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APPROACHES REGARDING THE ENVIRONMENTAL IMPACT ASSESSMENT OF FOREST ROADS WITH A SPECIAL EMPHASIS ON THE ROMANIAN FORESTRY SECTOR

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Abstract: *Forest roads represent one of the forestry operations with the most visible impact upon the environment. At EU level, project proposals that are likely to have an impact on the environment are regulated by EIA Directive (85/337/EC). EIA of forest roads focuses on solutions that are compatible with environmental values and sustainable forest management principles over the entire life cycle of the forest road. This paper presents a subject review of EIA of forest roads, stressing its applicability in the Romanian forestry sector. EIA is a transparent tool based on a participatory approach that fosters the selection of most suitable forest road alternatives which are technically feasible, economically viable, environmentally sound and socially acceptable.*

Key words: *environmental impact assessment (EIA), forest roads, forest engineering, decision making.*

1. Introduction

Since early 1990's, environmental impact assessment (EIA) of forest roads has gained more and more attention among stakeholders from the forestry sector and became an important tool for assessing different options of forest road routes, considering resource allocation, environmental and social constraints. Forest roads represent one of the most visible forestry operations [10] with impacts on environment in various ways: from landslides, soil erosion and transports of sediments to disturbance of ecosystems, disturbance of landscape's scenic beauty and social impacts. It is the responsibility of forest engineers to tackle these sensitive issues when planning forest roads and to provide solutions for minimizing the negative impact on the environment, while maximizing the benefits of a new forest road. Despite the reduced density of forest roads in Romania, harvesting costs vary between 14 and 16 €/m^3, depending on the type of cut (final or thinning). This fact is possible due to cheap labour and current behaviour of Romanian forest operators, which mostly combine harvesting operations, as externalized services for forest owners, with the purchase of timber on stump, plus harvesting services and timber trading. However, the environmental impact of such

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behaviour is considerably higher due to old harvesting technologies and skidding timber on long distances by chaotically building skidder trails. Hence, low density of forest roads triggers high damages on residual stands and the environment and, therefore, enhancement of primary and secondary forest infrastructure would reduce the risk of such damages and would foster more productive, safer and environmentally friendly harvesting technologies. But increasing the density of forest roads represents another challenge in changing the former behaviour of forest road network planning in Romania from valley roads to slope roads that must fulfil multiple objectives. Under these circumstances, EIA is an evaluation tool that should be used in the early stages of planning in order to identify the possible effects of forest roads on the environment and the mitigation measures needed for minimizing those impacts. The final outcome of the planning process will always be a compromise between different preferences of the stakeholders, but the solutions must be well documented and they must be technically feasible, economically viable, environmentally sound and socially acceptable [15].

2. Materials and Methods

Forest road network planning is a complex problem because it involves multiple conflicting objectives and functions of forest roads. This paper will present a way of structuring the decision problem and will describe the phases of EIA of forest roads, underlining the importance and necessity of integrating the EIA concept in the process of planning forest roads in Romania.

2.1. Problem structuring

Forest roads represent fixed assets serving for timber transport and for facilitating the access of workers and machineries at forest stands, for execution of forest operations. Thus, road network planning should consider *a priori* the selection of silvicultural strategy and harvesting systems, the type and location of harvesting machineries in order optimize harvesting system efficiency, to fulfil multiple forest functions and to reduce residual stand damage [15]. In addition, forest roads are important for wildlife management, for local communities, for social activities and they provide access to risk zones in case of natural hazards. Therefore, forest roads should be seen as organic endowments of forest ecosystems, and regarded as assets for facilitating the execution of these operations and in the forest development as a whole [11], addressing ecological aspects from the initial phases of planning prior to technical designing. Recent studies [3], [7] showed different forms of impact on environment by forest road construction. Balancing conflicting objectives of forest roads, considering their environmental impact is a complex problem which needs to be very well structured and understood by decision makers. Therefore, a clear set of criteria and measurable indicators of the goals that must be achieved by forest roads should be defined. This is possible through the analytic hierarchy process (AHP), a theory based on hierarchically structuring a decision problem into its most basic elements, allowing the assessment of qualitative and quantitative criteria and variables at each level of the hierarchy structure through pairwise comparisons using a scale of absolute judgements [12]. From an environmental point of view the goal of forest roads is to minimize their overall adverse effects on the environment while maximizing the benefits (Figure 1). FR1, FR2 and FR3 represent alternatives of road routes that can be compared using AHP and sensitivity analysis, according to specified criteria and indicators through

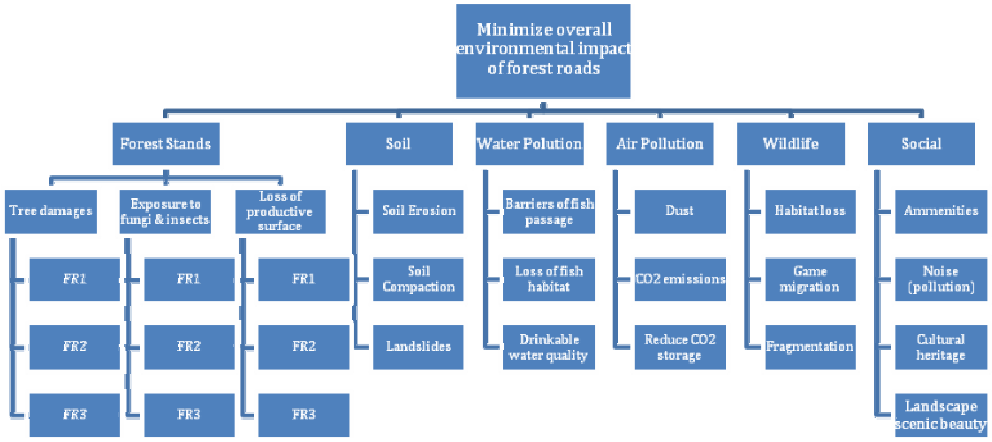

Fig. 1. *Example of problem structuring in case of forest roads*

pairwise comparisons and utility additive functions, resulting in a ranking of the proposed options. Thus, decision makers can easily decide upon which solution to implement.

2.2. Environmental impact assessment of forest roads

At the level of the EU, assessment of developmental projects which are likely to have significant impact on the environment has been regulated since 1985 through the EIA Directive (85/337/EEC), amended in 1997, 2003 and 2009, and codified under Directive 2011/92/EU [18]. The EIA Directive aims to protect human health, to improve the quality of life through a better environment and to maintain the levels of biodiversity and ecosystem conservation, demanding project developers to provide an EIA report for the project proposal and a decision making process based on a transparent and participatory approach, involving all relevant stakeholders.

Forest roads are projects with visible impact on the environment, thus road network planning should consider the impact assessment. There is an extensive approach system of cost-efficiency analysis incorporating different criteria related to needs, risks and effects for assessing forest road options in a mountainous region highlighting the importance of a participatory process in the literature [5]. Type of indicators referring to natural environmental values (e.g. soil, water or biosphere) and social environmental values (e.g. Socioeconomic conditions, health and safety, cultural heritage, scenic beauty of the landscape) and phases of a road network planning are also mentioned [8]:

- Development and evaluation of technical feasibility of forest road alternatives;
- Assessment of environmental impact;
- Public involvement;
- Decision making.

However, the EIA should be used in the early stages of route planning, and not after technical designing of forest roads in order to harmonize the technical, environmental and social solutions of the proposed forest road options. The issue of EIA of forest roads will be approached in the following lines according to phases defined in UNEP EIA Training Resource Material [20].

2.2.1. Screening and scoping

The main goal of this phase is to determine if a project proposal requires EIA and, if so, to identify the most relevant

environmental factors that should be addressed by EIA of forest roads. *A priori* to route planning, one should identify environmental values that might be affected by the proposed forest road [6], during the survey phase of the project area, while mapping positive and negative cardinal points [16]. A scaling system can be used for creating a database of sensitive areas from an environmental point of view. GIS layers of different environmental values can be then created, highlighting the areas with restrictions on a general EIA map, which can be used when planning new road routes for avoiding as much as possible sensitive areas [5]. However, due to technical constraints, not all sensitive areas can be avoided by the planned route; in this case, mitigation measures must be proposed for minimizing the impact of forest road construction.

During the screening phase the following type of questions should be raised and looked for an answer: *Does the forest road proposal significantly affect people (surrounding communities), flora, fauna, soil or water ecosystems? Does it affect the landscape, cultural heritage, biodiversity or fixed assets?* If the answer is yes, then the following question should be: "*To which extent does the construction of forest road affect the respective environmental values?"* All these questions could be efficiently approached using screening checklists [10]. A rating of the factors results, guiding the decision maker for choosing the most appropriate mitigation measures in EIA.

Out of the identified environmental factors, only the most relevant ones for the forest road proposal should be considered in the EIA. For example, one goal of building a forest road is the minimization of its overall environmental impacts. This objective, in its turn, is decomposed into other more specific sub-objectives (e.g. minimization of impacts on soil, on water, of habitat disturbance). These sub-objectives are to be assigned measurable indicators which characterize each criterion, and consequently each objective is a function of its sub-objectives [4]. Based on this approach, identified environmental factors can be ranked. Considering that forest roads are usually projects with local importance, the EIA should use a simple structure, including a description of the project background, the identification of environmental factors and risk exposure to possible sources of disturbance, the impact analysis and the requirements for mitigation and monitoring. Elaboration of a thorough EIA of forest roads is necessary only in case of projects affecting extensive forest areas, or when the project develops in protected areas, in areas with important cultural heritage and where the risk of irreversible impacts on such values is increased.

2.2.2. Impact analysis

Due to their peculiar location generally in remote areas, EIA of forest road proposals focuses more on the impact on the natural environment factors (air, water, soil, biodiversity). However, the current trend of EIAs driven by the public involvement is to include social and economic impacts [20].

Besides classical consistent forest road construction damages to forest stands [7], EIA enlarges the focus of possible impacts, considering soil, water, wildlife, natural landscape and social aspects. Forest roads are dynamic ecosystems, their boundaries being the limits of their measurable ecological effects [9]. This is a sound approach, since forest roads interact with other ecosystems, create conditions for development of micro-biotopes and develop towards a mature steady state, when a new ecological equilibrium is met.

There are two methods currently used in Romania for assessing the impact of forest roads on environment [3]: *quantitative*

analytical method (AM) - which considers reliability grades from 1 to 10 that highlight the effect factors have on the environment, and *graph analytical method (GAM)* - which determines the global pollution index (GPI) using a diagram. The impact on biodiversity refers to sensitive biotopes located on the path of the proposed forest road, endemic species and important habitats [1].

The impact of forest roads on soil occurs over the entire area of the road base and its immediate surroundings under the form of soil pollution, compaction, erosion, damage of local soil ecosystems and landslides. However, these drawbacks should be addressed using a holistic approach, considering that road building provides improved forest accessibility that finally will reduce both energy consumption during timber harvesting and transport, and the negative impacts of large scale harvesting machinery on forest soils [17].

Water pollution is another likely impact of forest roads. The water from precipitation washes the side slopes of forest roads and the embankments, resulting in the transport of sediments and chronic sedimentation, which might affect the existing fish population or other water ecosystems. Evacuation of water from road bed is a critical requirement during the whole life cycle of the forest road and is possible through a system of side ditches and transversal culverts set under the road embankment. Due to chronic sedimentation, blocked ditches or objects transported by torrential streams, culverts might fail and the water might flow over the road bed surface, causing erosion and increasing the transport of sediments. Although in a certain way culverts might hinder the passage of aquatic life forms, stream crossing can be done using fords or a combination of fords with culverts [2].

Wildlife disturbance might occur under the form of habitat loss, habitat fragmentation, migration and reduction of game population. Although forest roads affect wildlife at a smaller extent than public roads and disturbance effects are lower in forested habitats, evaluation of the primary effects of a new forest road must consider also the cumulative effects of other infrastructure networks in the nearby [14]. Due to construction works habitats might be hampered, banishing game populations. However, some of these impacts are temporary, only the fragmentation due to increased density of forest roads might occur on long term and the other pressures may decrease [17]. The evaluation of the forest roads effect on long term fragmentation is difficult, since forest roads pose different barriers to living organisms and different species have different thresholds of tolerance to barriers [9]. However, wildlife populations could recover after the road construction disturbance, depending on traffic intensity and noise production during the life cycle of the forest road, adapting to the new conditions. In addition, forest roads are borderlines with some positive ecological effects [14].

The *social impact* of forest road construction usually refers to: risk of damaging surrounding local amenities; risk of labour accidents during construction works; noise pollution; cultural heritage disturbance; disturbing the scenic beauty and recreation premises of natural landscape. Notwithstanding, construction of forest roads has also positive social effects in terms of employment possibilities, improved access to remote areas or interest points and development of new capacities among local people.

Regarding the scale of impacts, the behaviour of decision makers differs in respect of risk acceptance. Some might be willing to take the risk regardless of the potential impacts, while others would tolerate a higher probability of hazard occurrence if the impacts are likely to be

minor [4]. Nevertheless, in an EIA of forest roads, possible impacts and mitigation measures must be well documented, being the responsibility of the decision maker to consider or to disregard the evaluated risk.

2.2.3. Mitigation measures

Mitigation measures refer to those actions required for enhancing the environmental and social benefits of a proposal, ensuring that residual adverse impacts are kept within acceptable levels [20]. In case of forest roads, the first measures are taken during the planning by developing different alternatives of road routes that are avoiding the sensitive areas. However, it is very likely that environmental disturbance is not completely avoided; in this case, active mitigation measures are required. Depending on the type of impact and its magnitude, different measures must be undertaken.

Minimizing damages on residual forest stands is possible by a reduction in the use of explosives, execution of retaining parapets, employment of excavator instead of bulldozer [3], [7]. A minimum width of the corridor opening while balancing cut and fill volumes would reduce the loss in timber production. Adverse effects on soils and water can be mitigated by ensuring the evacuation of water from the road bed surface from the early phases of construction through a proper execution of drainage works, replanting the side slopes and building reinforcement works for areas sensitive to landslides [2].

For minimizing the impact on air and water, use of bio-fuels, bio-lubricants and state of the art machineries are required. In addition for forest watersheds with the main function to protect water for drinking purposes, more strict mitigation measures are required: avoidance of fords as a solution for stream crossing; use of bio-materials for culverts and bridges or avoidance of those materials which may corrode in time.

The impact on wildlife might be mitigated by reducing the noise pollution, avoiding the use of blasting or creating man-made habitats mimicking the natural biotopes where those habitats have been hampered. For reducing fragmentation impact, development of protection belts (trees and shrubs) in the case of roads located in open areas should be considered [3]. This would also lead to reduced visual impact of the denuded landscape due to excavation works. Other options in this respect could be the adaptation of road alignment to contour lines, clear cut restrictions along the road or replanting of side slopes of the road [13].

In order to reduce the risk of settlement damage and labour accidents, use of excavator instead of bulldozing, labour safety measures and special protective belts below the embankment of the forest roads are required. In terms of noise pollution, use of silent machineries during road construction is necessary.

All possible measures should be considered in the EIA of forest roads, for providing the decision maker with relevant information about the impact of each alternative in terms of costs, social and environmental impact [20].

2.2.4. Reporting

In general terms, EIA of forest roads is a comprehensive report that identifies the environmental issues, assesses their impact and proposes mitigation measures prior to project development. However, this is not the case for all forest road proposals. In Ireland [10] an Initial Environmental Evaluation consisting of screening procedures and proposed mitigation measures is the only necessary report for assessing the impact of forest road proposals. In Romania, the assessment of

the environmental impact of forest roads is called Environmental Impact Study (EIS), regulated by the Order of Ministry of Waters and Environment Protection no. 860/2002 and consists of different working phases [2]. Depending on project size and significance of impacts, two stages of the EIS are in use, the approval process lasting between one and four months [19]. The latter case also involves public consultation.

In Austria, forest road projects were regulated based on more general rules and principles by the Forest Act enforced in 1975 and they must comply with forestry and nature conservation authorities [13]. This is a good example of interdisciplinary cooperation of stakeholders through a participatory approach which lead to proposals for good quality of forest road by considering different development options, which can be both economically affordable and environmentally sound.

Comparison of the road alternatives from an environmental point of view should include [20]: adverse and beneficial impacts; effectiveness of mitigation measures; distribution of benefits and costs, including cost benefit analysis and NPV assessment and any other opportunities for community and environmental enhancement. The EIA report of forest roads is subject to public consultation for a period of time which differs among countries.

2.2.5. Review and public involvement

During this phase the adequacy and quality of EIA report are checked taking into consideration public opinion, determining if the information is sufficient for a final decision and identifying the deficiencies of the report. The project developer must update accordingly the EIA report before environmental approval can be issued.

The review is made by different independent bodies or institutions subordinated to central authorities, depending from country to country. In Romania, the evaluation of the EIS report of forest roads is subject to approval by the National Agency of Environment Protection (NAEP) which issues an environmental agreement or notice.

It is in this phase when the project proposal becomes subject to public consultation. Involved stakeholders, local community and civil society may address critical opinions on the subject matter of developing the forest road proposal. However, only those forest road proposals which are located in protected areas or in their immediate buffer zones, or projects that have significant impact on sensitive environmental values or on the local communities are mostly argued by the general public.

2.2.6. Decision making

Following the EIA review and public consultation then forest road proposals receive the approval from the environmental bodies. It is the developer's responsibility to implement all mitigation measures mentioned in the EIA report and in the environmental agreement, in order to reduce the adverse effects of the forest road construction on the environment.

2.2.7. Implementation and follow-up

The implementation phase refers to the construction of the approved forest road. Project development should be supervised and monitored in order to verify that proposed mitigation measures are satisfactorily implemented and the impacts are within allowed limits [20]. Attention is also paid to management of unforeseen events and to ensure that environmental benefits are maximised, while development costs are kept within reasonable boundaries. The completion of forest road construction works should end with a formal reception

phase of the works, where a commission of experts inspects the quality of the forest road execution and verifies the compliance with the requirements set within EIA.

The impact of forest roads on the environment does not stop when the construction works finished. The follow-up procedure refers to the impact of the forest roads during its entire life-cycle, when road maintenance is required. A forest road is a technical ecosystem which interacts with surrounding ecosystems and matures until it reaches a steady stable state [9]. Hence, forest roads become part of the forest ecosystem and enhance the fulfilment of different functions that forest alone could not fulfil. However, the lack of forest road maintenance does not harm only forest management activities, but can seriously affect the environment through road failures, landslides, soil erosion and transport of sediments. It is therefore necessary, that forest roads are permanently maintained and rehabilitated during their entire life cycle. Ditches and culverts should be cleaned on a regular basis, reinforcement works should be inspected and repaired, road platform should be graded and compacted after a certain amount of timber is transported on the road.

3. Discussions

Forest roads represent the backbone for sustainable management of forests. Addressing the issue of EIA of forest roads in the Romanian context came as a straightforward fact when considering the current old harvesting technologies used in Romania that hamper environmental and social values trough massive soil erosion, water pollution and increased risk of accidents among forest workers. Environmental and social aspects are mostly disregarded by the stakeholders involved in the timber supply chain, especially by harvesting contractors, the main focus being on profit maximization. Therefore, a holistic approach to enhancing the forest road network considering the selection of state of the art harvesting systems could create the premises for improving the quality of harvesting operations and for reducing their side effects. Improving forest infrastructure, skidding distance will decrease and consequently good premises for introducing more environmentally friendly and ergonomic harvesting technologies (e.g. cable yarders, forwarders or cable-forwarders, harvesters), increasing the quality and productivity of timber harvesting. Notwithstanding, development of forest roads also involves environmental disturbance at different scales, that has to be considered during the planning phase. Hence, EIA is seen as a necessary and useful tool for supporting decision making in forest engineering. Using EIA from the early stages of road network planning will bring benefits both for forest management, forest owner benefiting from a well documented forest infrastructure, a reduced risk of stands damage and reduced impact of harvesting activities on the environment, and also for the forest contractors which could improve their productivity and harvesting quality.

EIA of forest roads should focus on identification and analysis of potential risks of developing a road option and on proposing effective mitigation measures for minimizing the adverse effects on the environment.

4. Conclusions

The aim of this paper was to present the way environmental aspects should be considered when developing different forest road proposals in Romania, following the phases of EIA. Some of the accounted benefits of EIA of forest roads are: environmental friendly technical solutions in forest road design and construction,

consideration of harvesting systems and development options in forest road network planning, effective mitigation measures and increased overall social benefits. Consequently, EIA becomes an important tool that should be used by forest engineers and forest managers when planning forest roads, because it gives the possibility to thoroughly analyse different options of road alternatives and thus documenting the decision making process. In this respect, multiple criteria analysis (MCA, AHP) should be seen as a decision support tool that helps decision makers to make decisions. MCA can guide the decision maker in the decision making process and provides the best results when it is combined with sensitivity analysis.

EIA is a transparent tool using a participatory approach for supporting decision making, fostering and raising awareness about the importance of environmental values when developing forest operations and it should not be a burden on a project proposal, but a tool for making its implementation acceptable from an environmental point of view. Therefore, the scope of the EIA of forest roads should be focused only on those values which are most likely to be affected by the road construction.

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