XXIVth WORLD ROAD CONGRESS

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MEXICO - NATIONAL REPORT

STRATEGIC DIRECTION SESSION STA

"MITIGATING THE IMPACT OF ROADS IN CLIMATE CHANGE"

SUCCESFUL CASES

1. BACKGROUND FOR ENVIRONMENTAL ROAD MANAGEMENT IN MEXICO.

Mexico is a country with a wealthy nature, lifeblood of national welfare and development as human beings. The rational and sustained use of natural resources, as well as its preservation, has been a fundamental concern for diverse administrations of the country; at least in the past 5 decades. Hard to deal environmental problems as a result of pollution lead the Federal Government in the sixties to start an administration process to improve environment. This effort was intensified from 1972, with the creation by the Executive of an **Improvement of Environment Under Secretariat** and the participation of Mexico in the United Nations Conference about Human Environment in Stockholm, Sweden.

First records of environmental studies in Mexico go back to 1977, when the former **Agriculture and Water Resources Secretariat** applied these for hydraulic infrastructure. In parallel, at the same time, the **Human Settlements and Public Works Secretariat (SAHOP)** prepared territorial studies denominated ECOPLANS for State and Municipal regions, where the content focused on rational use of natural resources, as a mean of development and support for population centers. These ECOPLANS were the preamble of today's procedures for environmental management, since they included analysis criteria for environmental impact as well as an environmental description in its natural and socioeconomic components, the study of development actions and the set up of politics to carry out those actions with the participation and surveillance of authorities related.

Later in 1982, the **Public Works Law** was passed and the requirement for planning was established and the anticipation for effects and consequences on environmental impact. To enforce this law, the **Public Works and Environmental Impact Office** was created inside the already mentioned **Improvement of Environment Under Secretariat** from 1981 to 1982. This Under Secretariat had the responsibility of analyzing the environmental impact of public works projects.

After 1982 the Federal Law of Environmental Protection was enacted. Thus elaborating and presenting a manifestation of environmental impact became mandatory to start any works that might exceed the permissible limits in technical regulations and norms to be applied. However, those limits were restricted to contamination of the atmosphere with emissions of particles, water and noise pollution since those were the only current regulations and there were no norms published at that time. Even though, under this law, more than 500 studies of environmental impact were prepared for: roads, oil, airports, tourism, industrial, mining, agriculture and electrical projects. Additionally, for some atmospheric and hydrodynamic aspects, some physical and mathematical specific models were developed to simulate previous and after project conditions. Later on, new instruments arose and the use and development of technologies to assess environmental impact evolved.

Nonetheless the content of those studies was acceptable; its evaluation was complex due to the lack of normative elements to define the possible effects from identified impact. In the eyes of such limits it was necessary to turn to the use of norms and parameters from abroad, with the restrictions that involve the different conditions from one country to another. Therefore, it was necessary to define those projects whose environmental impact

was to be observed. The lines to overcome those deficiencies were established in the General Ecological Equilibrium and Protection of Environment Law (LGEEPA); published on the 28th of January 1988 and reformed on the 13th of December 1996 and its regulatory norms for environmental impact (RLGEEPA) published in 1988 and reformed in the year 2000. Under this law, projects that must prepare evaluation for environmental impact were defined and technical regulations issued by the Federal Government were validated through the denomination Ecologic Technical Norm.

In 1982 the **Urban Development and Ecology Secretariat (SEDUE)** was the first federal office to manage the environmental policy, by means of an established legal frame; functions that were taken lately by the **Secretariat of Social Development (SEDESOL)** in 1992, adding new responsibilities of environmental policy that provide the creation of decentralized agencies like the National Institute of Ecology and the Federal Lawyers Office for Environment Protection (PROFEPA).

The first one had the responsibility to regulate and dictate resolutions about environmental impact and ecological legislation. The second one was in charge of surveillance and was able to fine those failing to observe the law or causing environmental damage. Up to 1994 these two decentralized institutions continued operating under the Environmental, Natural Resources and Fishing Secretariat (SEMARNAP)

Between 1989 and 2000, the evaluation procedures for environmental impact considered studies of environmental impact manifestation under three different modes according to the project complexity and terms indicated by law (RLGEEPA). These were: General Mode, Intermediate and Advanced. The guides to prepare those studies were published in the official gazette of the SEDUE (Urban Development and Ecology Secretariat) in September 1989 (vol. 1 No.3). With modifications to RLGEEPA, in 2000 environmental impact manifestations were presented in two modes: Regional and individual.

Table 1.- CHRONOLOGY OF MEXICO ENVIRONMENTAL AGENCIES

SEDUE Dec./1982	• Concepts of environmental impact evaluation and ecologic legislation are created as instruments for environmental policy. • Federal public Works are included in environmental impact evaluations. • By publishing LGEEPA in 1988 functions of surveillance and inspection are strengthened and fines are applied. • Jurisdiction between States and Federation is arranged.
SEDESOL May./1992	• Agreement to speed up paperwork with tourism, energy and communications sectors. • Regulation and Inspection and Surveillance functions are separated. The later are responsibility of PROFEPA. • The Lumber of projects submitted to the process of environmental impact evaluation increases as a result of PROFEPA actions.
SEMARNAP Dec./1994	• Creation of the Under Lawyers Office for Natural Resources with functions of **inspection, surveillance and verification** of environmental impact regulations observance.
SEMARNAT Dec./2000	PROFEPA withdraws from the fishing sector, thus **inspection and surveillance** are further strengthened. • Improvement in the attention given to environmental priority and critical considered areas.

In recent times (2010) PROFEPA is an institution controlled by the Environmental and Natural Resources Secretariat (SEMARNAT) with the responsibility to evaluate and supervise the observance of legislation; preserving and protecting forest resources, wilderness, endangered species, ecosystems and genetic resources, beaches and protected natural areas, waste waters, etc.

SEMARNAT through the General Directorate of Environmental Impact (DGIRA) is now the organization responsible to authorize environmental impact studies under the two modes. Regional is the one that includes roads.

2. PRESENT DAY CONTEXT FOR ENVIRONMENTAL MANAGEMENT OF ROADS IN MEXICO

Environmental protection has become a daily task for road administrators in Mexico, mainly in project planning and construction. Even though, the scope of environmental monitoring has increased recently for the operational stages of the road, there is still a lack

of strategy for environmental monitoring on the whole road network at national and regional levels.

For the aim of this document, environmental management will be dealt with three fundamental aspects: environmental legislation, evaluation of environmental impact procedures and monitoring and supervising procedures.

2.1. ENVIRONMENTAL ROAD LEGISLATION.

The first step for environmental legislation in Mexico was in March, 1988; when the General Ecological Equilibrium and Protection of Environment Law (LGEEPA) was approved. This law has been adjusted as time goes by to keep it updated in accordance with present problems.

The law empowers the federation to authorize highway construction after environmental impact studies. This action is performed by the General Directorate of Environmental Impact and Risks (DGIRA) of the Environment and Natural Resources Secretariat (SEMARNAT) through the elaboration of an Environmental Impact Manifestation (MIA)

The MIA's go through a process of evaluation for environmental impact that lasts no more than 60 days according to law. In this time, authority can decide to authorize the project, ask for additional conditions or deny authorization. The rules for LGEEPA mention that authorization is required if maintenance or rehabilitation works are made in the right of way and for any request for change in the land use in forests or protected natural areas.

MIA can be presented in two modes: regional and individual. First case is for roads and second is used for works related to transport infrastructure.

Minimum content established in rules for MIA's is: project generals, developer and study responsible, works description; applicable planning and legislation instruments linked, regional environment system description and indications about deterioration and development trends; identification, description and evaluation of environmental impacts accumulative and residual of the system; strategies for prevention and mitigation of environmental impacts; regional environmental forecasts and if needed alternatives evaluation and identifying method instruments and technical elements to support the results of the MIA.

Land use changes for highway construction according to the Sustainable Forest Development General Law must be authorized by SEMARNAT as well, based upon a Technical Justification Study (EJT) and the technical opinion of the National Forest Council, where it should be shown that the biodiversity is not jeopardized, neither it will induce soil erosion nor water quality deterioration or diminishing water collection with the forest affectation as a result of the works.

Additionally the environmental evaluation in Mexico is subject to the Wild Life General Law, as well as diverse regulations protecting flora and fauna under extinction threat or danger, or if they are endemic to the country or region. This legislation is for general applicability including highway projects. Furthermore, for highways where sections or

bridges are located or cross through Maritime Federal Zone or Maritime Surface, construction must be authorized by the Directorate of Maritime, Surface and Coastal Federal Zone of SEMARNAT.

There are other regulations for emissions, environmental noise control, water exploitation, dangerous waste and others to be considered in road environmental impact evaluation, thus this works are clearly regulated by several legal instruments in Mexico.

2.2. ENVIRONMENTAL EVALUATION PROCEDURES

The environmental impact evaluation procedure in Mexico through SEMARNAT sets conditions to carry out works and activities that might cause ecological unbalance or to exceed limits and restrictions established in legislation for environmental protection and preserving and restoring ecosystems, to avoid or reduce negative effects over the environment. This mechanism has a preventive approach and is mandatory.

The process of environmental impact evaluation for highway projects starts after the technical and economical evaluation. This process lasts for 60 working days and goes three stages. First evaluation refers to file integration and administrative sufficiency review; second is about legal feasibility to achieve the project and third concerns environment compatibility through environment analysis. Process ends with a resolution.

The process is based in the MIA sent to SEMARNAT, which according to law evaluates possible effects from works or activities to develop in the ecosystems. The procedure acknowledges the whole project and system elements and not only the resources to be affected or used. The purpose is to look forward for observing functional integrity and ecosystem burden in the use of natural resources for indefinite periods.

3. PUBLIC POLICY (INFRASTRUCTURE PROGRAM AND BYPASS PROGRAM)

3.1. PUBLIC POLICY

Public policy sets environmental sustainability as a guiding principle for development according to the National Development Plan 2007-2012, thus this was included in the Communications and Transport Sector Program 2007-2012 and it stands for 1) greenhouse gas effect reduction (GEI); 2) impel climate change adaptation measures.

Several strategies were established for these aims for both infrastructure and transport sub-sectors. Two of them, related to infrastructure will be discussed in this document.

3.1.1. Road Maintenance Program

Sector strategy regarding physical status improvement for roads is expected to achieve, at the end of 2012, 90% of the road network in good operating conditions according to international standards as a goal. (Table 2)

Table 2. Sector goal indicator set by the National Development Plan 2007-2012

Indicator Name	Unit of Measurement	Base Line (2006)	Goal (2012)
Federal road network and freeways in good conditions according to international standards.	Percentage of road kilometers in roads and freeways in good conditions according to international standards	72%	90%

This road surface improvement implies important advantages considering greenhouse gas effect emissions (GEI). From an environmental point of view, improving road surfaces directly impacts gas emissions reduction. This is demonstrated through computer models like HDM-4 (Highway Development Management), that incorporates an environmental sub-model designed to appraise the quantity of emissions generated by vehicle operation in roads, according to surface geometrical characteristics and types of vehicles moving on roads.

As an example, Table 3 shows the level of emissions generated by contaminating type, classified in three different levels of road conditions. Furthermore, Table 4 shows the International Roughness Index (IRI) compared to the qualitative level of the road, according the Road Maintenance Directorate (DGCC) data.

Table 3. Emissions by vehicle classification vehicular type A, B y C, in grams per kilometer emitted annually according to surface conditions.

VEHICLE	**A**					
STATUS	**HC**	**CO**	**NOx**	**PM**	**CO_2**	**SO_2**
GOOD	2,408.47	19,303.15	3,065.66	5.46	203,781.97	15.54
SATISFACTORY	2,445.77	19,571.18	3,129.16	5.50	206,376.28	15.74
UNSATISFACTORY	2,457.17	19,657.18	3,146.45	5.52	207,243.27	15.81
VEHICLE	**B**					
STATUS	**HC**	**CO**	**NOx**	**PM**	**CO_2**	**SO_2**
GOOD	898.29	2,329.22	5,188.01	245.57	416,446.22	82.11
SATISFACTORY	898.01	2,354.22	5,262.72	250.24	423,125.75	83.43
UNSATISFACTORY	905.72	2,362.36	5,272.09	250.16	423,563.56	83.51
VEHICLE	**C2, 3, 4**					

STATUS	HC	CO	NOx	PM	CO_2	SO_2
GOOD	4,893.54	32,371.58	5,585.16	22.91	293,227.19	57.81
SATISFACTORY	4,940.17	32,675.03	5,635.42	23.13	295,441.31	58.25
UNSATISFACTORY	4,900.65	32,422.61	5,595.65	22.95	294,116.72	57.99

Note: Annual emissions emitted by kilometer per each 1000 vehicles, type A, B or C according to road surface conditions. Vehicle classification type A refers to automobiles, type B to buses, and type C2, C3 y C4 freight vehicles with 2, 3 or 4 axis respectively.

Table 4. IRI Classification according to DGCC and road condition classification.

International Roughness Index (IRI)	Road Conditions
<2.80	**GOOD**
2.81 - 4.20	**SATISFACTORY**
>=4.20	**UNSATISFACTORY**

According to last tables, for each improved kilometer, the number of emissions sent into the atmosphere will be reduced as shown in Table 5.

Table 5. Emission savings per improved kilometer by vehicle type.

VEHICLE	**A**					
Emission type	**HC**	**CO**	**NOx**	**PM**	**CO_2**	**SO_2**
Savings	48,7	354,03	80,79	0,06	3461,3	0,27
VEHICLE	**B**					
Emission Type	**HC**	**CO**	**NOx**	**PM**	**CO_2**	**SO_2**
Savings	7,43	33,14	84,08	4,59	7117,34	1,4
VEHICLE	**C2, 3, 4**					
Emission type	**HC**	**CO**	**NOx**	**PM**	**CO_2**	**SO_2**
Savings	7,11	51,03	10,49	0,04	889,53	0,18

3.1.2. Infrastructure Program – Bypass Program

The Infrastructure Program seeks to fulfill construction programs, road modernization programs, interstate corridors and a program of access and bypass program. The later is oriented towards achieving a wide access and bypass road construction program for main cities in the country, to improve the road infrastructure and urban infrastructure connection; supporting thus, urban reordering and contaminant emission decrease due to decongestion of urban streets.

Therefore, 31 bypass and access will be constructed, so that long itinerary traffic gets continuity. These projects to reduce greenhouse effect emissions are shown in Table 6.

Table 6. Bypass projects considered for greenhouse contaminant effect reduction.

ACCESS AND BYPASS PROGRAM			
PROJECT	**FEDERAL STATE**	**TYPE OF CONSTRUCTION**	**FINANCING SOURCE**
Bypass Ciudad Obregón	Sonora	2 Lane	Available assets use
Guanajuato – Dolores Hidalgo – San Miguel de Allende			
Bypass Guanajuato	Guanajuato	2 Lane	Federal Budget
Bypass Hermosillo	Sonora	2 Lane	Available assets use
Pachuca - Tampico			
Bypass Huejutla	Hidalgo	2 Lane	Federal Budget
Pachuca – Portezuelo – Palmillas	Hidalgo	2 Lane	Federal Budget
Irapuato – Guadalajara			
Bypass la Piedad	Guanajuato	4 Lane	Concession (PPP)
Bypass Irapuato	Guanajuato	2 Lane	Concession (PPP)
México – Guadalajara Freeway Access	Michoacán	12 meters enlargement	Concession (PPP)
Mazatlán – Culiacán			
Bypass Mazatlán	Sinaloa	2 Lane	Available assets use
Bypass Culiacán	Sinaloa	2 Lane	Available assets use
Guadalajara – Puerto Vallarta			
Compostela – Puerto Vallarta	Nayarit	2 Lane	Concession (PPP)
Bypass Puerto Vallarta	Jalisco	2 Lane	Concession (PPP)
Puerto Vallarta – El Tuito	Jalisco	12 meters enlargement	Federal Budget
Bypass Reynosa	Tamaulipas	2 Lane	Available assets use
Acapulco – Zihuatanejo			
Bypass Tecpan	Guerrero	2 Lane	Concession (PPP)
Puebla – Tlaxcala			
Bypass Tlaxcala	Tlaxcala	4 Lane	Available assets use
Xoxtla – Tlaxcala	Tlaxcala	4 Lane	Available assets use
Pátzcuaro – Uruapan – Zamora			
Bypass Uruapan	Michoacán	2 Lane	Available assets use
Veracruz – Tampico			
Bypass Veracruz	Veracruz	From 2 to 4 Lane	State concession (PPP)
Villahermosa – Mérida			
Bypass Villahermosa	Tabasco	2/4 Lane	Available assets use
Bypass Champotón	Campeche	2 Lane	Available assets use
Bypass Morelia	Michoacán	2 Lane	Available assets use
Bypass Guadalajara South	Jalisco	2 Lane	Available assets use
Bypass Cuernavaca	Morelos	2 Lane	Available assets use
Bypass Tepic	Nayarit	2 Lane	Available assets use
Bypass Acapulco	Guerrero	2 Lane	Available assets use
Bypass Chilpancingo	Guerrero	2 Lane	Available assets use

Bypass Southwest México City			
Chamapa – Lechería	Distrito Federal	6 Lane	Available assets use
La Venta – Colegio Militar	Distrito Federal	4 Lane	Concession (PPP)
Colegio Militar – Chalco	Distrito Federal/México	4 Lane	Concession (PPP)
Bypass Chihuahua	Chihuahua	2 Lane	Concession (PPP)
Bypass Ciudad Juárez	Chihuahua	2 Lane	Concession (PPP)
Bypass Puebla South	Puebla	2 Lane	Concession (PPP)
Bypass West San Luis Potosí	San Luis Potosí	2 Lane	Concession (PPP)
Bypass La Laguna	Durango/Coahuila	2 Lane	Concession (PPP)
Amazoc – Perote – Xalapa			
Perote – Xalapa y Lib. de Xalapa	Veracruz	2 Lane	Concession (PPP)
Bypass Allende - Juárez	Nuevo León	2 Lane	Available assets use

4. ENVIRONMENT SUPERVISION

4.1. ENVIROMENT MONITORING AND SUPERVISION

Road projects need authorization before starting construction. Executing the works is conditioned to observe mitigation measures and specific restrictions established by a study and competent authorities.

An Environmental Management Plan (PMA) must be made, where mitigation measures activities are settled and synchronized to road construction activities. Additionally, programs for wildlife rescue and relocation, reforestation and soil restoration are other activities organized by PMA.

Environmental supervision is made at the same time of construction, where monitoring activities for soil, water, air, wildlife protection and any other aspects specified for the project, as well as the mitigation measures and conditions are observed. Furthermore, the results of the application for diverse mitigation measures to verify the actual reduction or annulment of the environmental impact must be also monitored and if necessary provide extraordinary measures for environmental protection.

The information raised from monitoring and supervision and from progress reports is sent periodically to SEMARNAT for its follow up. This agency has its own auditing staff coming from the PROFEPA, who randomly perform a verification of the requirements specified in the environmental impact authorization. This staff is empowered to apply administrative sanctions and even to stop construction works in case environmental protection restrictions are not properly observed.

By applying these actions of resolution, monitoring and supervision, as well as surveillance by the competent authority, road construction is now carried out observing

environmental impact with care and protection, so infrastructure works are no longer environment damage responsible.

5. ENVIRONMENTALY SUCCESFUL ROAD CASES:

The demographic and industrial indicators growing fast, the lack of planning and management strategies, the ignorance regarding socioeconomic and ecological values for ecosystems; have created serious pollution problems as well as the valuable economic and natural resources worldwide. To set against this damage, sustainable development emerges as an alternative that incorporates the environmental variable by making compatible maintenance and the better use of natural resources with social and economical development. Road construction is not indifferent to these issues, thus insofar as it is possible, choosing to consider these actions and environmental protection and recovering measures, infrastructure development in Mexico will line up straight to promoting of sustainable development. Some examples are shown in three cases of environmental success. One is related to design (section 5.1), the second to construction (section 5.2) and the third to road operation (section 5.3).

5.1. **ROAD PROJECT: JALA – PUERTO VALLARTA; SECTION: COMPOSTELA II – LAS VARAS – BUCERIAS – JUCTION BYPASS PUERTO VALLARTA, IN A 109.4575 KM DISTANCE, NAYARIT Y JALISCO STATES.** (ENVIRONMENTAL AND MITIGATION DESIGN TO PRESERVE HABITAT AND CONNECTIVITY INCREASE IN THE ECOSYSTEMS)

The Jala-Puerto Vallarta project, in the Compostela II-Las Varas-Bucerias-Junction Bypass Puerto Vallarta has been authorized for Environmental Impact. This will be a road with a total lengh of 108.241 km and will run parallel to the present federal road 200.

This project crosses by the Compostela and Bahia Banderas municipalities in the State of Nayarit and Puerto Vallarta in the state of Jalisco. The projected outline will carry A4 type characteristics, with 2 lanes each sense, 3.5 m wide each, a 2 m central barrier and 2.5 m emergency lanes, making a total of 21 m of road surface for a projected speed of 110 km/h; inside a 60 m right of way.

5.1.1. Benefits

This is an alternative way of seeing road systems, since it is not only a highway construction to open people and freight transport and communication but encourage the creation of links among the different parts of isolated environmental communities, as a result of anthropogenic activities development like agriculture, stockbreeding and others; that were split up. It is precisely through direct actions like the environment

restoration and wildlife passages considered in this project that those parts can integrate.

5.1.2. Environment Characteristics.

The project goes through the Sierra del Vallejo that was originally designated as a Natural Protected Area (ANP) under a State Biosphere Reserve category. However, several landowners appealed against the decision and won the definite trial, consequently these pieces of land do not belong to the ANP reserve. Nonetheless, the zone is environmentally important, therefore the project seek to find out counteracting mitigation measures to lessen the effect of a fragmented ecosystem as well as the barrier effect (connectivity) and habitat loses.

Diverse vegetal communities can be seen through the road area. Medium caducifolio and subcaducifolio forest, oak woods, palm trees and other vegetation, as well as some systems of soil exploitation: seasonal and irrigation agriculture, induced and farmed pasture.

There is in addition a great richness of ground vertebrates (amphibious, reptiles, birds and mammals) listed in NOM-059-SEMARNAT-2001 as endemic endangered species or with special protection; especially important for the whole region is the western Mexican jaguar preservation.

5.1.3. Main environmental impacts caused by road construction and its mitigation.

Constructing a major road like this in a well preserved environment and of great importance to the country due to its wildlife biodiversity, leads to environmental impacts that influence the road feasibility and the ecosystem preservation. Table 7 shows some of these impacts and the proposed mitigation measures.

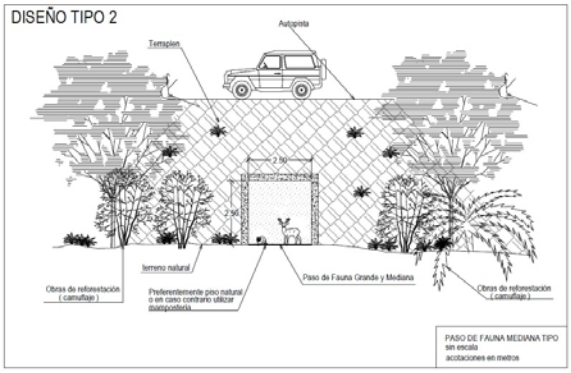
Table 7. Environmental impact due to road construction and proponed mitigation measures.

Possible Impacts	Mitigation Measures and Actions
Well preserved ecosystem major fragmentation	Previous evaluation of several route alternatives, selection of the environmental route, economically and technically adequate; with the less possible ecological damage
Habitat loses and vegetation fragmentation. Edge effect. Vegetal coverage loses and absorption capacity of the GEI.	Vegetation rescue program throughout the freeway. Ecologic restoration program for the right of way and other affected zones. Sign lay down to encourage wildlife protection.
Barrier effect for animal	Construction of 32 bridges and 7 tunnels to allow continuity in ecological corridors

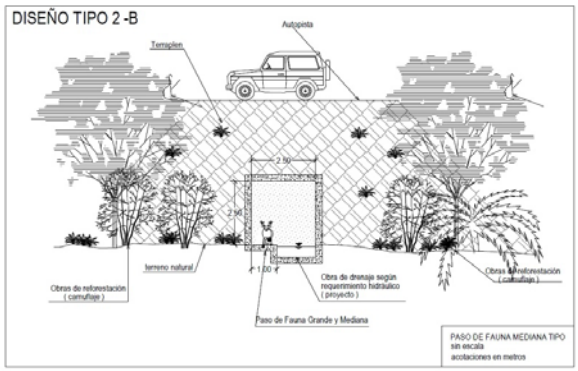
movement.	including jaguars.
Animal run over and noise frightening.	Construction of animal passages (upper and lower) related to a right of way restoration program as well as other affected areas, and near strategic pieces of land.
Road presence encouraging irregular human settlements in a natural vocation to be preserved land.	Controlled access freeway. Clear physical delimitation and surveillance of the right of way.

Fragmentation of habitat and barrier effect are the most relevant impacts, thus the project with the aim to preserve connectivity among environmental systems, has proposed the construction of a biological corridor throughout the whole freeway, reforesting and restoring the zone with regional wildlife to increase carbon caption (greenhouse effect gas) and recover the vegetal neighbor communities physiognomy as soon as possible; together with the installation of special structures and drainage works modifications to serve as animal passages, imitating actual environment and reinforced with wire mesh devices to induce the passage of animals.

The following pictures show some designs proposed for those passages



Animal pass design for biological corridors identified as zones to restore connectivity



Animal pass design using the installation of a drainage work from the Project to create sewers provided with mixed function for animal movement and water drainage

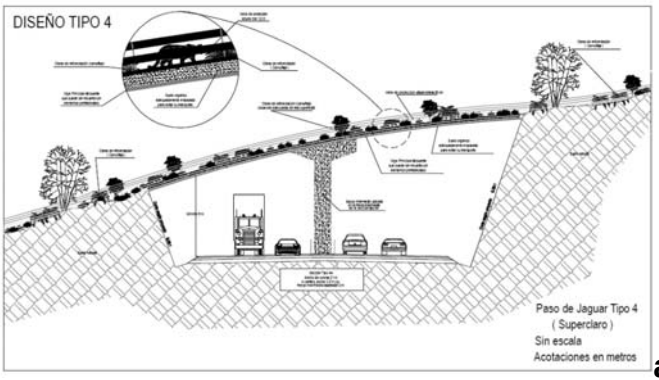
Figure 2. Designs for animal pass to restore connectivity

Additional to the last figures, in critical jaguar crossing zones and other major mammals identified by the movement corridors model (figure 3), some upper passages for animals will be constructed in strategic sites, like those shown in figure 4.

Corridor detail in critical north zone

Identified jaguar corridors.

Figure 3. North critical section detail. A proposed upper animal pass is shown and the drainage works (green box) with mixed function, facilitating animal flow in jaguar corridors (red polygon). Yellow polygon outlines zones where ecological restoration measures will be applied to increase connectivity and permeability of the whole region.



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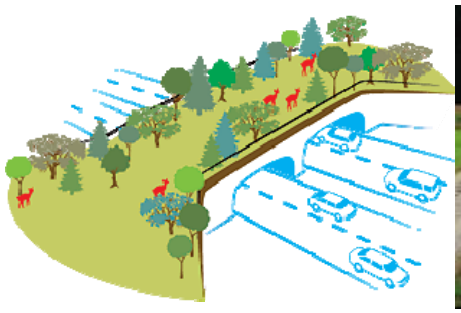

b

c

Figure 4.- a) Upper animal pass design for jaguar corridor protection (PIJ), b) General sketch for an upper animal pass c) Upper animal pass in developed countries.

Aditionally to the designed works for the new road, the project has an upper pass for the existing road that will serve together with a tunnel for the new road, to resume connectivity in an important jaguar corridor (figure 5)

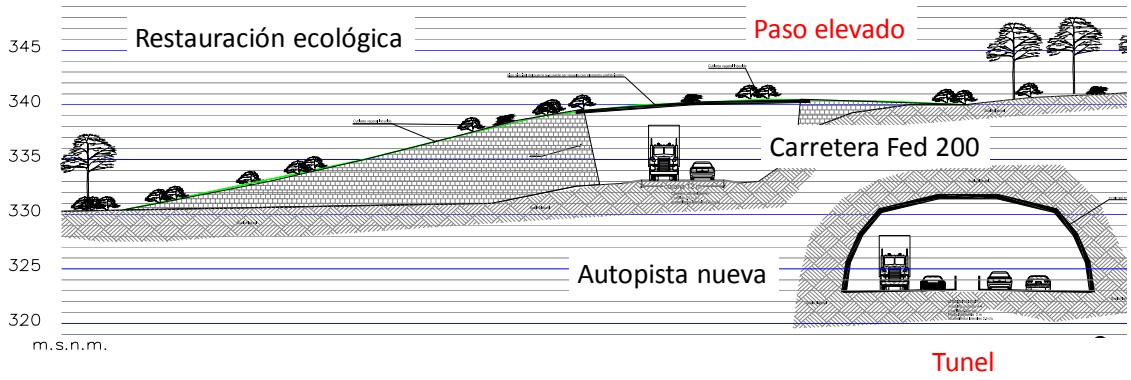

Figure 5.- Animal upper pass construction for the 200 existing federal road for ecological compensation to recover the jaguar movement corridor interrupted by the old road construction. The new road Project looks for a tunnel so the mixed action of both structures allows the corridor recovery.

With these projected actions the road will provide a better integration to the environmental system, making easier the connectivity and recovering affected habitat for the construction works, thus in the middle term, once the reforested trees gain an adult size, greenhouse effect gases will even be increasingly captured restoring the effect caused by the road construction and reactivating biological corridors through both old and new roads.

5.1.4. Case general results:

Constructing this road will bear important environmental impacts because it is a wide linear road located in a high quality environment zone. Nevertheless, it is as well an important and a high priority project for national development and economical growth since it will fulfill the existing need for efficient and safe conditions improvement over the service provided by the 200 federal road. Therefore, applying the proposed preventive, mitigation, compensation, restoring and control measures makes the project viable for environmental purposes and it might even revert the already made damage over the jaguar corridors in the region, facilitating the preservation of the Sierra Vallejo, Nayarit environmental reserve.

5.2. MÉXICO-TUXPAN FREEWAY: SECTION: TEJOCOTAL-NUEVO NECAXA (ECOLOGICAL RESTORATION PROGRAM IMPLEMENTATION FOR CONSTRUCTION SUCCESS EXAMPLE)

The Mexico-Tuxpan freeway construction is an example of compatibility between economical development and environmental care. The section Tejocotal-Nuevo Necaxa is 17.5 km long and goes through Acaxochitlan, Hidalgo and Huachinango, Puebla municipalities. There are several spots on the route where the road crosses the Mesofil Mountain Woods, which is a specific type of vegetation highly affected in Mexico, that shelter several protected species by regulation, like the arborescent fern (Cyathea Mexicana) and the maple (Acer Negundo). Mesofil Mountain Woods are characterized by

a high biodiversity since original plants from north and south America are mixed, and provide a great environmental service. The environmental impact study for this road proved to be an essential tool to prevent, mitigate and restore the ecological damages inflicted by the road works; considering that this road was located inside a Natural Protected Area and a Priority Regional Land. DGIRA extended their corresponding resolution authorizing this freeway construction by establishing three relevant requirements for the preservation and restoration of losses in environmental services.

a) A Protection Species Status rescue program, including the endangered classified species *Carpinus Caroliniana* by NOM-059-SEMARNAT-2001.
b) A right of way and work construction damaged areas restoration program.
c) Compensating actions for the Necaxa River covered forest.

The carried out Ecological Restoration Project (PRE), is the outcome of the observance for those requirements, including rescuing ecologically important protected species useful for reforesting purposes along the freeway right of way. The project focused in spreading using different methods and controlled conditions nursery preservation till the moment of reinsertion in the area, within a planting outline and erosion conditions defined in the executive project of the PRE.

Approximately 50,000 plants ranging from 10 to 150 cm from several species were rescued; four of them were protected by SEMARNAT. These were taken to a rustic nursery to later spread the seeds or vegetation parts.

Ecological restoration has developed a scientific basis for unbalanced ecosystem reconstruction. The International Ecological Restoration Society defines the process as “a process to help restoring a degraded, damaged or destroyed ecosystem”; its purpose is to restore an affected system, as close as possible, with a similar arrangement of species, characteristics and functions. The seedling rescued and spread in the nursery remained for another two years to be transplanted to rehabilitation areas (this means a project focused on some ecosystem functions recovered using native species)

More than 120,000 plants from 31 species from the Mesofil Mountain Woods were spread out for reforesting the right of way of the Mexico-Tuxpan freeway in the section Tejocotal-Nuevo Necaxa, including the sides damaged by bridge construction.

5.2.1. Case general results:

The ecological restoring project carried out in the Mexico-Tuxpan freeway used native species from the Mesofil Mountain Woods and cuts, slopes and sides affected were recovered.

Ecological restoration seeks to re-establish in medium and long terms, the fundamental interactions among soil, vegetation and fauna. With these, the greenhouse effect gas collection lost in the construction works is recovered. The ecological restoration of the Mexico-Tuxpan freeway was the first experience in its kind and it will be reference for future projects in Mexico.

5.3. MEXICO CITY BYPASS (NORTHERN ARC)

(SUCCESS OPERATIONAL CASE FOR EMISSION REDUCTION)

The Northern Arc in Mexico City is a toll road 223 km long, crossing the States of Mexico, Hidalgo, Tlaxcala and Puebla with junctions at toll roads Mexico-Queretaro, Mexico-Pachuca, Mexico-Tuxpan, Mexico-Puebla and Mexico-Morelia-Guadalajara.

The Northern Arc is one of the 14 main line corridors offering a direct connection throughout all country regions and will form a logistics platform.

5.3.1. Benefits.

Some estimated benefits for this road are time and operating costs decrease for those traveling from north to south in the country. Besides, traffic congestion reduction in Mexico City since many vehicles now crossing by will stop doing so.

SCT estimates once the freeway is totally functioning are that at least 1´000,000 vehicles will not go through Mexico City; therefore 108,000 tons of carbon dioxide (CO_2) will be diminished.

This road project will carry out at least the construction of three industrial parks, a freight airport and multimodal platforms distributed in four States, thus they will become the first logistics center of its kind in Latin America.

5.3.2. Case general results.

Road work construction to avoid traffic congestion in urban zones bypassing long itinerary vehicles helps to improve time travel and cost operating savings for those vehicles, mainly freight vehicles as well as gas savings, therefore reducing green house effect impact.

6. FUTURE TRENDS

6.1. RESEARCH

Research in Mexico regarding climate change, effects and mitigation or adaptation measures have been merely diagnosis, weakly in the transport sector and practically none in roads.

The Communications and Transport 2007-2012 sector program describes that the Mexican Institute for Transport is the research center for the Federal Government, and must support in a coordinated way with SCT, the comprehensive development of the transport sector; both in public and private arenas by carrying out scientific research tasks, technological innovation and technical regulation draw up, to improve safety, quality, modernity, reliability and efficiency for the infrastructure and its associated services, considering society and environment impacts. Thus, contribute to professional updating and human resources education for the sector.

6.1.1. Products

The Mexican Institute for Transport (IMT) has developed research studies focused in estimated emissions generated by the transport sector in Mexico, such as:

6.1.1.1. HDM-4 Parametric analysis for the environmental effect sub model

This study was made to analyze the HDM-4 environmental sub model with the idea to use the tool for evaluating emission estimates for roads, where traffic, road and climate variables are involved. By using the sub model incorporated in the HDM-4, it is possible to know generated emissions on a net or segment of the net while operating road transport.

Besides annual emission totals per vehicle, it is possible as well to analyze the net annual variation of those emissions as a consequence of different construction alternatives for a basis case (without or with a minimum project) that usually represents a minimum standard for routine maintenance.

This information potential is evident considering that energy efficiency and environmental effects, is these days widely recognized, to be incorporated for project and policy analysis, therefore, decision makers should be capable to understand energetic and negative environmental impacts implications for those activities.

Implementing emission calculations using “Environmental effects” sub model as integrated part of HDM-4, will allow including this environment variable in the decision making process, thus becoming a strategic instrument for air quality management.

6.1.1.2. Vehicle emissions pilot study for Federal Queretaro roads based upon model HDM-4

This research purpose was to use the environmental effects sub model for HDM-4 to carry out emission calculations of: Carbon Monoxide (CO), Carbon Dioxide (CO_2), Nitrogen Oxide (NO_x), Sulfur Dioxide (SO_2), Hydrocarbons (HC), lead (Pb) and Particulate Matter (PM); in Queretaro State Federal roads.

First the physical status for the whole Federal network was defined as well as development of its geometrical configuration and traffic.

With these data results becoming from different pollutants were analyzed to determine which one has the higher emission index, thus representing a major problem besides the greenhouse effect emissions.

The achieved information can be used for developing road emission inventories and define critical spots for gas emission, therefore, establishing mitigation measures such as: geometric or road surface characteristics improvement, high emission index vehicle restriction, implantation of maintenance strategies or environmental program development to protect wildlife.

Another relevant aspect is that commercial corridors emissions can be estimated, thus alternative use of transport modes could be evaluated, where the environmental variable, specifically gas emissions, is considered for people or goods modal transport selection.

It might also set standards for having microscopic scale emission data to estimate external transport costs and establish a tax model for highly contaminating vehicles or to internalize those costs to global transport costs.

6.1.1.3. Method proposal for estimating emission contaminants generated by vehicles in places like Mexico City.

This work focuses in a proposed method for estimating emissions generated by fossil fuel consumption, during urban travel in mobile sources, specifically vehicles.

Automobile operation transport is in Mexico City and great cities the main cause for air pollution. The proposal is based upon emission inventories for some cities in Mexico using the tool MOBILE version 6. To use the software it was necessary to obtain input data, from interviews applied to Uruapan City drivers about type of fuel, air conditioned use, fuel consumption amount, accumulated mileage and others.

The method incorporates three main aspects to be considered as necessary: 1.- Local conditions (elevation, temperature, relative humidity and fuel characteristics), 2.- Characterization of vehicle fleet (age, fuel type and vehicle classification), 3.- Operating vehicle data (obtained from interview analysis). With the compiled information model MOBILE 6 was fed to get emission factors for 8 vehicle types, such as: Motorcycles, Automobiles, Pick Ups, Light Vehicles, Buses and Heavy Vehicles.

Results show that the quantity of emissions generated by vehicle operation in the City of Uruapan: carbon monoxide, nitrogen oxides, total organic compounds, particulate matter (PM), sulfur dioxide, carbon dioxide and other 6 toxic contaminants (HAP’s)

It is believed that the emission inventory results might allow municipal environmental authorities to take environmental impact mitigating measures for these air contaminants that are damaging human health in the referred city.

The proposed method has was very useful to know in a macroscopic way the vehicle emission level generated in cities like the one selected for the study.

6.2. EDUCATION

Regarding academic research and education, surface transport has been widely developed by creating specialty and postgraduate courses in different places around the country, starting from the sixties until some recently created. Some postgraduate programs have subjects or topics related to environmental impact and its integration to construction works and road activities like the University of San Nicolas de Hidalgo in Morelia, Michoacan, the University of Puebla and the University of Queretaro. The Campeche University has two specialties dedicated to highways and urban roads with subjects considering environmental impact as well.

The National University of Mexico and the University of Chihuahua offer postgraduate courses focused in road infrastructure, however there are not environmental impact and mitigation as a part of their official program.

It is well known that surface transport usually has a higher contribution to the country's development, having as a target; a balanced territorial development, suitable infrastructure for a better use of natural resources of the country; therefore there is a need for education to be strengthened with institutional agreements, national and international, to consolidate transport efficiency. Some of these have been made with the Federal Highway Administration and the Texas Department of Transportation as well as several Federal and State national Secretariats.

6.2.1. Master degree courses.

SUMMARY OF MASTER IN SCIENC COURSES RELATED TO SURFACE TRANSPORT IN MEXICO

INSTITUTION	LEVEL	NOTES
UNAM	SPECIALTY	THERE IS NOT ENVIRONMENTAL IMPACT OR MITIGATION SUBJECTS IN THE PROGRAM CONTACT: ERNESTO MENDOZA SÁNCHEZ. +52 (55) 5622 8001
CAMPECHE	SPECIALTY	TWO OPTIONS: HIGHWAYS OR URBAN ROADS. BOTH INCORPORATE ENVIRONMENTAL IMPACT SUBJECTS GIVEN IN ONE SEMESTER CONTACT: JORGE ALEJANDRO BERZUNZA. +52 (981) 816 7878
QUERÉTARO	MASTER DEGREE	ENVIRONMENTAL IMPACT SUBJECTS INCLUDED CONTACT: ALDO ALFARO. +52 (442) 242 9059
PUEBLA	SPECIALTY	THREE OPTIONS: MAINTENANCE, CONSTRUCTION AND PROJECT DESIGN. NONE OF THEM HAS ENVIRONMENTAL IMPACT STUDIES. CONTACT: RAÚL CARRILLO VIZCAYA
MORELIA	MASTER DEGREE	ENVIRONMENTAL IMPACT SUBJECTS INCLUDED CONTACT: JORGE ALARCÓN IBARRA. +52

		(443) 322 3500 EXT. 4346.
CHIHUAHUA	MASTER DEGREE	NO ENVIRONMENT IMPACT STUDIES CONTACT: CECILIA OLAGUE CABALLERO +52 (614) 411 1644.

6.3. SUSTAINABLE ROADS

Sustainability is a term widely used and accepted all over the world. It comes from a United Nations Conference about environment in 1972, however it was until 1987, where the Brundtland Report defined sustainability as *"satisfying present needs without endangering future generations capacity to satisfy their own needs".*

Sustainable development can be conceptually divided in three categories: environmental, economical and social. Figure 8 shows a sketch of the aspects to be observed in any project to reach sustainability.

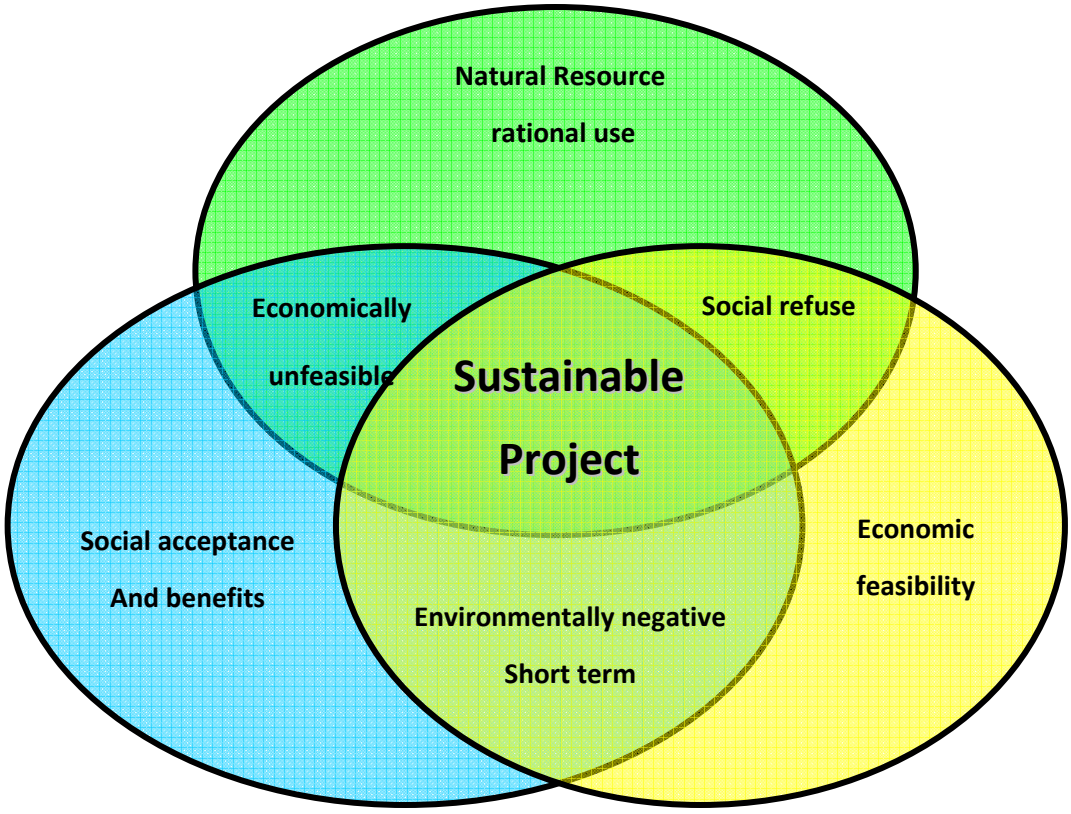

Figure 8. Aspects involved defining a sustainable project

The aim of sustainable development is to reconcile economic, social and environmental human activities and create feasible projects. The three aspects should be considered by transport infrastructure administrations.

Sustainability applied to roads is not only referred to the environment care but any aspect claiming to be sustainable must guarantee, besides environment care, safe and quality mobility and social and economic feasibility to contribute for the country's development.

The problem is defining which way to follow so road sustainability is achieved, directly related to particular circumstances of the country. The national scene analysis plays an important part in strategy design suitable to the country directed to road sustainability.

International outlook shows several programs related to sustainable mobility or road transport sustainability but only a few of them are focused specifically in infrastructure. Therefore, it will be necessary to deal with an integral sustainability way that incorporates those aspects.

The European Road federation (ERF) defines sustainable roads as those efficiently and effectively planed, designed, constructed, modernized and maintained through environmental integrated policy preserving social and economic expected benefits in terms of safe mobility.

A road sustainable program might include social-economical and environment impacts to raise sustainability as well as best considered practices for sustainable projects.

Impacts over the three pillars of sustainability can be positive or negative. Some of them might contribute to the economic development of the country, growing gross domestic product or employment by road infrastructure construction. Social aspects referred to mobility, safety or accessibility; are beneficial to society. Environmental negative ingredients are pollutants specially greenhouse effect emissions that are responsible for global warming among other impacts.

Evaluation of impacts can be made for the different stages of road infrastructure projects, thus sustainability criteria should be identified for planning and project design as it was stated in other sections and for construction, maintenance and operation as well.

Sustainable projects specifically look for several targets; each one might choose diverse practices as pavement recycling, rain water management, non fossil energy use in road systems and others.

Thus a project requires that this need is dealt with in the communications and transport sector, looking forward to establish a Sustainable Roads Program. The support for this is based upon the guidelines of the National Development Plan that stands for increasing quality and competitiveness infrastructure coverage, which is the main objective for the communications and transport sector, understanding quality of infrastructure as encouraging reliability, opportunity, efficiency and environment care when developing infrastructure for communications and transport, to improve productivity and development of the sector.

7. CONCLUSION

This report shows the efforts made in Mexico for climate change effects mitigation, divided in three main lines. First, referred to environment legislation, administrative procedures for road project environmental impact evaluation and environment management, second,

referred to implementing mitigation measures for environment impact control, preserving natural wildlife and its biological corridors; to increase green areas for greenhouse effect gas collection and third, referred to road project policy implementation oriented towards greenhouse effect emission reduction, such as bypass construction and road surface conditions improvement.

There are several plans and programs in the country where the aim to reduce greenhouse effect emissions responsible for global warming but they are not directly related to roads. These are meaningful efforts conducted to the same goal.

In this work the environment accompanying evolution process has been discussed and Mexican continuous efforts oriented to environment protection and at the same time developing road transport infrastructure, milestone of any country's development, were presented. Legislation, vision and road construction related actions have evolved towards environmental impact and its mitigation experience and knowledge changes; benefiting the planet, communities and the whole nation. Some successful cases have been shown and the efforts that have been done preparing new generations to face future challenges.

A road project can be considered as sustainable if planning, design, construction and operation are environmentally and socially founded so the needed development for the country is allowed.

Mexico has been working on right direction but there is still too much to do, for achieving a real environmental development integration; therefore, it is important sustain present actions going on in the country, so benefits are increased, environment preserving actions are extended and continue educational aspects as well as human resources training oriented towards environmental impact knowledge and developing research in climate change mitigation topics.

Finally it is important to stand out the Communications and Transport Secretariat (SCT) efforts as the road operating administrator in Mexico, to observe environment applicable regulations for roads and to protect environment through investments over implementing mitigation measures.

The sustainable road program should be a pending task for SCT that will allow, national level, to have goals and policy oriented towards effective and efficient roads planned, designed, constructed, modernized and maintained through integrated environment

respectful policy, preserving social and economical expected benefits in terms of safe mobility.

8. BIBLIOGRAPHY

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