'ROADS AND FLOODS'

Best Practice Guidelines for the Integrated Planning and Design of Economically Sound and Environmentally Friendly Roads in the Mekong Floodplains of Cambodia and Viet Nam

31 May 2009

Table of Contents

Introduction

This document presents a set of Best Practice Guidelines for road development and rehabilitation in the Mekong floodplains of Cambodia and Viet Nam. The guidelines are developed under the 'Roads and Floods' project[1]. The guidelines are based on the review of local practice, international experience, and case study results. They are intended for use by professionals and organisations involved in road planning and design in the Mekong floodplains, as well as those involved in environmental and integrated assessments of road developments in the Mekong basin or structural developments in this basin in general.

The Best Practice Guidelines are based on the case study results, the review of current international practice as well as the practice in the Mekong Basin. In the presentation of the Best Practice Guidelines, each of the recommendations is followed by an explanation including reference to their origin.More information on the 'Roads and Floods' project, its activities and results can be found in the Roads and Floods Synthesis Report.

The set of Best Practice Guidelines for road development and rehabilitation in the Mekong floodplains of Cambodia and Viet Nam consists of the following three Best Practice Guidelines:

- Best Practice Guidelines for Integrated Planning of Road Development and Rehabilitation.
- Best Practice Guidelines for Environmental Assessment of Road Development and Rehabilitation.
- Best Practice Guidelines for Technical Design of Road Development and Rehabilitation.

The Best Practice Guidelines are presented in the Annexes.

[1] Douven, W.J.A.M., M. Goichot and H.J. Verheij (2009), Best Practice Guidelines for the Integrated Planning and Design of Economically Sound and Environmentally Friendly Roads in the Mekong Floodplains of Cambodia and Viet Nam, synthesis report of the 'Roads and Floods' project (part of MRC-FMMP Component 2) by Delft Cluster, WWF and MRC, RFMMC, Phnom Penh, Cambodia.

Annex 1. Best Practice Guidelines for Integrated Planning of Road Development and Rehabilitation

Best Practice Guidelines for Integrated Planning of Road Development and Rehabilitation in the Mekong Floodplains of Cambodia and Viet Nam

May 2009

CONTENTS

1 INTRODUCTION TO THE BEST PRACTICE GUIDELINES OF FMMP-C2

In the FMMP-C2 'Flood Structures and Flood Proofing' a number of Best Practice Guidelines are developed. The aim of these Best Practice Guidelines is to enable the MRC and national line agencies to better take into account flood-related considerations in their day-to-day technical activities. The 'Roads and Floods' Best Practice Guidelines are part of the FMMP-C2 Best Practice Guidelines.

The 'Roads and Floods' Best Practice Guideline do not provide detailed guidance, also because the local situations in Cambodia and Vietnam vary quite a lot and request tailored solutions. The guidelines do provide recommendations how to improve existing guidance.

2 HOW TO USE THIS BEST PRACTICE GUIDELINE

The Best Practice Guideline for integrated plannning is targeted at the following audiences:

- National and provincial government agencies charged with planning and the land transport sector in order to take into account flood-related considerations in the assessment and evaluation of their activities in an improved way. Additionally, transport and public works type of ministries and their associated agencies plus MRC and related riparian staff, particularly of BDP, in order to assess basin developments.
- Development banks that often fund infra-structural works and / or studies producing guidelines for infra-structural planning and design.
- Developers of road development and rehabilitation projects in the Mekong floodplains, consultants, research groups and NGO's who are involved in environmental assessments in the LMB.

The Best Practice Guideline for integrated plannning is a set of recommendations which may be followed during the process of road development and planning in the Mekong floodplains. The Best Practice Guideline can be used for both infrastructure and road policies, plans and programmes (at strategic levels) and individual development and rehabilitation projects.

3 BACKGROUND ON DEVELOPMENT OF THE BEST PRACTICE GUIDELINE

This Best Practice Guideline for integrated plannning was designed on the basis of:

- Review of current planning systems in Cambodia and Viet Nam.
- Review of international guidelines and best practices.
- In-depth analysis of a number of road development and rehabilitation cases in Cambodia and Viet Nam.

The above-listed activities were part of the 'Roads and Floods' project and detailed information on the project, its activities and results can be found in the Roads and Floods Synthesis Report (Douven et al., 2009).

4 PURPOSE AND SCOPE

The overall goal of the Best Practice Guideline is to mainstream the planning and development of roads within the vulnerable and highly valuable Mekong floodplain system with their consequences including economic, environmental and social impacts, both short- and long-term ones.

The specific objectives of the Best Practice Guideline are the following:

- To promote the adoption of integrated planning approaches to road development and planning in the Mekong floodplain.
- To provide guidance on the application of integrated planning approaches in road development and planning in the Mekong floodplain.

The Best Practice Guideline can be used for both infrastructure and road policies, plans and programmes (at strategic levels) and individual development and rehabilitation projects. The Best Practice Guideline is particularly relevant at the following stages of road development and rehabilitation:

- Concept development.
- (pre)-feasibility studies.

The Best Practice Guideline for integrated planning is a set of recommendations to improve existing guidance on the process of road development and planning in the Mekong floodplains. The structure of the recommendations is the following:

- General recommendations related to the planning process.
- Recommendations for economic considerations.
- Recommendations for institutional arrangements and financial resources.
- Recommendations for research and capacity building.

5 RECOMMENDATIONS FOR INTEGRATED PLANNING

GENERAL RECOMMENDATIONS RELATED TO PLANNING PROCESS

#	RECOMMENDATION	CONTENT
1	***Apply an integrated planning approach when developing roads in the vulnerable and highly valuable Mekong floodplain system, that considers the consequences of the development throughout the system including environmental and social impacts***	This is an overall recommendation addressing the importance of integrated planning in road planning and development in the Lower Mekong Basin. This integrated approach is required because of the strong interaction between structures (roads) and the vulnerable and valuable Mekong floodplain. The recommendation distinguishes two important elements in the integrated planning approach; 'Considering consequences throughout the system' and 'Including environmental and social impacts', which will be both addressed in recommendations given below. Recent and future regional-wide and national-wide transportation development and planning are important factors supporting the integrated planning for road development and rehabilitation. Some of the recent and future developments in this repect are mentioned in the Roads and Floods project Synthesis Report (Chapter 3). *Recommended reading:* The Roads and Floods Synthesis report presents a planning process with accompanying methods and approaches particularly focussed at (pre-)feasibility planning stages. The approach is presented in Annex 3 of the Roads and Floods Annex Report and was applied to the project's case studies and used to structure the presentation of the cases (Chapter 5 of the Synthesis Report).
2	***Strengthen the relationship between road development and rehabilitation and environmental assessment***	In order to sufficiently consider environmental impacts of road development and rehabilitation in the planning processes it is important to strengthen the link between development and environmental assessment procedures. In both Cambodia and Viet Nam, these environmental assessment procedures exist (Chapter 3 of the Roads and Floods project Synthesis Report), but need strengthening in order to consider impacts on floodplain hydraulics and related ecology more comprehensively. Viet Nam and Cambodia have an EIA system in place, while Viet Nam has also established an SEA system. Figure 1 illustrates how road planning and management can be interrelated with environmental assessment procedures, like Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA). Viet Nam has both the EIA and SEA system in place; Cambodia doed not have a SEA system in place at the moment. Still, if no SEA system is in place, it is relevant to consider environmental impacts at the strategic level. Figure 1 shows the different steps in the infrastructure project cycle, and how the EIA and SEA procedures help assess, manage and mitigate environmental impacts. At the strategic level this will lead to greater integration of a government's environmental commitments in national economic planning and provide a framework under which diverse private sector interests can operate. Addressing potential damage to infrastructure earlier in the project cycle can avoid 'last–minute' problems that in the past have led to disruption of transport traffic, important loss of investment and, high maintenance costs. Moreover, it will facilitate consideration of alternative design options, which will be included in the

#	RECOMMENDATION	CONTENT
		cost estimates, help avoid irreversible environmental outcomes and protect natural resources for future generations, and foster a higher degree of acceptability for projects among stakeholders.

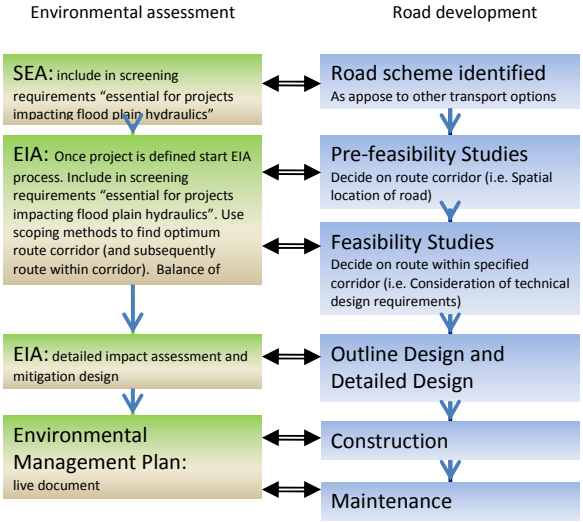


Figure 1 Relation between road development and environmental assessment steps after the Master plan stage.

P.s. In Cambodia the pre-feasibility step is only for IEE and the feasibility step for EIA.

3	***Apply a (sub)-floodplain system's approach in which not only local impacts of roads but also regional and cumulative impacts are considered***	The case study results of the 'Roads and Floods' project (Chapter 5 Roads and Floods project Synthesis Report) showed that road construction and rehabilitation at one location often cause negative impacts elsewhere, e.g. in terms of increased velocities at adjacent roads with an expected increase in road damage. Hence, particularly in the case of road development in floodplains, it is important to not only consider the project and project area in itself, but also the interactions with the surrounding area. It is recommended to analyse these interactions at the scale of the sub-floodplain system. This also relates to the incorporation of cumulative impacts. In planning and management these impacts at project level should be included in environmental assessments (like EIA), but more importantly at strategic regional and / or basin planning level through an SEA, if available.
4	***Provide sufficient coordination between road development and rehabilitation planning and other sector planning***	Given the strong interaction with floods, road development and rehabilitation planning needs to be closely coordinated with other planning activities. Key examples of integration with other sectors are given below. **Dike planning and management** Roads in the Mekong delta are often built on top of dykes and levees. Planning and management of both roads (transport) and dikes (water management / flood protection) is the responsibility of different ministries. Coordination between these ministries is strongly recommended in order to apply more environmental friendly solutions of road development in the Mekong floodplains.

#	RECOMMENDATION	CONTENT
		Integrated Flood Risk Management Roads can strongly affect the local and regional hydraulic system and hence affect flooding regime both at a local and regional level. Moreover, roads themselves are vulnerable to floods and subsequent damage can be tremendous. Hence, road development should be in line with IFRM concepts and the IFRM guidelines currently under development. This will require close cooperation between road developers and those agencies active in flood risk management. Such interaction does, to a considerable degree, take place in the Viet Namese delta. In this region, dikes, roads and water engineering structures are often integrated, and hence flood risk management, transport and water management sectors must work together to achieve solutions. This sectoral integration appears to be strongest at the provincial scale. *Recommended reading:* - FMMP-Component 2 Best Practice Guidelines on IFRM Planning and Impact Assessment **Disaster management** Disaster risk management in the Lower Mekong Basin is closely linked to infrastructure development, as roads (often build on embankments are important structures for aid and evacuation in times of floods. ADPC (2008) gives a number of recommendations how disaster risk assessment can be better incorporated in road planning process. *Recommended reading:* - ADPC (2008), Incorporating disaster risk assessment as part of planning process before construction of new roads; *RCC Guideline 3.1,* Consultation Version 2.1, April 2008, ADPC. **Integrated Water Resources Management** Roads can strongly interact with the Mekong and its floods, hence road planners and developers should closely work together with agencies responsible for the management and development of water resources. Integrated Water Resources Management is one of the guiding principles in the management and development of water resources in the Lower Mekong Basin (at national levels and regional level through the MRC). *Recommended reading:* - Chapter 4 of the Roads and Floods project Synthesis Report for a description of Integrated Water Resources Management (IWRM). - Website Global Water Partnership: http://www.gwpforum.org
5	***Assess possible transboundary (provincial, national) impacts of road development and rehabilitation in the Mekong floodplain and cooperate at the inter-provincial and/or international level***	MRC plays a central role in supporting and facilitating cooperation at the international level. Moreover, issues of integral road planning and design should be addressed in Greater Mekong Subregion (GMS programmes. Recommended reading: - MRC and ERM (2002) - Greater Mekong Subregion (GMS) website: http://www.adb.org/GMS/

#	RECOMMENDATION	CONTENT
6	***Tailor alignment and design solutions to the specific floodplain hydraulic and ecological situation of the local situation***	The case study results presented in the Roads and Floods project Synthesis Report (Chapter 5) make clear that the level and scope of roads and floods interactions, to a large extent, is determined by the local context, including the floodplain system, its ecological value and the associated social and economic development. It was beyond the scope of the Roads and Floods project to give recommendations for specific local projects, apart from the case studies presented in its Synthesis Report. However, in road (and dyke) planning and management practice this local context should be considered guided by the set of Best Practice Guidelines developed and the case studies presented.

ECONOMIC CONSIDERATIONS

#	RECOMMENDATION	CONTENT
7	***Recognise and quantify the value of floodplains and its benefits for local population as much as possible***	Include the benefits of floods for the local population in road development and impact assessments, and do not consider only the damage caused by floods. The costs and benefits ideally should be considered in monetary terms, otherwise it is recommended to make use of expert judgement to be able to assess the value in monetary or other terms. See also recommendations Poulsen et al. in Box 4.4 in the Roads and Floods project Synthesis Report (Chapter 4). Recommended reading: - De Groot et al. (2006) - Baran, et al. (2007b) - Poulsen et al. (2002)
8	***Apply integrated cost-benefit analyses while assessing and evaluating road development and rehabilitation alternatives***	Roads in floodplains often act as barriers, increasing the river water level and duration of inundations with direct impact to population and their livelihoods. Roads may also impact the movement and reproduction cycle of fish. Most fish species breed during the floods in the river and on the floodplains. Fisheries in the Lower Mekong provide 80 % of animal protein to 60 million (MRC, 2003). The poor depend on wild fisheries. It is considered important to properly assess and integrate the livelihood benefits of floodplains into water development and infra-structural planning at various scales. Apart from the assessment of livelihood benefits of floodplains, the costs and benefits of how a project may effect different social groups should be analysed, taking the role of local institutions and differences in household assets into account Integrated cost-benefit analysis takes into account both the benefits of improved transport infrastructure and the damage to natural floodplain ecosystem and the livelihoods it supports. It should also include the benefits of floods for the local population in road development and impact assessments, apart from damage caused by floods. The latter ideally in monetary terms, otherwise it is recommended to make use of expert judgement to be able to assess the value in monetary or other terms. Integrated cost-benefit analysis also takes short term and long term developmental and environmental costs dimensions into account in road planning and design. The cases illustrate that such an approach does not need to be seen as a barrier to

#	RECOMMENDATION	CONTENT
		roads development, and on the long term could lead to lower road costs as well as less environmental impacts. However, this approach should be applied in the early stages of road planning in order to improve its sustainability and subsequent economic benefits (see further next section). Recommended reading: - De Groot et al. (2006) - Poulsen et al. (2002)
9	***Consider road development and rehabilitation alternatives that allow for a gradual upgrading of the road system***	Investment funds for infra-structural development, particularly in Cambodia are limited and the country is dependant on international donors. This asks for guidance how to gradually upgrade and develop the infrastructure network. Above-mentioned recommendations in this financial section could be beneficial in helping lower the long term costs of maintenance and reducing the negative impacts to the environment. The challenge is to come up with solutions that are affordable for the LMB Lower Mekong Basin countries. The case results give an indication that a higher initial investments might probably lead to lower medium term costs and ecological impacts. This requires a financial assessment considering investment, operation and maintenance, as well as damage risk at the early planning stages (see previous recommendations). Such analysis would also contribute to a more efficient use of limited financial resources.

INSTITUTIONAL ARRANGEMENTS AND FINANCIAL RESOURCES

#	RECOMMENDATION	CONTENT
10	***Improve / strengthen the institutional framework to support integration between the relevant sectors and at the necessary scales***	This relates to an earlier recommendation on need for cooperation among sectors. Multi-sectoral interests of road development, such as transport, agriculture, flood risk management, water management, environment, should be taken into account which will require collaboration between different sectors at various administrative levels. In Cambodia the national working groups on infrastructure developments could be suitable fora for this purpose. In Viet Nam coordination committees at national level, or the provincial level could adopt a similar role.
11	***Enhance (or develop and maintain) sustainable financing mechanisms in order to facilitate implementation of integrated road policies/projects***	At this moment financial schemes are separated, which hampers integrated solutions. E.g. because road investment budgets, road operation and maintenance and ecological rehabilitation budgets are not held by the same budget holders linked, integrated solutions which trade off short term costs against long-term costs and benefits can not be facilitated.

RESEARCH AND CAPACITY BUILDING

#	RECOMMENDATION	CONTENT
12	***Improve knowledge of the floodplain system in terms of interactions between floodplain hydraulics and basin developments, functions of the system, particularly the ecological functions, critical thresholds to maintain these functions and values of the functions.***	The above-mentioned recommendations require good understanding of the floodplain system. Improve knowledged is needed of the basin system in terms of floodplain hydraulics and interactions with basin developments, functions of the system, particularly the ecological functions, critical thresholds to maintain these functions and values of the functions. Particular fish species have particular habitat requirements which relate directly to hydraulic parameters such as velcoties or water depth or type of sediment deposit (which is directly dictacted by hydraulic characteristics). Develop floodplain risk assessments in an inderdisciplinary manner (see FMMP-C2 Flood risk asssessment BPGs), vulnerability assessment, rapid assessment of biodiversity and its links to the hydraulic characteristics on a spatial level, floodplain valuation, base line development, monitoring to support environmental assessments of basin developments, including roads. This research would help improve the sub-floodplain descriptions as presented in Annex 2 of the Roads and Floods project Synthesis Report.
13	***Invest in education, training and technical support to introduce and / or strengthen practice of integrated planning and environmental assessments of road development and rehabilitation***	Capacity needs to be enhanced to support introduction and implementation of the recommendations. Here is a role for the countries in cooperation with the MRC, but also of educational and research institutes.
14	***Promote Mekong-riparian countries cooperation and exchange of knowledge and practices***	It is important to promote the knowledge available within countries and institutes and to share amongst them. Role for NMCs at the national level, MRCS, including the RFMMC in Phnom Penh at the regional level.

6 REFERENCES

ADPC (2008), Incorporating disaster risk assessment as part of planning process before construction of new roads; RCC Guideline 3.1, Consultation Version 2.1, April 2008, ADPC.

Baran, E., T. Jantunen, and C. K. Chong (2007a), *Values of inland fisheries in the Mekong River basin*. WorldFish Center, Phnom Penh.

De Groot, R.S. (1992), *Functions of nature: Evaluation of nature in environmental planning, management and decision making*, Wolters-Noordhoff, Amsterdam, 1992. 315 pp.

Douven, W.J.A.M., M. Goichot and H.J. Verheij (2009), Best Practice Guidelines for the Integrated Planning and Design of Economically Sound and Environmentally Friendly Roads in the Mekong Floodplains of Cambodia and Viet Nam, synthesis report of the 'Roads and Floods' project (part of MRC-FMMP Component 2) by Delft Cluster, WWF and MRC, RFMMC, Phnom Penh, Cambodia.

ERM (2002), *Development of an EIA/SEA System for the Lower Mekong Basin: Background review*, April 2002, London.

Poulsen A.F., Ouch Poeu, Sintavong Viravong, Ubolratana Suntornratana and Nguyen Thanh Tung (2002) *Fish migrations of the Lower Mekong River Basin: implications for development, planning and environmental management*. MRC Technical Paper No. 8, Mekong River Commission, Phnom Penh. 62 pp. ISSN: 1683-1489.

Annex 2. Best Practice Guidelines for Environmental Assessment of Road Development and Rehabilitation

Best Practice Guidelines for Environmental Assessment of Road Development and Rehabilitation in the Mekong Floodplains of Cambodia and Viet Nam

May 2009

CONTENTS

1 INTRODUCTION TO THE BEST PRACTICE GUIDELINES OF FMMP-C2

In the FMMP-C2 'Flood Structures and Flood Proofing' a number of Best Practice Guidelines are developed. The aim of these Best Practice Guidelines is to enable the MRC and national line agencies to better take into account flood-related considerations in their day-to-day technical activities. The 'Roads and Floods' Best Practice Guidelines are part of the FMMP-C2 Best Practice Guidelines.

The 'Roads and Floods' Best Practice Guideline do not provide detailed guidance, also because the local situations in Cambodia and Vietnam vary quite a lot and request tailored solutions. The guidelines do provide recommendations how to improve existing guidance.

2 HOW TO USE THIS BEST PRACTICE GUIDELINE

The Best Practice Guideline for environmental assessment is specifically targeted at the following audiences:

- National and provincial government agencies involved in environmental assessments of road projects (incl. EIA, IEE, CIA and SEA[1]) and / or the screening, scoping (preparing ToR for EIS[2]), and EIS review phases. Hence, mainly ministries of environment and associated agencies.
- Development banks that often fund infra-structural works and / or studies producing guidelines for infra-structural planning and design.
- Developers of road development and rehabilitation projects in the Mekong floodplains, consultants, research groups and NGO's who are involved in environmental assessments in the Lower mekong Basin.

This section presents recommendations to improve the present Cambodian and Viet Namese EIA guidelines and specifically the sectoral EIA guidelines on infrastructure (under development) in both countries. The focus of the recommendations is on the screening (including IEE), scoping and EIS review phases, as these are the key entry points for the competent authority either sets the boundary conditions for project design or plays a role in reviewing project design. Checklists are included that help improve national EIS screening, scoping and EIS reviews guidelines.

[1] Environmental Impact Assessment (EIA), Initial Environmental Examination (IEE), Cumulative Impact Assessment (CIA), Strategic Environmental Assessment (SEA).
[2] Environmental Impact Statement (EIS)

3 BACKGROUND ON DEVELOPMENT OF THE BEST PRACTICE GUIDELINE

This Best Practice Guideline for environmental assessment was designed on the basis of:

- Review of environmental assessment systems in Cambodia and Viet Nam.
- Review of international guidelines and best practice documents in the field.
- In-depth analysis of various cases in Cambodia and Viet Nam.

The above-listed activities were part of the 'Roads and Floods' project and detailed information on the project, its activities and results can be found in the Roads and Floods Synthesis Report (Douven et al., 2009).

4 PURPOSE AND SCOPE

The overall goal of the Best Practice Guideline for environmental assessment is to strenghthen environmental assessments of the development and rehabilitation of roads in the vulnerable and highly valuable Mekong floodplain system and to cover the specific floodplain hydraulic and ecological conditions of the Mekong floodplain. The specific objectives of the guideline are the following:

- To give general recommendations on how to improve environmental assessments of road development in Cambodia and Viet Nam.
- To give specific recommendations on how to include floodplain related considerations in the EIA / IEE screening, scoping and review phases.

The Best Practice Guideline is particularly relevant at the following stages of road development and rehabilitation:

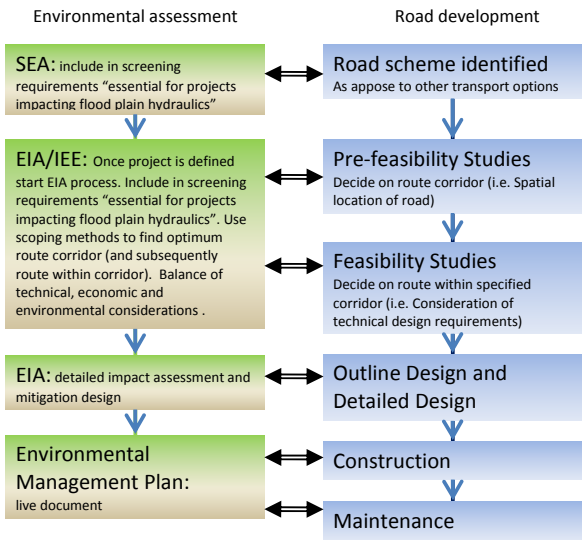
- Concept development.
- (pre)-feasibility studies.
- Design studies.

The Best Practice Guideline for environmental assessment consists of a list of recommendations to improve existing guidance on EIA / SEA type of procedures related to the developing and planning a road in the Mekong floodplain. Apart from a set of general recommendations it contains specific input to the screening and scoping phases of EIA as well as the review of Environmental Impact Statements. Checklists are included that help improve national EIS screening, scoping and EIS reviews guidelines. The structure of the guideline is:

- General recommendations.
- Recommendations EIA / IEE Screening.
- Recommendations EIA Scoping.
- Recommendations EIS review.

5 GENERAL RECOMMENDATIONS FOR ENVIRONMENTAL ASSESSMENT

#	RECOMMENDATION	CONTENT
1	***Strengthen the system and process of Environmental Impact Assessment, specifically the coverage of floodplain hydraulics and related ecology***	Environmental Impact Assessments (EIAs) for large infra-structural developments are mandatory in Cambodia and Viet Nam (like the other MRC countries). Hence, the EIA process would be the most logical entry point for considering impacts of roads on the floodplain system. There is room for improvement, as the current EIA guidelines only to a very limited extent address floodplain hydraulic and ecological aspects.
2	***Amend environmental regulations if they do not currently require EIAs for all projects***	In the screening phase, improvement is needed to specifically address development in a vulnerable floodplain system like the Mekong. In general EIA is only mandatory for (inter)national and larger provincial road developments. It is recommended to review the current EIA screening guidance to assess whether adjustments are needed.
3	***Mainstream environmental assessment with road development and rehabilitation***	In order to sufficiently consider environmental impacts of road development and rehabilitation in planning processes it is important to strengthen the relationship to environmental assessment procedures. In both, Cambodia and Viet Nam, these environmental assessment procedures are existing, but need strengthening in order to better consider impacts on floodplain hydraulics and related ecology. Viet Nam and Cambodia have an EIA system in place, while Viet Nam also has an SEA system established. Figure 1 illustrates how road planning and management can be interrelated with environmental assessment procedures, like EIA and SEA. The different steps in infrastructure project cycle are shown, and how the EIA and SEA procedures help assess, manage and mitigate environmental impacts. Infra-structural sector policies, plans and programmes define individual projects. Strategic Environmental Assessments (SEA) provide the framework for implementing Environmental Impact Assessments (EIA). At the strategic level this will lead to greater integration of a government's environmental commitments in national economic planning and provide a framework under which diverse private sector interests can operate. Addressing potential damage to infrastructure from potential flood events earlier in the project cycle can avoid 'unforseen' problems that in the past have led to the disruption of transport traffic, important loss of investment and, high maintenance costs. Moreover, it will facilitate improved consideration of alternative design options, which will be included in the cost estimates, help avoid irreversible environmental outcomes and protect natural resources for future generations, and foster a higher degree of acceptability for projects among stakeholders.

#	RECOMMENDATION	CONTENT
		 *Figure 1 Relation between road development and environmental assessment steps after the Master plan stage.* *P.s. In Cambodia the pre-feasibility step is only for IEE and the feasibility step for EIA.*
4	***Include at the EIA scoping and EIS review phases the assessment of impacts of road development and rehabilitation projects on the floodplain hydro-dynamics and ecology***	Existing environmental assessment guidelines and recommendations in Cambodia and Viet Nam do not include instructions on what aspects to consider when developing in a vulnerable floodplain system like the Mekong, e.g. how to include valuation of the lost benefits of floodplains. The scoping and the Environmental Impact Statement (EIS) review phases are key entry points for such improvements, and this Best Practice Guideline gives suggestions for improvement (next pages). Cumulative impacts of road developments should be better considered at project level or more strategic levels (see also below).
5	***Initiate and / or strengthen the use of Strategic Environmental Assessments of infrastructure policies, plans and programmes***	Infrastructural development in a floodplain system like the Lower Mekong Basin would need a Strategic Environmental Assessment to address impacts and cumulative impacts of individual developments as they, particularly in a floodplain system, impact on and / or are impacted by the surrounding environment. In Viet Nam there is a SEA system in place, and it is recommended to apply it for infrastructure development in the Mekong Delta. In Cambodia there is no SEA system in place, yet. It is recommended to initate the use of SEA in Cambodia. The cumulative impact of many structures can be assessed, although this is complicated as it is more than simply adding up the individual impacts of each structure.

#	RECOMMENDATION	CONTENT
6	***Adopt regional initiatives to address transboundary environmental impacts, like the GMS and proposals for a environmental assessment system for the MRC.***	Regional programmes such as the Strategic Environmental Framework for the Greater Mekong Sub-region (GMS), which promote strategic environmental assessments addressing the cumulative impacts of basin development projects should be adopted. There is a need for a commonly agreed and understood EA system for the MRC to be applied for those developments that are likely to have transboundary impacts (ERM, 2002). *Recommended reading:* - ERM (2002)
7	***Improve the capacity of EIA practitioners in implementing and reviewing the EIA processes.***	The capacity of EIA practitioners needs improvement in various aspects: in implementing the EIA process in general (including stakeholder participation), producing terms of references for EISs taking a holistic approach (scoping), consulting local stakeholders and scientists to make use of available knowledge, producing EIS (developers, consultants), reviewing EISs and monitoring project implementation and environmental impacts.

6 GENERAL RECOMMENDATIONS FOR SECTORAL EIA GUIDELINES FOR THE ROAD SECTOR

This section presents recommendations to improve the present Cambodian and Viet Namese EIA guidelines and specifically the sectoral EIA guidelines on infrastructure (under development) in both countries. Recommendations are targeted at the screening, scoping and EIS review phases. This needs to follow through, ie. into design and EMP follow up.

RECOMMENDATIONS EIA / IEE SCREENING

The screening guidelines are intended to ensure that at an early stage of the EIA process the floodplain hydraulic and ecological aspects are considered, and hence better decisions on the need for EIA are made.

#	RECOMMENDATION	CONTENT
8	***Review the current EIA screening list in order to address the environmental impacts of building infrastructure (roads) in a floodplain system like the Mekong***	In both Cambodia and Viet Nam, EIA is only required for the construction of (inter)national road developments. Road development at provincial and local level as well as road rehabilitation do not require EIA. The development of infra-structural works in a vulnerable floodplain system like the Mekong, can cause not only environmental impacts during construction, but particularly also during operation at local scale but also at the sub-floodplain scale. Therefore, it is recommended to review the current screening lists and e.g. add road projects in the floodplain to current screening lists (e.g. provincial roads and large rehabilitation works). For individual cases the screening checklist presented in Annex 1 (see recommendation #9), could further guide in deciding upon whether an EIA is needed.
9	***Consult the screening checklist as a guidance to whether an EIA or IEE for road developments in the Mekong floodplain is needed***	Annex 1 presents parts of the screening checklist that was developed by the European Community (EC, 2001a). The annex presents those parts of the EC checklist most relevant for checking possible impacts related to road developments in a floodplain system.

RECOMMENDATIONS EIA SCOPING

The scoping guidelines, like the screening guidelines are intended to ensure that at an early stage of the EIA process the floodplain related aspects are sufficiently considered. The scoping guidelines, however, particularly focus on improving the terms of reference for EIS of road development and rehabilitation projects.

#	RECOMMENDATION	CONTENT
10	***Consult the scoping checklist as a guidance to develop terms of reference for EIS for road developments in the Mekong floodplains***	Annex 2 presents parts of the scoping checklist that was developed by the European Community (EC, 2001b). The annex presents those parts of the EC checklist most relevant for scoping impacts related to road developments in a floodplain system that can be used as input for the development of the terms of reference for EIS for road developments in the Mekong floodplains.

RECOMMENDATIONS EIS REVIEW

The EIS review guidance has two intended objectives: (1) to help developers and their consultants to produce better quality EIS's, and (2) to help the relevant authorities to review the EIS's more effectively, so that decisions can be made on the best informed information.

#	RECOMMENDATION	CONTENT
11	***Consult the EIS review guidance to produce better quality EIS's of road developments in the Mekong floodplains, and to review them more effectively***	The checklist in Annex 3 (EC, 2001c) is designed as a method for reviewing the adequacy of the EIS in terms of addressing environmental impacts by road developments in the Mekong floodplains and generally accepted good practice in EIA. By adequacy it is meant that the completeness and suitability of the information from a content and decision-making viewpoint is considered. The EIS review checklist can be used in one of two ways (EC, 2001c), either: ▪ To assess the adequacy of an EIS for decision making in which case the output of the checklist is an assessment of the adequacy of the information. If the information is inadequate the checklist prompts the user to identify what further information is required; or ▪ To assess the quality of EIS generally for either research or monitoring purposes. So for example the checklist can be used to investigate which parts of the information required by the Directive are usually best or worst in quality across a number of EIS, or to investigate the overall quality of EIS submitted for different types of projects, or to investigate trends in quality over time. Annex 3 presents parts of the EIS review checklist that was developed by the European Community (EC, 2001c). The following parts most relevant for reviewing EIS's of road developments in a floodplain system are presented in Annex 3: ▪ Description of the environment likely to be affected by the project ▪ Description of the likely significant effects of the project ▪ Description of Mitigating Measures

7 REFERENCES

EC (2001a), *Guidance on EIA: Screening*, Office for Official Publications of the European Communities, Luxembourg.

EC (2001b), *Guidance on EIA: Scoping*, Office for Official Publications of the European Communities, Luxembourg.

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Douven, W.J.A.M., M. Goichot and H.J. Verheij (2009), Best Practice Guidelines for the Integrated Planning and Design of Economically Sound and Environmentally Friendly Roads in the Mekong Floodplains of Cambodia and Viet Nam, synthesis report of the 'Roads and Floods' project (part of MRC-FMMP Component 2) by Delft Cluster, WWF and MRC, RFMMC, Phnom Penh, Cambodia.

ANNEX 1. EIA / IEE SCREENING CHECKLIST

The table below presents parts of the screening checklist that was developed by the European Community (EC, 2001a). Those parts most relevant for checking possible impacts related to road developments in a floodplain system are selected, and adjusted whenever necessary for use in the Lower Mekong Basin.

The check list could also be used to screen whether an EIA or Initial Environmental Examination would be needed (as in Cambodia).

Table: Recommended EIA / IEE screening factors to be considered for road developments in a floodplain system (adapted from EC (2001a)).

Questions to be considered (for further guidance on factors to be considered see the more detailed questions listed in the Scoping Guidance in Annex 2)	**Yes / No / ? Briefly describe**	**Is this likely to result in a significant effect? Yes/No/? – Why?**
Brief Project Description:		
1. Will construction, operation or decommissioning of the Project involve actions which will cause physical changes in the locality especially with respect to hydraulics (flood duration, flood extend, waterdepth, flow velocities), topography, land use, changes in waterbodies, etc?		
2. Will the Project result in social changes, for example, in demography, traditional lifestyles, employment? (threat to fish industry/migration and or agriculture)		
3. Are there any other factors which should be considered such as consequential development which could lead to environmental effects or the potential for cumulative impacts with other existing or planned activities in the locality?		
4. Are there any areas on or around the location or further away which could be affected (especially in terms of ecology or agriculture) by the project?		
5. Are there any areas on or around the location which are used by protected, important or sensitive species of fauna or flora e.g. for breeding, nesting, foraging, resting, overwintering, migration, which could be affected by the project?		
6. Are there any areas on or around the location which contain important, high quality or necesary resources e.g. freshwater, surface waters, forestry, agriculture, fisheries, which could be affected by the project?		
7. Is the project location susceptible to erosion, flooding and or is the project itself a source for drastic changes of existing conditions which could cause the project to present environmental problems?		

ANNEX 2. EIA SCOPING CHECKLIST

The table below presents parts of the scoping checklist that was developed by the European Community (EC, 2001a). Those parts most relevant for scoping possible impacts related to road developments in a floodplain system are selected and adjusted whenever necessary for use in the Lower Mekong Basin. These parts can be used as input for the development of the terms of reference for EIS for road developments in the Mekong floodplains.

Table: Recommended EIA scoping factors to be considered for ToR for EIS of road developments in a floodplain system (adapted from EC (2001b)).

No.	Questions to be considered in Scoping	Yes/No/?	Which Characteristics of the Project Environment could be affected and how?	Is the effect likely to be significant? Why?
1. Will construction, operation or decommissioning of the Project involve actions which will cause physical changes in the locality (topography, land use, changes in waterbodies, etc)?				
1.1	Permanent or temporary change in hydraulics which will reflect negative on the land use, landcover or topography including increases in intensity of land use?			
1.2	Impoundment, damming, culverting, realignment or other changes to the hydrology of watercourses or aquifers?			
1.3	Does it affect existing stream crossings?			
1.4	Changes with respect to flood duration, flood extent, water depth and flow velocities			
2. Will the Project result in social changes, for example, in demography, traditional lifestyles, employment?				
2.1	By resettlement of people or demolition of homes or communities or community facilities eg schools, hospitals, social facilities or most important by affecting traditional means of employment like fishery and agriculture?			
3. Are there any other factors which should be considered such as consequential development which could lead to environmental effects or the potential for cumulative impacts with other existing or planned activities in the locality?				

No.	Questions to be considered in Scoping	Yes/No/?	Which Characteristics of the Project Environment could be affected and how?	Is the effect likely to be significant? Why?
3.1	Will the project lead to pressure for consequential development introducing new industry (means of employment) which could have significant impact on the environment eg more housing, new roads, new supporting industries or utilities, etc?			
3.2	Will the project lead to development of supporting facilities, ancillary development or development stimulated by the project which could have impact on the environment eg: - supporting infrastructure (roads, power supply, waste or waste water treatment, etc) - housing development - extractive industries - supply industries - other?			
3.3	Will the project have cumulative effects due to proximity to other existing or planned projects with similar effects eg providing safe passage and escape routes to higher ground in case of extreme high floods?			

ANNEX 3. EIA REVIEW CHECKLIST

The table below presents parts 3 and 4 of the EIS review checklist that was developed by the European Community (EC, 2001c). These parts most relevant for reviewing EIS's of road developments in a floodplain system are selected and adjusted whenever necessary for use in the Lower Mekong Basin.

Table: Recommended EIA review to be considered in reviewing EIS of road developments in a floodplain system (adapted from EC (2001c)).

Description of the environment likely to be affected by the project				
No.	**Review question**	**Relevant?**	**Adequately addressed?**	**What further information is needed?**
Aspects of the environment				
1.1	Are the existing land uses of the land to be occupied by the Project and the surrounding area described and are any people living on or using the land identified? (including residential, commercial, industrial, agricultural, recreational and amenity land uses and any buildings, structures or other property)			
1.2	Are the topography, hydraulics, geology and soils of the land to be occupied by the Project and the surrounding area described?			
1.3	Are any significant features of the topography or geology of the area described and are the conditions and use of soils described? (including soil quality, stability and erosion, agricultural use and agricultural land quality)			
1.4	Are the fauna and flora and habitats of the land to be occupied by the Project and the surrounding area described and illustrated on appropriate maps?			
1.5	Are species populations and characteristics of habitats that may be affected by the Project described and are any designated or protected species or areas defined?			
1.6	Is the water environment and links to associated ecology of the area described? (including running and static surface waters, groundwaters, estuaries, coastal wasters and the sea and including run off and drainage. NB not relevant if water environment will not be affected by the Project)			
1.7	Are the hydrology, hydraulics, water quality and use of any water resources that may be affected by the Project described? (including use for water supply, fisheries, angling, bathing, amenity, navigation,effluent disposal)			
Data collection and survey methods				
2.1	Has the study area been defined widely enough to include all the area likely to be significantly affected by the Project?			
2.2	Have all relevant national and local agencies been contacted to collect information on the baseline environment?			
2.3	Have sources of data and information on the			

	existing environment been adequately referenced?			
2.4	Where surveys have been undertaken as part of the Environmental Studies to characterise the baseline environment are the methods used, any difficulties encountered and any uncertainties in the data described?			
2.5	Were the methods used appropriate for the purpose?			
2.6	Are any important gaps in the data on the existing environment identified and the means used to deal with these gaps during the assessment explained?			
2.7	If surveys would be required to adequately characterise the baseline environment but they have not been practicable for any reason, are the reasons explained and proposals set out for the surveys to be undertaken at a later stage?			
Description of the likely significant effects of the project				
Scoping of effects				
3.1	Is the process by which the scope of the Environmental Studies was defined described? (for assistance, see the Scoping Guide in this series)			
Prediction of direct effects				
3.2	Are direct, primary effects on fauna and flora and habitats described and where appropriate quantified?			
3.3	Are direct, primary effects on the hydrology, hydraulics and water quality of water features described and where appropriate quantified?			
Prediction of secondary, temporary, short-term, permanent, long-term, accidental, indirect, cumulative effects				
3.4	Are long term effects on the environment caused over the lifetime of Project operations or caused by build up of pollutants in the environment or change in hydraulics described?			
3.5	Are effects on the environment caused by activities ancillary to the main project described? (ancillary activities are part of the project but usually take place distant from the main Project location e.g. construction of access routes and infrastructure, traffic movements, sourcing of aggregates or other raw materials, generation and supply of power, disposal of effluents or wastes			
3.6	Are indirect effects on the environment caused by consequential development described? (consequential development is other projects, not part of the main Project, stimulated to take place by implementation of the Project e.g. to provide new goods or services needed for the Project, to house new populations or businesses stimulated by the Project)			
3.7	Are cumulative effects on the environment off the Project together with other existing or planned developments in the locality described? (different future scenarios including a worst case scenario should be described). For further guidance on assessment of cumulative impacts)			
3.8	Are the geographic extent, duration, frequency, reversibility and probability of occurrence of each			

	effect identified as appropriate?			
3.9	Are impacts on issues such as biodiversity, global climate change and sustainable development discussed where appropriate?			
Evaluation of the significant effects				
3.10	Is the significance or importance of each predicted effect discussed in terms of its compliance with legal requirement and the number, importance and sensitivity of people, resources or other receptors affected?			
Impact assessment methods				
3.11	Are methods used to predict effects described and are the reasons for their choice, any difficulties encountered and uncertainties in the results discussed?			
3.12	Where there is uncertainty about the precise details of the Project and its impact on the environment are worst case predictions described?			
3.13	Where there have been difficulties in compiling the data needed to predict or evaluate effects are these difficulties acknowledged and their implications for the results discussed?			
3.14	Is the basis for evaluating the significance or importance of impacts clearly described?			
3.15	Are impacts described on the basis that all proposed mitigation has been implemented i.e. are residual impacts described?			
3.16	Is the level of treatment of each effect appropriate to its importance for the development consent decision? Does the discussion focus on the key issues and avoid irrelevant or unnecessary information?			

Annex 3. Best Practice Guidelines for Technical Design of Road Development and Rehabilitation

Best Practice Guidelines for Technical Design of Road Development and Rehabilitation in the Cambodian and Viet Namese Floodplain

May 2009

CONTENTS

1 INTRODUCTION TO THE BEST PRACTICE GUIDELINES OF FMMP-C2

In the FMMP-C2 'Flood Structures and Flood Proofing' a number of Best Practice Guidelines are developed. The aim of these Best Practice Guidelines is to enable the MRC and national line agencies to better take into account flood-related considerations in their day-to-day technical activities. The 'Roads and Floods' Best Practice Guidelines are part of the FMMP-C2 Best Practice Guidelines.

The 'Roads and Floods' Best Practice Guideline do not provide detailed guidance, also because the local situations in Cambodia and Vietnam vary quite a lot and request tailored solutions. The guidelines do provide recommendations how to improve existing guidance.

2 HOW TO USE THIS BEST PRACTICE GUIDELINE

The Best Practice Guideline for technical design is targeted at those organisations involved in road planning and design (hence, transport and public works type of ministries and associated agencies). The following four groups of users can be distinguished:

- Technical staff who actually plan and design roads (so who are the direct users of national guidelines), including companies carrying out technical studies.
- Staff in charge of the construction and monitoring of road projects.
- Staff involved in the review of technical guidelines.

The Best Practice Guideline for technical design specifically supports the planner and designer during the phase in which the road design alternatives are identified (figure 1). During this phase, road planners and designers identify design alternatives on the basis of, amongst others, the local context (ecologically important area) and policy objectives, which are both derived from earlier steps in the planning process. The technical guidelines give guidance on how to use the technical design options (Box 1) to identify alternatives that match the objectives set. Alternatives can combine different technical design options.

Box 1 Technical design options in road development and rehabilitation.

- The resistance of the road structure to erosion (e.g. type of pavement or protection of embankment slopes).
- The elevation of the road structure (e.g. increasing or lowering the elevation of roads).
- The through-flow structures of the road (e.g. culverts and bridges).
- The alignment of the road.
- The distance to the river.

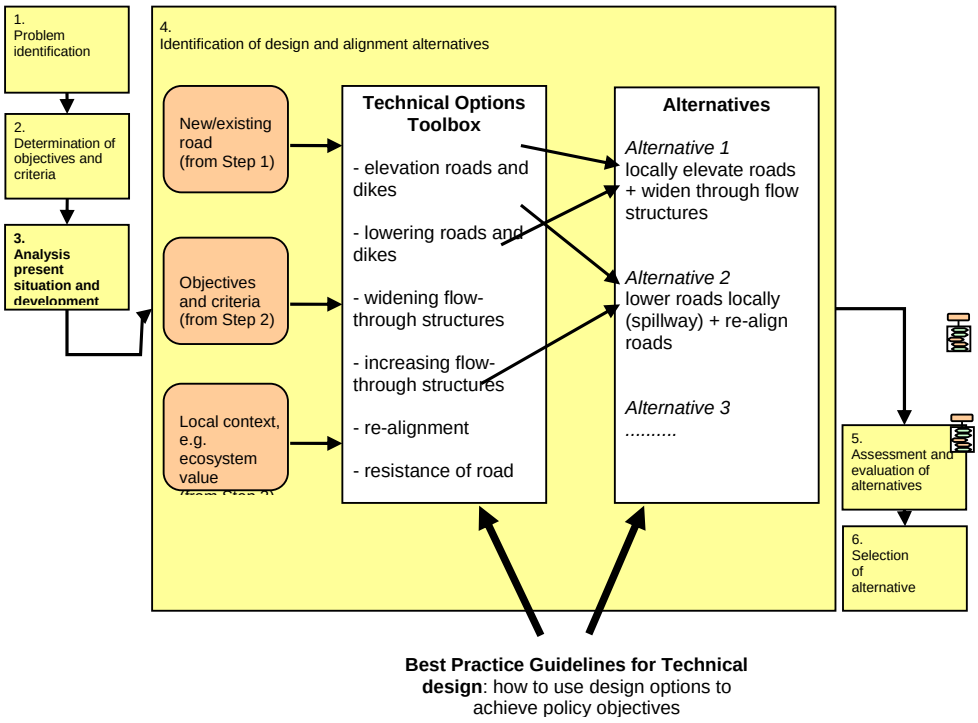


Figure 1 The step in the road development process in which road alternatives are identified and the role of the Best Practice Guidelines for technical design.

3 BACKGROUND ON DEVELOPMENT OF THE BEST PRACTICE GUIDELINE

This Best Practice Guideline for technical design was designed on the basis of:

- Review of current technical guidelines in Cambodia and Viet Nam.
- Interviews and consultations with government officials from the responsible governmental bodies.
- Review of international guidelines and best practice documents in the field.
- In-depth analysis of various cases in Cambodia and Viet Nam.

The above-listed activities were part of the 'Roads and Floods' project and detailed information on the project, its activities and results can be found in the Roads and Floods Synthesis Report (Douven et al., 2009).

4 PURPOSE AND SCOPE

The overall goal of the Best Practice Guideline for technical design is to improve the technical design and design considerations of the development and rehabilitation of roads in the vulnerable and highly valuable Mekong floodplain system. The specific objectives of the guideline are the following:

- To give general recommendations on how to assess the "best technical" design on one hand and balance the technical considerations with the environment (e.g. ecological importance, fisheries, agriculture etc) on the other hand.
- To give specific recommendations to minimize long term costs on maintenance.

The Best Practice Guideline is particularly relevant at the following stages of road development and rehabilitation:

- Design studies. Assessing design considerations and options and their interaction with floods for specific road construction and rehabilitation in the Lower mekong Basin.

The Best Practice Guideline provides a list of recommendations to improve existing guidance in order to come to a best design and provides general rules and options in order to prevent damage and make reliable damage potential assessments. It has to be mentioned that if the road embankment also has a primary function as a levee there will be more and strict demands to the embankment body.

The structure of the Best Practice Guideline is the following:

- General recommendations for technical design guidelines and enforcement.

- Recommendations on technical design road structures.

    - General recommendations.
    - Recommendations to improve guidelines and practices on flow-through structures.
    - Recommendations to improve guidelines and practices on road embankments.
    - Recommendations to improve guidelines and practices on the road surface.

5 GENERAL RECOMMENDATIONS FOR TECHNICAL DESIGN GUIDELINES AND ENFORCEMENT

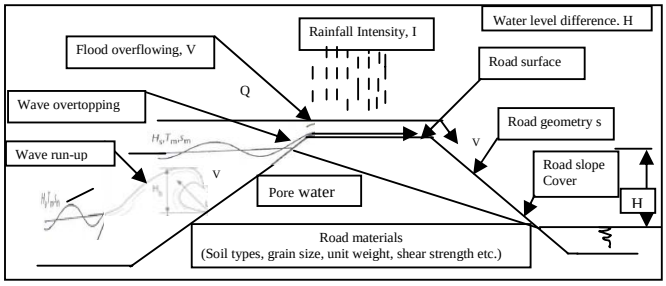
#	RECOMMENDATION	CONTENT
1	***Update and review the present Cambodian and Viet Namese road design standards and guidelines to better address the specific conditions of the Mekong floodplain so road designers have better guidance and best-practice examples of how to develop flood proofed and environmentally friendly roads in the Mekong floodplains***	Both Cambodia and Vietnam have standards and guidelines on road development and rehabilitation. For instance, in Cambodia the MPWT/AusAid (2003) and MRD/ADB (2004) are in use, while in Viet Nam TCN and TCXDVN manuals are in use- However, these guidelines are based on guidelines of foreign countries. It is recommended to adjust these guidelines to the specific conditions in the Lower Mekong Delta.
2	***Refer in the road design standards and guidelines and the dike standards to the interrelation between dikes and roads***	Very often the functions of flood protection and transport are integrated. Roads are constructed on top of dykes. In that situation not only the standards for raods and bridges should be used but standards for dikes should also be taken into account. Viet Nam for example has independent standards for sea and river dikes published by MARD and standards for roads and bridges published by MoT. In general, roads often act (intentionally or not) as an obstruction or resistance to the flood pattern.
3	***Enforce compliance of the updated and reviewed Cambodian and Viet Namese road design standards and guidelines also between the different government bodies within one country.***	Both Cambodia and Viet Nam have many standards and guidelines on road development and rehabilitation. At the moment there is however a patchwork. Cross-sectoral coordination needs to be improved to harmonize these standards. Link to harmonisation initiatives in Cambodia with ADB.

6 RECOMMENDATIONS FOR IMPROVED TECHNICAL DESIGN GUIDELINES IN THE LOWER MEKONG DELTA

As illustrated in the Roads and Floods project Synthesis Report the ecological value of the floodplains in the Lower Mekong Delta are great and support a florishing and rich fisheries and agriculture industry. Industries which are a major source of income and livelyhood of large groups of the population and very depending on the typical (partly undisturbed) flood characteristics of the floodplains. Although both Cambodia and especially Viet Nam do have (comprehensive) guidelines for road construction and rehabilitation the interaction with the flood hydraulics and the cause and effects both on smaller and larger scale can be more structured and detailed within the existing guidelines.

The current Cambodian and Viet Namese guidelines are not specific for roads in floodplains and can significantly be improved by integrating dyke standard practices and EIA studies (see table 2-2 of paragraph 2.3.3 of Verheij and van der Ruyt (in prep.)). The dike guidelines provide approaches and design rules to improve the damage reduction of the specific road tailored to the specific flood plain hydraulics (paragraph 4.3.1 of the technical guidelines), while a specific EIA study provides the impacts of one or more roads to the hydraulics and ecology and important related industries in the larger region. Incorporating dike standards and EIA into one guideline or process of road development would enable the responsible government bodies to weigh the costs and benefits over both the long and short term.

The technical guidelines are part of a more comprehensive process as illustrated in Figure 1. The technical considerations and guidelines are to be considered general best options. However specific ecological areas and the specific region might impose specific criteria on roads. The design options and recommendations should therefore always be checked and balanced with the relevant criteria. Eventually the chosen design should meet the different objectives in the integrated approach of road construction and rehabilitation so the ecological and environmental aspects are taken into account and incorporated in the technical design.

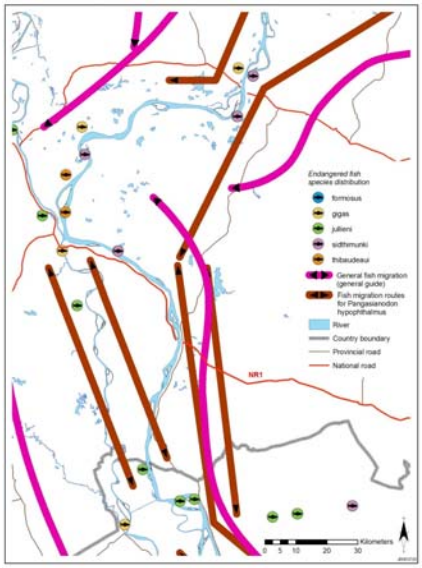
#	RECOMMENDATION	CONTENT
4	***Incorporate a hydraulic analysis or determination of the flood hydraulics and loads on road structures from existing databases***	To ensure an integrated and well balanced process of establishing the best possible design the flood plain hydraulics analysis should be a first step in road design, rehabilitation and construction. The hydraulics determine the damage potential to the road itself but also the impact of the road construction or benefits of ecology, fisheries and rice production areas
5	***Differentiate and specify the different damage and failure mechanisms in the technical guidelines***	Roads and road embankments are subjected to hydraulic loads in terms of water height, flow velocities, waves and rain. Through-flow structures are subjected to flow velocities. The different hydraulic components act differently on different damage mechanisms which can deteriorate a road (embankment and or surface). The existing guidelines lack differentiation between the different damage mechanisms.  *Figure 1 Hydrodynamic and geotechnical failure mechanisms.*
6	***Incorporate the methodology of hydraulics and damage potential assessment and the possible need for protection measures. The existing guidelines could be complemented with methods used in the Viet Namese Dike guidelines***	Recording and specifying the different damage mechanisms in the guidelines is not enough, of course. To asses the damage potential of the prevailing hydraulic conditions a methodology in how to assess the damage potential should be incorporated in the guidelines.
7	***Establish safety levels and threshold values per damage mechanism and per road class related to the hydraulic conditions and damage potential (or accepted damage)***	If the methodology, the link between hydraulics and damage potential is incorporated, the different safety levels or threshold values for the different road types should be incorporated in the guidelines. The Viet Namese TCN's already mention flood levels for roads and bridges.

#	RECOMMENDATION	CONTENT
8	***Make costs analysis for the different options of slope protection, costs of flow through structures (bridges and culverts etc) and quantify the options in the integrated approach***	In order to evaluate and weight the different design options with different protection grades cost indicators must be established. It is important to estimate costs for different levels of investment costs according high standards and lower standards as this affects the operational and maintenance costs. Also damage costs should be estimated taking into account the probabilities of floods.

RECOMMENDATIONS TO IMPROVE GUIDELINES AND PRACTICES ON FLOW-THROUGH STRUCTURES

The previous recommendations purely focused on the methodology and the "technical" tools that support the integrated approach. Besides the reference to these basic tools and methodologies which should be incorporated in the guidelines the examined cases in this project revealed some other recommendations and possible best practices. The recommendations in this paragraph are related to the different design options like flow-through structures, road embankment (crest level and steepness) and road surfaces.

#	RECOMMENDATION	CONTENT
9	***In an 'open' floodplain like south Cambodia a resilience design is much more preferred over a resistance design. In Viet Nam a resilience design is also preferred but should be closely integrated with the existing irrigation systems***	The main impact and goal of an integrated approach is a better understanding of the broader impacts of road development in a fragile floodplain like the Lower Mekong Delta. The analysed cases in this project support the general concept of resilience being the preferred general design option over a resistance approach design. This is best illustrated from the case NR 8 (paragraph 5.3). A newly constructed road crosses over valuable fish migration paths. A resistance design would lead to (possible) irreversible and great damage to ecology and fishery.
10	***The number and dimensions of flow through openings (bridges and culverts) should be such that interference with the natural hydraulics of the (sub) floodplain in terms of extent (flooded area) and***	The "level" of resilience is dependent on the number and dimensions of flow-through openings (bridges, culverts etc) and determines the change in flood duration (time) and extent (area). However it is impossible to mention how many flow through structures per unit length of road are required. This depends on the discharge. In case of a valuable flood plain ecology or agriculture the duration and extent are of great importance.

#	RECOMMENDATION	CONTENT
	duration is minimal	 *Figure 3: Example of a culvert with a number of openings*
11	***In Cambodia, particularly, the road should not obstruct fish migration routes and the location of bridges should correspond with the (major) migration routes***	Fish migration routes are very important in Cambodia. The location of bridges in the resilience design are therefore of great importance and determine the impact on traditional fish industry (not farms).  *Figure 4: Fish migration routes extending over large areas of the lower Mekong Delta area of Cambodia (MRC Database).*
12	***Culverts have relatively small openings and are less suitable to maintain the fish migration routes, bridges are preferred to minimize impact on fish ecology***	Bridges and culverts should be designed to allow flood waters, sediment and fish to pass. Large through-flow structures (see Figure 3) are preferred with a rough, unprotected bed offering hiding places to the fish. Recommendations for the designs of culverts for fish passage can be found in WDFW (2003); see www.wdfw.wa.gov/hab/..../culver_manual_final.pdf. It is important to create hiding places for the fish on the bottom of the culverts. In the vicicnity of flow-through structures fishing can be very effective (Halls et al, 2007).

#	RECOMMENDATION	CONTENT

Figure 5: Example of a small culvert

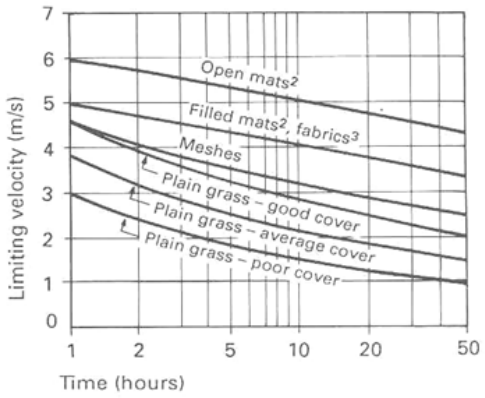
13 ***Scour protection near bridges and other flow-through openings, which are part of the resilience design, need heavy scour protection in order to prevent massive and reoccurring damage to the abutments and eventually the structure itself.***

A resilience design provides more equal hydraulic water levels on both sides of the embankment (figure 2) and thus a lesser need to protect the road embankment versus macro-instability on the "dry" side of the road embankment, however results in locations of higher concentration of flow velocities near the flow-through openings. Around these opening there is a necessity for scour protection of the bottom (Figure 6). Design rules for a bed protection are adressed in for instance the Rock Manual (CUR/CIRIA/CETMEF, 2007) or in Dikes and Revetments (Pilarczyk, 1998). Without a proper scour protection the adjacent slopes of the bridge can be severely damaged (Figure 7). Bridge and abutment scour can be estimated with for instance the Scour Manual (Hoffmans & Verheij, 1997).

Figure 6: Example of scour protection of the bottom downstream the bridge.

Figure 7 Damage to a bridge abutment.

RECOMMENDATIONS TO IMPROVE GUIDELINES AND PRACTICES ON ROAD EMBANKMENTS

#	RECOMMENDATION	CONTENT
14	***For the National and major Provincial roads slope protection is preferred using gabion mats or stone covers when the hydraulic studies indicate flow velocities exceeding 0.7 m/s and the soil conditions are unfavourable to erosion. For National and Provincial roads near the major river streams (permanent streams) a stone protection is recommended as standard design***	Scour protection to protect (costly) structures is essential however the road embankment structures are also subjected to scouring and erosion. This is observed in the field during the monitoring surveys and follows from the hydraulic data and case studies. Flow velocities in the LMD can reach velocities far exceeding threshold values of bare soil and are thus highly erosive on the natural soils. Rock protections, mattresses or plain grass is rerequired to protect the embankment slopes. Design rules for rock, mattresses and grass are provided in respectively the Rock Manual (CUR/CIRIA/CETMEF, 2007), Dikes and Revetments (Pilarczyk, 1998) and Hewlettl et al (1987).  Notes: i. *Recommended limiting values for erosion of plain and reinforced grass* *ii. Minimum nominal thickness = 20 mm* *iii. Installed within 20 mm of soil surface or in conjunction with a surface mesh* *Figure 8 Allowable flow velocities for mattresses and plain grass.*
15	***Use vegetation hedges to prevent wave erosion of the upper part of the embankment slope and shoulder***	Waves during the long rain season is a progresive and almost continuous mechanism responsible for shoulder erosion. Vegetation is a relative easy method to prevent shoulder and upper slope erosion due to waves. This is illustrated in Figure 9.

#	RECOMMENDATION	CONTENT
		 *Figure 9 Vegetation to protect a slope against wind waves.*
16	***The recommended crest level for National roads and (major) Provincial roads should be based preferably on a flood frequency for example 100 year plus an additional 0.5 meters for factors as wave runup. For (major) regional roads the crest level should correspond with a minimum height of the water level of floods with a recurrence of 10 years plus 0.25 meters***	Different forms of highly erosive hydraulic loads arise from the wave overtopping and water overflow mechanisms. In both cases the crest level is too low for respectively the waves which top over the crest and water level which is higher than the crest level. Wave overtopping and overflow can be prevented by raising the crest level to a minimum level corresponding with a high flood event plus a safety height to prevent overtopping. The method of determining the crest level is published for instance in the Dutch guide for the design of river dikes (CUR/TAW, 1995).
17	***For road embankments up to 4 meters high a slope gradient of 1:3 proves to provide sufficient safety protection against the macro-instability mechanism during the rise and fall of the water level***	The road embankment body can also be damaged by the macro-stability mechanism; firstly when there is a high discrepancy between the water levels on both sides of the embankment and secondly when there is a fast fall in water level and the embankment is still saturated. Calculations should be made to check every new road design and construction taking into account the specific geological conditions and construction materials. However, based on experience gentle slopes of limited height will be stable under all conditions and soil physical properties.

#	RECOMMENDATION	CONTENT
18	***Investigate the geotechnical characteristics of the top soils and take adequate measures in road designs, for example removal of inappropriate top soils***	The top soils are very weak in the Mekong delta and very often can not be used without stabilisation. During road design and rehabilitation the properties must be determined allowing

RECOMMENDATIONS TO IMPROVE GUIDELINES AND PRACTICES ON THE ROAD SURFACE

#	RECOMMENDATION	CONTENT
19	***Provide the road surfaces of National roads and major Provincial roads with asphalt. Minor Provincial roads or major Regional roads are recommended to be covered with minimum of coarse gravel on a draining (convex) clay substrate***	Besides the obvious hydraulic problems resulting from the depth, flow and velocity of inundated water rain runoff is also an important aspect. Rain is of major influence on the unprotected road surfaces. Rain infiltration reduces the baring capacity of the clayey soils and thus increasing damage due to transport loads and increasing maintenance cost. Protection of the road surface leads to a long term maintenance cost reduction, improvement of transport and has little ecological impact.  *Figure 10 Example of unprotected road and rain and traffic load induced annual reoccurring damage*

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