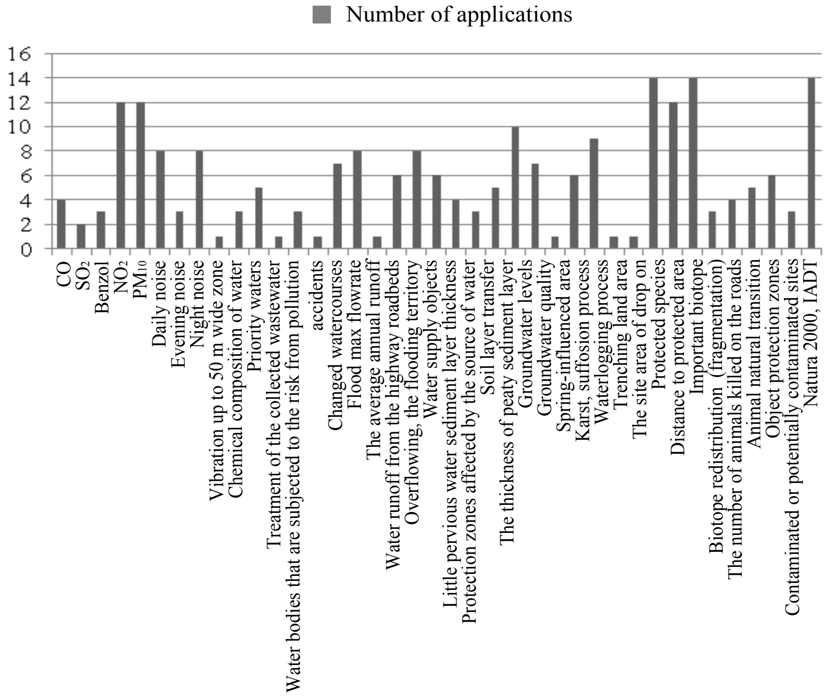

Fig. 2.2 The use of environmental parameters in EIA reports of motor road projects

This summary of the selected and evaluated 39 environmental parameters can serve as the basis for a common system of indicators that are offered road project evaluation and optimization of EIA methodologies.

The results show that in practice the quality of the EIA depends on the EIA performance qualifications and professional approach to the process i. e., the environment condition and the changes of parameters in use is left to the expert's discretion. Different approaches can be used for the characterization of the same environmental factor - ignorance, descriptive or numerical assessment, which may also affect the quality of the EIA report and public confidence in the EIA results. This approach prevents or reduces the possibility of alternatives to the project to compare and evaluate the environmental parameters or indicators, and there is no reference point for environmental monitoring of the project implementation and operation. It reaffirms the importance of selecting a quality indicator EIA and a single environmental indicator system development - parameters and criteria for approval - is needed.

2.2. The Measurement of Environmental Parameters

In order to evaluate the conformity of assumptions within the framework motor road project EIA to actual quality of the environment after the implementation of the project, an experiment was conducted in a number of environmental parameters of air and noise pollution assessment of the size and intensity of traffic. For the experimental implementation of the object was selected Saulkrasti bypass. It is the first since independence from the newly built road link Latvian. Via Baltica bypass built within a total length of 20.24 km. Bypass construction in order to relieve the city from Saulkrasti car traffic - basically the transit traffic: from passenger cars by 50% of freight transport by 100%. The road passed into the 2007th year. All measurements are carried out in accordance with ISO standard's requirements. The following example illustrates the noise and traffic measurement conditions.

2.2.1. The Noise Measurement Method

Road noise L_{day} measurements were carried out in February and March 2010 (winter and spring period) during the daytime in Saulkrasti Bypass 4 measurement sites. In each site 5 measurements were made.

The measurement was taken for the demarcation of the highest projected figure for the impact factor with the widest range - the noise issue affecting recreation areas and areas with public authorities. The assumption is based on the fact that the sound propagation is usually caused by road traffic effect (impact), which extends the farthest.

Environmental noise assessment procedures are established by the Cabinet of Ministers of the Republic of Latvia by the regulations Nr. 597 of 13.07.2004 and by measuring the Saulkrasti road ring, were taken into account. In assessing noise performance, it is assumed that the duration of the day is 12 hours, and lasts from. 7:00 to 19:00. In assessing the noise indicators L_{day} takes into account the direct sound, but do not consider the sound reflected from the façade (adjusted for measurement minus 3 dB (A)). Measurements shall be 1.5 m above the ground surface, but the results of adjusting the alignment of 4 m height above the ground surface. The measurement time was not less than 3 minutes. The measurement site should not be crossing, and avoid proximity to the forest, the forest walls reflect sound. Measurements will not give objective results in circumstances where a motor road bed is wet. The measurements are performed at low wind speed, and should be selected in diverse places. Environmental noise measurements are carried out with calibrated measuring instruments

In the course of the measurement data analyzed were obtained in real conditions on the A1 motorway between Lilaste - Skulte (Saulkrasti Bypass) with the road noise - L_{eq} pointer to the sound level meter and analyzer IHR 945A. Instrument is intended to general acoustic measurements and noise monitoring. The sound power is 0.1 dB resolution. Noise meter SVAN 945A measurement error was <± 0.7 dB. The uncertainty is specified ± 3 dB, and it was subject to human error.

While measuring the noise, both noise reflection and absorption have to be taken into account. The measuring site is selected at the point where the sound doesn't reflect against house facades or any other obstacle. If such a place cannot be finding, then it should be taken into account the results of the analysis. The noise is affected by the wind direction and speed. If you increase the distance from the noise source is decreasing rapidly, the degree to which the noise level can be measured. The distance of noise measurement object from the motor road was not the same in all the cases.

2.2.2. The Establishment of Traffic Intensity

In international practice, the volume of traffic is measured by special cameras, but if it is done manually, it is recommended to have 3 measurement groups: working days, weekends and holidays. In order to measure the normal and high volume of traffic, weekends are usually disregarded because of traffic in a lower level. This does not apply to public holidays, as often these days the traffic is normal or high. Normal and high traffic volume is defined by the monthly period. Any day can be choosing except holidays or just a day at work.

Working days can only be chosen if one knows that the weekend traffic is lower than on weekdays.

The accounting of traffic intensity in the place of experiment in the Saulkrasti bypass was carried out simultaneously with noise measurements in the same four points:

- Medzābaki,
- Saulainā ieleja,
- Pārupes Street,
- Kurši.

Each point in the volume of traffic was measured for 1 hour, a visual listing of road vehicles every 20 minutes by registering the data in a field journal. Records were held within 5 working days during the period from March 4 to April 1, from 10.00 till. 20 o'clock. At the sites of the experiment, vehicle tracking time was changed on daily basis to obtain more complete picture of the traffic on the current road. Trucks, light trucks, public transport and motorcycles were counted separately. The results were used to determine the size of environmental indicators.

2.3. Models of Indicators and Determination of Parameters

The aim of the work is to find parameters by the help of one-factor linear and non-linear models by regression analysis and to select the type of regression. The best choice in the equation based on the correlation coefficient and the square of the correlation coefficient values.

In order to determine the best models (regression equations) noise, particulate matter PM10, carbon monoxide and oxides of nitrogen indicator of change of car traffic has been carried out measurements and calculations resulting from the analysis of the data using univariate (simple) regression analysis. The results show the selected model adequacy and the usability of environmental indicators described in the following range.

In order to compare the environmental impact of road and environmental indicators to determine the value of the independent variable traffic, selected environmental indicators of pollution in the environment were characterized by specific values:

- noise indicator - Noise values relative to the number of cars;
- particulate emissions indicator - particulate emission values relative to the number of cars;
- carbon monoxide indicator - carbon monoxide emission values relative to the number of cars;

- nitrogen oxide emissions from light - NOx emission values relative to the number of cars.

95% credibility intervals for the mean and individual indicator values have been set for all indicator changes. By the help of the model calculations of uncertainty characterized by average values (regression line) confidence interval, while the new measurement uncertainty of the forecasts used indicator of individual values of the interval.

The confidence interval calculations and graphical representation made by a computer program STATGRAPHICS Plus help. The rest of this indicator confidence intervals are defined by analogy, so only show graphical results.

2.3.1. Changes in the Noise Indicator

2.3.1.1. Determination of the Noise Indicator Model and its Parameters

The processing of empirical data to obtain equations for detecting indicator changes as a function of the flow of cars was made using statistical data processing methods, i.e. correlation and regression analysis. In this study, the processing of statistical data and the development of a single-factor empirical model was done with the help of STATGRAPHICSPlus software.

One of the most important questions in statistical data analysis is how big the data set to be processed should be, i.e. how big it needs to be in order to be representative and allow an adequate empirical model to be determined. Practice shows that the number of measurements has to be 10 to 20 times greater than the number of independent variable (factors) in the regression equation. It is about 10 in single-factor regression equations. The size of the data set used to determine the changes in the noise indicator was 20.

The relationship between the parameters in order to select the type of regression equation is clarified with the help of single-factor linear and non-linear models and by performing a regression analysis. The selection of the best equation was made on the basis of the values of the correlation coefficient and the square of the correlation coefficient.

The closeness of the link (correlation) between the random independent (flow of cars) and dependent (indicators) variables can be measured using a correlation coefficient. In the case of a single-factor mathematical model, the Pearson expression is used (2.1):

$$r = \frac{\sum_{i=1}^{m}(x_i - x)(y_i - y)}{(m-1)S_x \cdot S_y}, \tag{2.1}$$

where

xi, yi - pairs of independent and their corresponding dependent variables;

x, y - average arithmetic values of the pairs of independent and their corresponding dependent variables;
S_x, S_y - sample variance of the variables.

The accuracy of the mathematical models used to describe the closeness of the correlation is evaluated using correlation coefficients R^2. If the correlation coefficients are between 0.8 and 0.9, the correlation is considered to be good. It should be noted that computer programs for processing statistical data usually calculated the square of the correlation coefficient.

If the R^2 value is multiplied by 100, then a value (percentage) is obtained which characterizes the changes in the dependent variables described in the regression equation. For instance, R^2=0.9 indicates that the regression equation under consideration accounts for 90% of the changes in the random independent variable.

A comparative analysis of various models shows that when determining changes in the noise indicator, better parameters can be obtained using a non-linear model.

$$Y = a \cdot X + b, \tag{2.2}$$

Several models whose variables are non-linear may be transformed into linear models by transforming the variables. The following equation where obtained when the model was converted (2.2) into a logarithm (2.3):

$$ln(Y) = ln(a) + bln(X), \tag{2.3}$$

where the relationship between the Y and X logarithms is linear.

A log – linear or log - log model is obtained and single-factor regression analysis of the linear models can be applied. By making (2.2) into a logarithmic equation, the model is made linear and analysis is simplified.

Table 2.1 shows the statistical significance of the model's parameters and an assessment of the model itself.

Table 2.1

Characteristic of the non-linear model for noise

Regression Analysis - Multiplicative model: Y = a*X^b					
Dependent variable: It Independent variable: Nd					
Parameter	Estimate	Standard Error	T Statistic	P-Value	
Intercept	3.84032	0.273133	14.0613	0.0000	
Slope	-0.958303	0.0482229	-19.8724	0.0000	
NOTE: intercept = ln (a)					
Analysis of Variance					
Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	1.24674	1	1.24674	394.91	0.0000
Residual	0.0568263	18	0.00315702		
Total (Corr.)	1.30356	19			

The value of the correlation coefficient is R=-0.9779 and R^2=95.64%. This means that a close correlation between variables can be observed and model used accounts for 95.64% of the It changes of the dependent variable. The noise indicator change model (regression equation) determined using regression analysis is:

$$It = 46{,}5403 \cdot N^{-0{,}9583}, \qquad (2.4)$$

It should be noted that in (2.4), the coefficient a value 46.54 corresponds to value 3.84 in Table 1. These values are linked by the expression ln(46.54)=3.84. The changes in the noise indicator described by (2.4) are shown graphically in Figure 2.3. The confidence intervals for average and specific values of the noise indicator It for a probability of 95% are also shown in Figure 2.3.

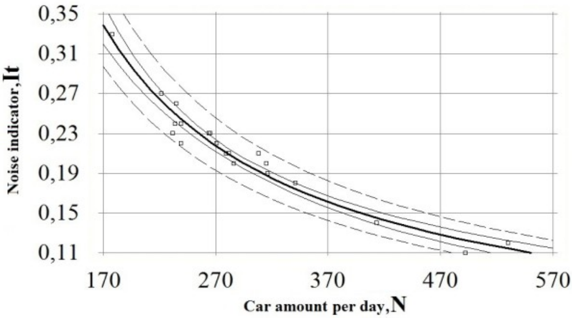

Fig. 2.3 Changes in the noise indicator as a function of the flow of cars, and 95% confidence intervals for the average and individual value of the indicator

2.3.1.2. Evaluation of the Regression Equation

The regression equation (2.4) obtained is the mathematical model of the analysed phenomenon, which has to be evaluated further. The evaluation is done using dispersion analysis with Fisher criterion *F*. For this purpose the relationship between the dispersion of the dependent variable and the residual dispersion is considered (2.5):

$$F(f_1, f_2) = \frac{S_y^2(f_1)}{S_{atl}^2(f_2)}, \tag{2.5}$$

where

$S^2_y(f_1)$ - dispersion of the dependent variable y;
$S^2_{atl}(f_2)$ - residual dispersion.

The residue is the difference between the value of variable and the value calculated using the regression equation $y_i - y_{icalc}$. The degrees of freedom *f1* and *f2* can be calculated using (2.6):

$$f_1 = m - 1, \quad f_2 = m - n, \tag{2.6}$$

where

m – volume of data sets;
n – the number of independent variables in the regression equation.

The *F* criterion can be determined from data tables, taking into account the degrees of freedom f_1 and f_2 and also the level of significance *P*. If the criterion *F* is greater than the critical value, the equation describes the analyzed data and it works properly. As it can be seen in Table 1, the value of the Fisher criterion F is 394.5. It was determined using a dispersion analysis. The calculated value is compared with a criterion table value determined using the values of the degrees of freedom:

$$f_1 = m - 1 = 20 - 1 = 19 \text{ and } f_2 = m - n = 20 - 1 = 19$$

The Fisher criterion table value F_{tab} is 2.17. It is evident that the relation $F > F_{tab}$ is valid and therefore (2.6) is adequate and can be used to describe the noise indicator within its range of variation. A comparison of noise index values measured and determined using (2.6) is given in Figure 2.4.

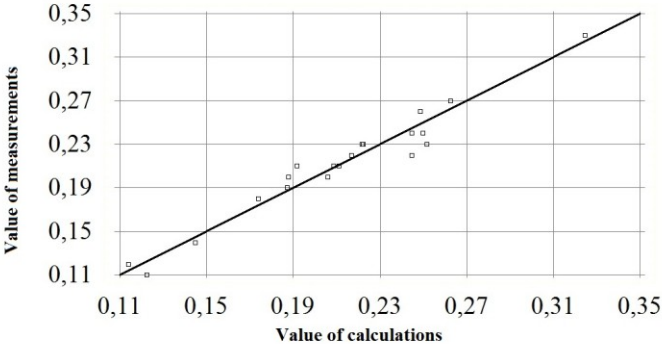

Fig. 2.4 Comparison of measured noise index values and those determined using the regression equation

The Figure 2.4 shows that there is a good correlation between noise index values.

2.3.1.3. Confidence Intervals of the Average and Individual Values of the Noise Indicator

Regression (2.4) is used to determine the average values of the noise indicator as a function of the flow of cars. These values differ from the actual values because they have been determined using a known uncertainty described by the confidence interval of the uncertainty. The value and the interval into which the measured variable fits have to be known to get a full picture of the measured variable. (2.7) can be used to determine the confidence interval of the average variable:

$$\overline{I_{ti}} - t_{a;m-2} \cdot s_{\overline{I}t} \le \overline{I_{ti}} \le \overline{I_{ti}} + t_{a;m-2} \cdot s_{\overline{I}t}, \tag{2.7}$$

where

t – t-statistic in line with Student's distribution law;
α – significance level;
m-2 – is degree of freedom of the average variable;
S_{It} – is quadratic deviation of the average indicator.

The root-mean-square deviation of the average noise indicator is calculated using (2.8):

$$S_{\bar{I}t} = \sqrt{\sigma^2(\frac{1}{m} + \frac{(X_0 - \bar{X})^2}{\sum X_i^2})}, \quad (2.8)$$

where

m - average value of the flow of cars;
X_0 - observed value of the flow of cars;
X_i –average values for the flows of cars in the data set.

Performing calculations using (2.7) throughout the entire car flow interval, upper and lower confidence limits are obtained. In Figure 2.4 95% confidence intervals are shown as hyperbolic curves to the closest regression line.

When evaluating intervals for specific noise indicator values using (2.8), both unexplained variations in the variables and the uncertainty of the regression are taken into account. Therefore the average root-mean-square deviation of the set increases due to the increase of the root-mean-square deviation. The confidence interval for the specific noise indicator value describes the difference between mean and specific measurement variables. The confidence interval for the specific variables is defined by the expression (2.9):

$$\overline{I_{t\iota}} - t_{a;m-2} \cdot s_{It0-\bar{I}t} \leq \overline{I_{t\iota}} \leq \overline{I_{t\iota}} + t_{a;m-2} \cdot s_{It0-\bar{I}t}, \quad (2.9)$$

The root-mean-square deviation of the specific noise indicator is calculated as follows (2.10):

$$S_{It0-It} = \sqrt{\sigma^2(1 + \frac{1}{m} + \frac{(x_0 - \bar{x})^2}{\sum x_i^2})}, \quad (2.10)$$

Confidence intervals for specific noise indicators are represented graphically in Figure 2.4. They are the ones which are furthest from the regression line curve. When looking at the curves of confidence intervals it can be seen that minimum values are near the mean values of car flows and increase when moving towards the minimum and maximum boundary values of the flows. This means that more accurate forecasts of the values can be found in the centre of the data set.

Calculations are performed and a graphical representation of confidence intervals created by the computer program STATGRAPHICPlus. The confidence intervals of the other examined indicators are determined by analogy, so only their graphical results are shown.

2.3.2. Changes in the Indicator for Particulate Matter

2.3.2.1. An Indicator Model for Particulate Matter (PM) and Determination of the Model's Parameters

To determine changes in the indicator for PM a data set of size of m=7 is used. The analysis of various single-factor regression models shows that the best parameters for determining changes in the indicator for PM are those in the non-linear model (2.11):

$$Y = a \cdot X - b, \tag{2.11}$$

The statistical significances of the parameters of the model and an evaluation of the model are given in Table 2.2.

Table 2.2

Characteristic of the non-linear model for PM

Regression Analysis - Multiplicative model: $Y = a*X^b$					
Dependent variable: Ipm Independent variable: N					
Parameter	Estimate	Standard Error	T Statistic	P-Value	
Intercept	2.09976	0.213558	9.83228	0.0002	
Slope	-0.728422	0.100702	-7.23347	0.0008	
NOTE: intercept = ln (a)					
Analysis of Variance					
Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	5.07962	1	5.07962	52.32	0.0008
Residual	0.485409	5	0.0970847		
Total (Corr.)	5.56503	6			

The value of the correlation coefficient obtained is R=-0.955 and R^2=91.27 %. This means that a strong correlation between variables can be observed and the model accounts for 91.27 % of changes to the dependent variable I_{PM}.

The model (regression equation) for changes in the indicator for PM determined using a regression analysis is (2.12):

$$I_{PM} = 8.1642 \cdot N - 0.7284, \tag{2.12}$$

Figure 2.5 shows the changes in the indicator for PM described in (2.12). Mean and specific values of the indicator for PM I_{PM} corresponding to a probability of 0.95 are also given in Figure 2.5.

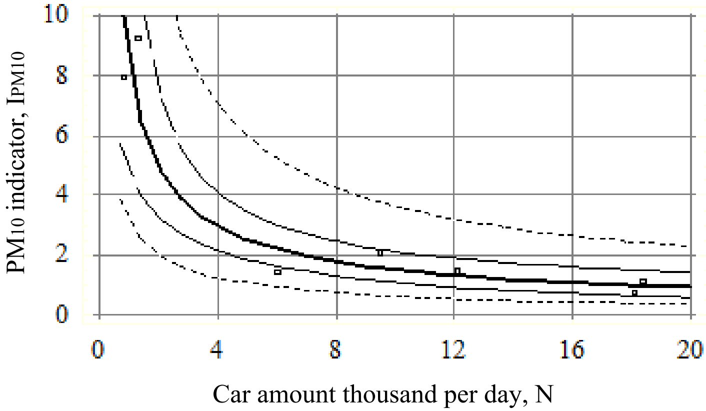

Fig. 2.5 Changes in the indicator for PM as a function of the flow of cars, and 95% probability intervals for average and specific indicator values

2.3.2.2. Evaluation of the Regression Equation

The degrees of freedom *f1* and *f2* needed for determining the Fisher criterion are calculated using equations (2.13):

$$f_1 = m - 1 = 7 - 1 = 6, \qquad (2.13)$$
$$f_2 = m - n = 7 - 2 = 5,$$

As can be seen in Table 2.2, the value of the Fisher criterion (determined by dispersion analysis carried out by a computer programme) is F=52.32. The table value of the Fisher criterion is $F_{tab.}$=4.95. It can be observed that the relationship is such that $F>F_{tab.}$, equation (2.12) is adequate and can be used for describing the changes in the indicator for PM within the stated boundaries.

2.3.3. Changes in the Indicator for Nitrogen Oxide (NO_x)

2.3.3.1. Determination of a Model for Nitrogen Oxide and its Parameters

A data set of size m=7 was used to determine changes in the indicator for nitrogen oxide. A comparative analysis of various single-factor regression models shows that the best parameters for determining changes in the nitrogen oxide indicator are those of a non-linear model (2.14):

$$Y = a \cdot X - b, \tag{2.14}$$

The statistical significance of the model's parameters and an assessment of the model itself are given in Table 2.3.

Table 2.3

Characteristic of the non-linear model for NO_x

Regression Analysis - Multiplicative model: $Y = a*X^b$					
Dependent variable: Inox Independent variable: N					
Parameter	Estimate	Standard Error	T Statistic	P-Value	
Intercept	2.86692	0.251281	11.4092	0.0001	
Slope	-0.910678	0.147263	-6.18403	0.0016	
NOTE: intercept = ln (a)					
Analysis of Variance					
Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	8.46642	1	8.46642	38.24	0.0001
Residual	1.10695	5	0.221389		
Total (Corr.)	9.57337	6			

The Table 2.3 shows that the P values of the significance level are less than 0.05, which means that the parameters of the equation are significant with a 95% confidence level. The value of the correlation coefficient R is -0.94 and that of R^2 is 88.4%. This means that a close correlation between the variables can be observed and the model established accounts for 88.4% of the changes in the dependent variable I_{NOx}. The model for changes in the nitrogen oxide indicator, determined with the help of regression analysis (i.e. the regression equation) is:

$$I_{NOX} = 17.5828 \cdot N - 0.9107, \tag{2.15}$$

Changes in the nitrogen oxide indicator described by (2.15) are shown graphically in Figure 2.6. The graph also shows the 95% confidence levels for mean and certain other values of the nitrogen oxide indicator I_{NOx}.

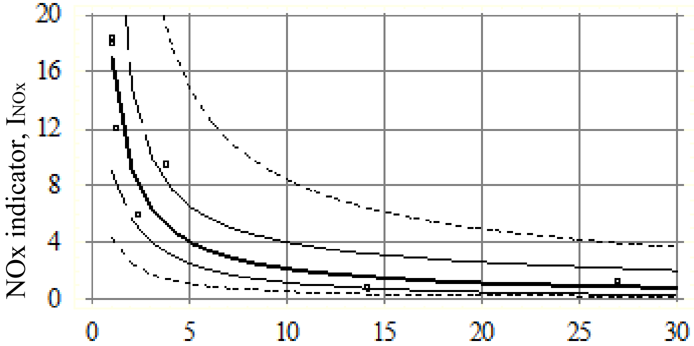

Fig. 2.6 Changes in the indicator for nitrogen oxides as a function of the flow of cars, and 95% probability intervals for mean and specific indicator values

2.3.3.2. Assessment of the Regression Equation

The calculation made in the previous section shows that the degrees of freedom necessary to determine the Fisher criterion are $f_1 = 6$ and $f_2 = 5$. Table 2.3 shows that the value F of the Fisher criterion, determined by a dispersion analysis carried out using a computer programme is 38.24. The table value of the Fisher criterion F_{tab} is 4.95, where the significance level P is 0.05. It can be seen that the relationship between F and F_{tab} is such that $F > F_{tab}$. This means that (2.15) is suitable and can be used to describe the nitrogen oxide indicator within its range of variability.

2.4. Benchmarking Method for Determination of Environmental Indicators

Benchmarks for road environmental impact assessment and forecast have been developed taking into the account measurement data of existing motor roads. The method is based on data correlation between two variables - dependent and independent. In this work, a method based on noise and practically verified PM10, NO_x and CO emissions in the atmosphere (the dependent variable) was correlated with the number of cars (the independent variable). Data was obtained from the road project environmental impact assessment reports. The method is verified in practice on data obtained from measurements and calculations.

The values projected for emissions of noise and pollutants into the atmosphere are included in the reviewed EIA of motor road project reports (in cases of both - road construction or reconstruction). They are determined using modelling software EnviMan (Airvio upgraded version) and on the basis of meteorological stations weather data, current and future average traffic load analysis, emissions by mode of transport (light and heavy) and their relationships. The model takes into account terrain features, vegetation, climatic factors, construction, motor vehicle volumes, ratio of fuel distribution among vehicles and vehicle emission factors (according to the European Environment Agency software COPERT-2).

The results obtained using complex calculation are compared with actual measurements on Latvian roads and the fixed benchmark.

Benchmark detection method was implemented by using two types of analysis paths

- At first, the relationship between environmental parameters was sought: the absolute values of the emission and its influencing variables. For example, the absolute value of change in the noise level (dB), particulate matter, nitrogen oxides or absolute value (micrograms/m3) of carbon monoxide concentration in the air depending on the number of cars travelling on the road in a period of time.
- Subsequently, the benchmark values of environmental indicators were determined, which were characterized by specific emission value corresponding to the independent variable. For specific values of noise level attributed to the number of cars (dB / car number / unit time) change in specific values of particulate matter or nitrogen oxide and carbon monoxide concentration in the air (microgram/m3/auto number / unit time) depending on the number of cars travelling on the road in a period of time.

2.4.1. The Benchmark Determination for PM10 Indicator

PM10 calculation data from EIA reports relative to the benchmark is shown in Figure 2.7. The calculated data of PM10 emissions indicator values are characterized by substantial dispersion. The calculated value (expected value) data analysis shows a weak correlation between emissions and transport units.

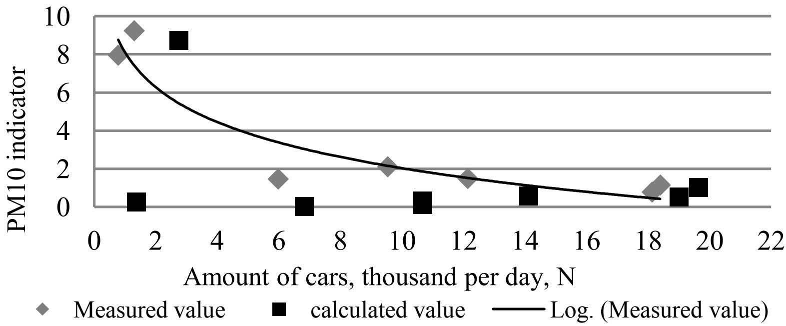

Fig. 2.7 Values of PM10 indicator from EIA reports and on-site measurements

The benchmarking method shows that measurement data displays satisfactory correlation with the number of vehicles, but the dispersion for calculated results can be significant and the correlation with the number of cars in this case is low. The method allows verifying the reliability of the data and the need to review the estimates and to identify additional variables that have higher impact on pollutant emissions into the air concentration is equal to or greater than the number of cars.

2.4.2. The Benchmarking Evaluation of CO Indicator

The CO indicator that is derived from the relationship between CO emission t/year and the number of cars per day is shown in Figure 2.8. This allows observing the CO emission indicator relative to the benchmark, where greater dispersion in this case is observed in the measurements.

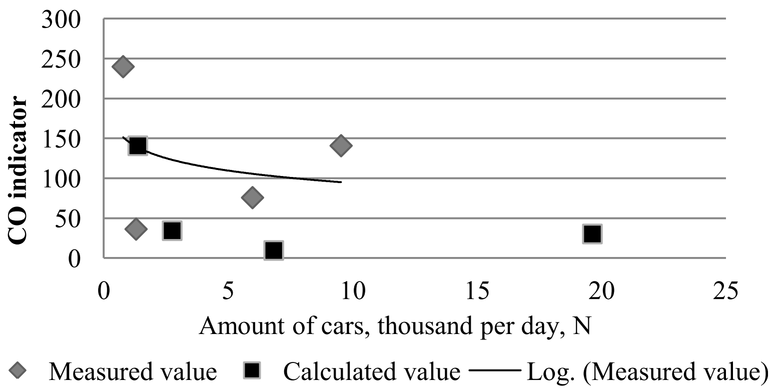

Fig. 2.8 Values of CO emission indicator from EIA reports and on-site measurements

2.4.3. The Evaluation of Benchmark of NO_x Indicator

Lower score is for the calculated NO_x emissions data indicator correlation against the number of transport units - Data distribution of the benchmark is higher (see Figure 2.9. below).

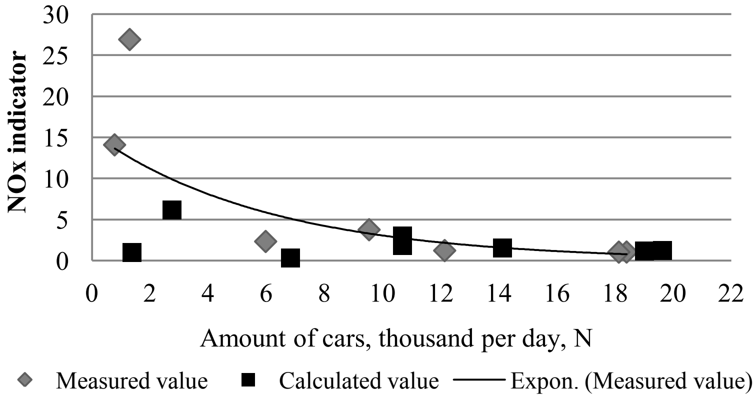

Fig.2.9 Values of NO_x indicator from EIA reports and on-site measurements

Comparing methods used in EIAs for emissions assessment, it is clear that the actual measurement benchmark model most accurately describes air pollution with particulate matter from roads. Relation of the remaining emissions data to the number of motor vehicles is satisfactory. This can be explained with that the measured data is often derived from calculations specific to the situation of the particular EIA at the time. There are also human factors affecting the measurement precision. If measurements are carried out in accordance with appropriate measurement methods, there is a high probability of lower dispersion in the data.

3. THE OUTCOME AND RECOMMENDATIONS

Results of the thesis is multi-layered and open future possibility to arrange a regulatory framework associated with environmental impact for reducing the subjectivity of the environmental impact assessment and help to form basis for an environmental indicator system should be implemented and a kind of valuation methodology that could be chosen so that EIA reports could be concretely oriented towards the planned activity and provide better answers about the real impact on the environment.

3.1. The Classification of the Planned Activity and the Environmental Factors

Summarizing the results obtained in the course of work, a group of environmental impact assessment methodology has been developed according to the algorithm illustrated in Figure 3.1. The algorithm includes 8 modules.

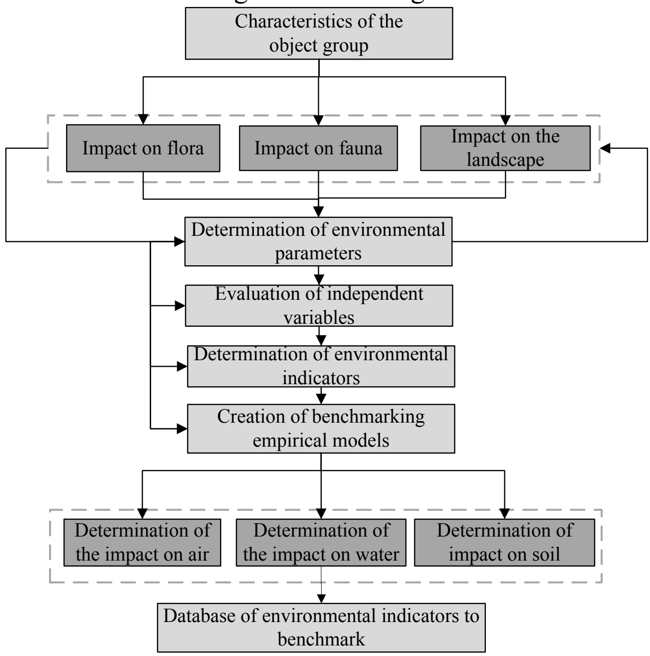

Fig. 3.1 EIA methodology algorithm for an object group

Module 1 Object group characteristics

The planned activities are grouped by adherence to sector and subsector. Next, they are grouped by economic activity and common engineering parameters, such as agriculture, industry, economic activity of farming, chicken farming complex. The object group characterization gives a general description of the activity, highlighting the major technological and engineering features.

Module 2 Definition of the environmental impact to factors

The possible effects to certain environmental factors are defined for each object group, based on existing expertise from the EIA and using checklists or matrices. The goal is to determine the entity of the compulsory reviewable environmental factors, as well as specify any additional effects that may occur depending on the site characteristics and the specific activities for technological solutions.

Module 3 Establishment of environmental parameters

Selection of environmental factors is closely associated with the likely significance and importance of evaluation. The significance judged by whether the group of objects in general can have an impact on a specific environmental factor or not. Effects are assessed on its own priorities with respect to the effects of other environmental factors, and the expected effect size. This module approves environmental factors for assessment contained in the second module.

Knowing the characteristics of a group of key engineering parameters, the independent variables and measurable environmental factors, the resultant entity of the interaction of environmental parameters (dependent variables) is determined. Those environmental parameters are selected, which clearly indicate the potential environmental quality changes that may result from a group of intended actions. The parameters determined for each of the second module selected environmental factors alone. Environmental parameters describe the existing environmental conditions and, together with the independent variables to be used to predict the impacts. They must be measurable, verifiable, understandable, and recognized industry experts, as well as other future environmental monitoring.

The module also serves as the basis of environmental and indicators system.

Module 4 Determination of independent variables

The potential for environmental impact assessment and environmental change forecast is based on the current situation in the realization of the performance characteristics. The relevant independent variables (for example, animal units, transport units, etc.) are determined for group of objects that may affect the environment changes. A set of independent variables is defines, which are mathematically expressed, measurable, verifiable and traced mathematical relationship to parameters characterizing environmental changes. On the set of independent variables based largely based on environmental indicators system for certain groups of the EIA. Independent variables are one of the main components of environmental changes characterizing the function, which is responsible for the dependent variable component.

Approval of selection of independent variables is based on the significance and importance of assessment (Module 3).

Module 5 Determination of environmental indicators

Environmental indicator is connection of both, the independent and the dependent variable that is characterized by changes in the environment. Each of the evaluation of subordinates raises environmental factors most relevant and the most relevant indicators for changes or connections. The indicator consists of a set of environmental indicators system to be considered during the EIA proposed activity of a particular group of objects. Environmental indicator system based on the most modern approach to environmental awareness, scientific research and environmental monitoring results as well experience of specialists.

Module 6 The establishment of benchmark empirical models

The regression analyses are used to create an empirical model system, combining pre-defined and defined environmental parameters, independent variables and environmental indicators. It allows you to determine the current and predicted environmental change in the maximum value (threshold), which affects the value of the independent variable changes. The empirical model also gives an idea of the background level and the next factors to changes in the environment.

Module 7 The impact of environmental factors determination

All environmental criteria summary and recommendations of a group of representatives of the EIA report for evaluation.

Module 8 The benchmark database of environmental indicators

The benchmark database is established for each group of objects, summarizing the data (parameters and independent variable values, their relationships) from the earlier EIA reports. The data accumulated for the relevance, which is characterized by changes in each of environmental factors. The database is regularly updated, improving the benchmark empirical models. Benchmarking method allows predicting the potential impact depending on the variables and serves as a tool to check the volume of calculated variables.

EIA methodology is needed to sort out the environmental impact assessment of the conditions for industries and industry groups, the consistency of assessments of withholding the information provided by the detail and quality as well as to serve as a support tool for the environmental impact assessment audits. Development and application of methodology will offered a significant contribution to the environmental impact assessment of total quality standard lifting, scientific and professional approach to the development of the EIA, as well as improved public confidence in the results of the EIA, which, in turn, will contribute to national economic growth in the long term, building trust from investors for EIA procedure as balancing instrument of the tripartite interests (investor- society- government /municipality).

3.2. The EIA Methodology for the Planned Activity

Summarizing the results of the study, an environmental impact assessment methodology has been elaborated for the specific planned activity, the algorithm of which is illustrated in Figure 3.2. The algorithm includes 8 modules. Certain actions provided for EIA methodology algorithm stems from a specific group of EIA methodologies, which are defined by the end result, the EIA must be included in the environmental indicators and benchmark databases.

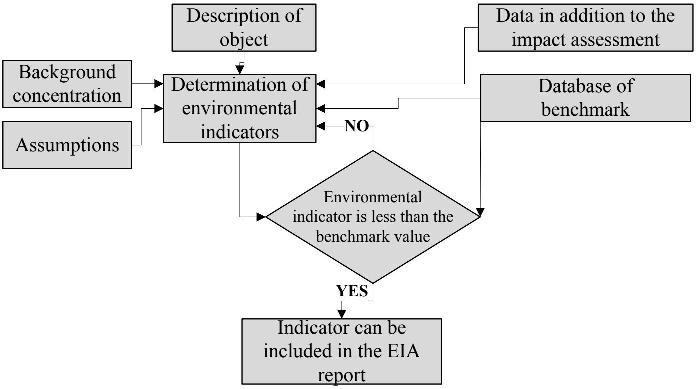

Fig. 3.2 EIA methodology algorithm for planned activity

Module 1 Description of object

The general engineering solutions and description of the main characteristics of the proposed activity provides in accordance with specifics. For example, production facilities indicate the planned equipment capacities, the production output, the location of buildings and facilities, the necessary engineering networks, projected raw material and resource consumption, waste volumes, etc. Infrastructure evaluation would provide the facility characteristics, according to its specifics. An inseparable part is the site characteristic of operations, including land ownership and compliance with the land use plan.

Module 2 Background concentrations

Collects information and analyzes data on the site and the surrounding environmental conditions and background concentrations for each environmental factor. Background concentration is characterized by numerical environmental parameters that are based on the measured or calculated and used to predict the impacts. Compulsory environmental parameters which need to be used are approved by the relevant group of EIA methodology, but it may be supplemented with other particular place or planned activity on environmental parameters (Module 4). Background concentration is the reference point from which the additional load on the environment and the possibility of capacity, or the carrying capacity of up to a limit.

Module 3 Assumptions

The environmental impact assessment is carried out at the earliest possible design stage, so not all technological parameters and characteristics are known. Therefore, in order to allow assessment of the potential impacts of the project and to model the situation, the assumptions by experience or analogy with similar projects.

Module 4 The data in addition to the impact assessment

Taking into account the characteristics of feasibility study of the planned activity, the site / environmental conditions, are assessed for additional impact on environmental factors – already included environmental indicators within system and / or new ones. It is a matter of experts' competence. In addition to identification of envisaged impacts, the simple techniques such as - checklists or matrixes are used. Identified impacts are envisaged parameters (second module) background concentration of and influences prognosis.

Module 5 Determination of environmental indicators

Environmental evaluation should be based on environmental indicators system, which is designed for each group of objects. The mandatory analysed environmental indicators can be determinate by the indicator system. An additional environmental indicator is determined by the set of additional environmental parameters and assumptions about possible changes in the environmental activities (Module 3 and Module 4). In addition to the parameters, based on which is developed additional indicators, must satisfy the criteria for approval of indicators assessed by the experts.

Module 6 The benchmark database

Environmental indicators which are to be evaluated must confirm to the included indicators in the benchmark database developed for the group of objects The database also shows what independent variables to be analyzed to ensure that environmental indicator would be appropriate and comparable. Benchmarking database, the actual data, which later acquired the activities of the environmental impact evaluation, should be a way of improving and clarifying.

Module 7 Environmental indicator comparison with the benchmark value

The mathematical relevance between environmental parameter and the corresponding independent variable generates numerical values for environmental indicator.

To find the value of the chosen indicator of uncertainty size, the indicator compared to the benchmark value (resulting from a database). If an environmental indicator value is close to the benchmark value, the indicator is used for the prediction of the potential impact. However, if the values differ, it is possibly significant impact of other factors (including the independent variables) on the environmental parameters or error in the output data (background environmental parameter or independent variable) to determine the value. In this case, identify the source of different and make appropriate adjustments to the calculation of the indicator or decline of this indicator using a specific EIA.

Module 8 The use of environmental indicator for impact forecast

Environmental indicators are accepted for the possible forecast f environmental change (Module 7). Assess the impact of directly using the benchmark method, according to the value of the variable changes in setting environmental indicator values against the benchmark, or by calculation, the results verified by the benchmark method. The results obtained in the EIA report, on which the assessment is sensitive to material and prepare mitigating measures and environmental monitoring plan for the future.

The EIA methodology for the planned activities is required by the Environmental State Bureau to arrange an environmental impact assessment and the level of detail and quality into the proposed activity, as well as by project developers and the environmental impact assessment developers (experts). The role of method is to unify the development of the EIA system and create a single environmental impact analysis framework for object group. As a result would be improved quality of the EIA and the reliability and audit ability of the obtained data, as well the public and decision-makers would be provided with objective information contributing to trust on EIA results.

CONCLUSIONS

1. A common system of indicators for environmental impact assessment for motor road projects has been developed. Analyzing of the current parameter and indicator usage in the EIA reports, the proposed system includes structured indicators, based on environmental parameters. This development is innovative in Latvia and applicable in other EU countries as well, since the legal framework of Latvia in the field of EIA is expressed through harmonization of the relevant EU directives. The indicator system

can form a basis of comparable historical data for retrospective comparison - it the most significant contribution of this system.

The obtained data from the usage of common indicator system (indicator values) can be compared among the analyzed project alternatives, taking into account environmental situation before and after the implementation of the project, as well as the comparison between similar projects. The indicator system usage for the EIA gives the opportunity to avoid subjectivity in the EIA process and provide the decision-maker with quantitative and verifiable environmental assessment.

2. The parameter validation algorithm has been developed in thesis, which is based on internationally agreed criteria and helps evaluate the eligibility of parameters to the criteria within system of indicators for other economic sector projects as well. The developed parameter validation method is practically verified on parameters of environmental changes in ground waters. The method is simple, understandable and easily implemented into practice of EIA. It can be developed, supplemented and applied for a variety of projects groups within environmental sectors.
3. The regression analysis of data used in the paper has made it possible to obtain an empirical equation that shows the effects of independent variables (number of vehicles) upon the noise volume and the amount of PM10, CO, NO_x emissions in the air. Mathematical data processing was performed using univariate regression analysis method. Appropriateness of the use of the empirical equation has been tested by regression analysis conditions. This equation can be used within the range of a given dataset for forecasting road noise and emission projections depending on the number of vehicles.
4. We have developed a method for the benchmark of data correlation of road projects for environmental impact assessment. The data from 14 road project EIA and actual measurements of Saulkrasti bypass have been used to set the benchmarks. The method has been practically verified with respect to PM10, CO, NO_x air emissions and noise correlation value with the number of motor vehicles. Approbation showed good results, confirming the practical usage for environmental impact assessment. Method makes it possible to use emission benchmark to forecast environmental impact, depending on the number of vehicles, with the results being adjusted to the specifications of transport. Through accumulation of empirical data, the method can be improved, as well as adaptable for determining relationships of other environmental indicators

and evaluation of impacts from different project groups. It may be used to verify the credibility of the result calculation. The practical application of benchmarking method in EIA would provide good economic effect, because it is based on the correlation results of accumulated data.

5. The indicator system elaborated by this thesis is flexible and further to be developed. Accumulation of the EIA report data in the future, and increase in the number of EIA for motor road projects, as the representative sample of study, will allow update the practical application of proposed indicator system developed within thesis. Through the introduction of a system of indicators, there is reasonable justification to carry out the environmental monitoring after the project implementation to form a complete database for further analysis.

6. The retrospective analysis of EIA reports, the process of the environmental impact assessment and the quality assessment of EIA reports have been carried out resulting in identification of the main similarities and risks within EIA system in Latvia and provisions of possible solutions for the optimization of EIA process.