Climate Change Risk Vulnerability Assessment

Project Number: 46422
February 2015

VIE: Second Northern Greater Mekong Subregion Transport Network Improvement Project (Additional Financing)

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PREPARING THE SECOND NORTHERN GREATER MEKONG SUB-REGION TRANSPORT NETWORK IMPROVEMENT PROJECT- HIGHWAY NO.217- PHASE 2

Supplementary Appendix
Volume 9

Scope: Km 0 ~ Km 104+ 900

Climate Change Risk Assessment (Draft)

February 2015

Engineers, Developers, Economists

Challenging mind, Changing dynamics

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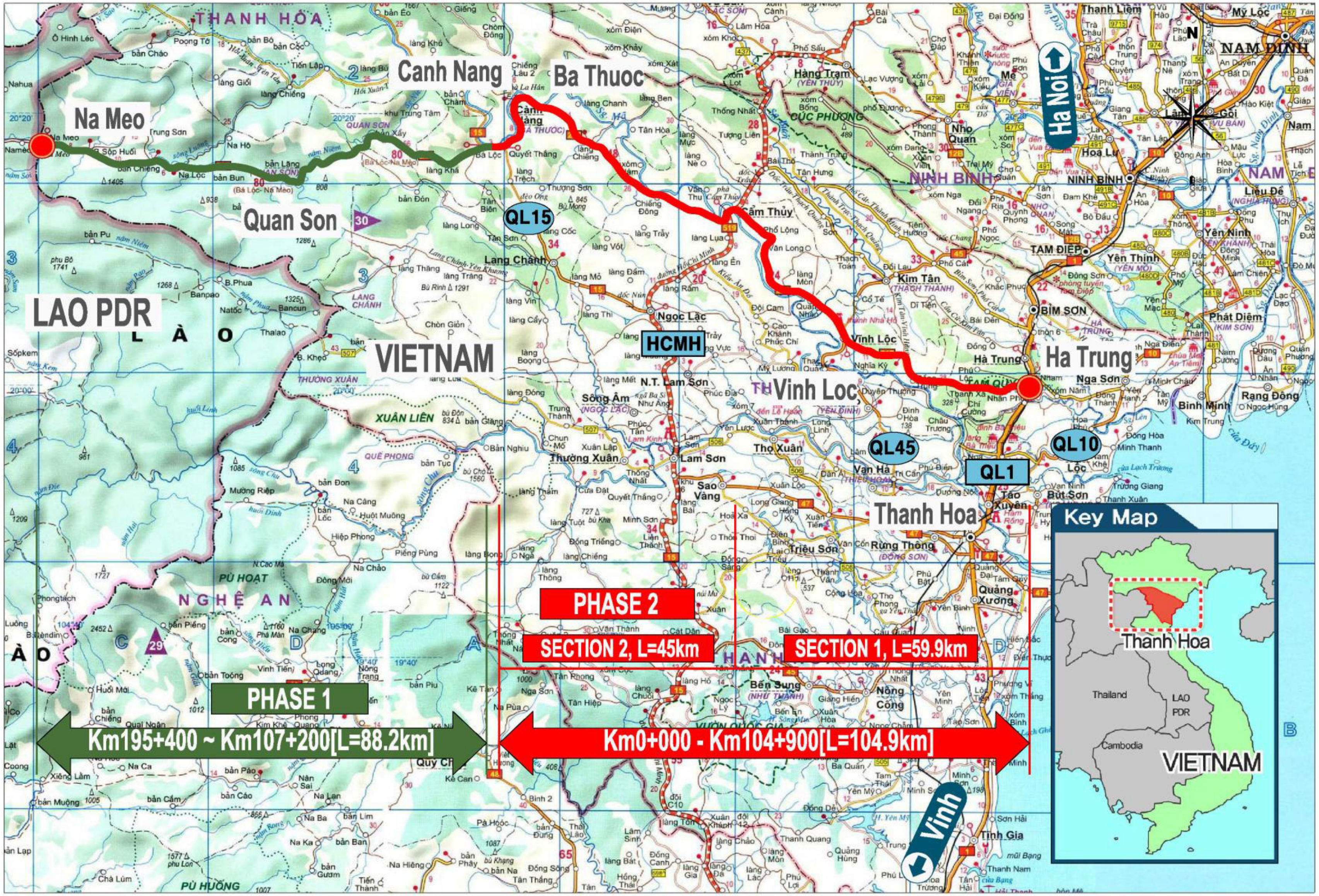
ABBREVIATIONS

ADB	–	Asian Development Bank
EPAR	–	Ethnic and Poverty Assessment Report
GOV	–	Government of Viet Nam
HFL	–	High Flood Level
IPCC	–	Intergovernmental Panel on Climate Change
NGO	–	non-governmental organization
MAGICC/ SCENGEN	–	Model for the Assessment of Greenhouse-gas Induced Climate Change/ Regional Climate SCENario GENerator
MONRE	–	Ministry of Natural Resources and Environment
MOT	–	Ministry of Transport
DSC	–	Design and Supervision Consultant
PMU1	–	Project Management Unit 1, Ministry of Transport
PPE	–	Personal Protective Equipment
QL217	–	National Road QL217 & improvements.
REA	–	rapid environmental assessment
RP	–	Resettlement Plan
SPS	–	ADB's Safeguard Policy Statement (2009)
SR	–	sensitive receiver
TA	–	Technical Assistance
TCVN/QCVN	–	National Technical Standards
TOR	–	Terms of Reference
TSD	–	Technical and Scientific Division (in PMU1)
TOR	–	terms of reference
TTMP	–	temporary traffic management plan
VRA	–	Viet Nam Road Administration

WEIGHTS AND MEASURES

dB(A)	decibel (A-weighted)
masl	meter above sea level
km	kilometre
km/h	kilometre per hour
m	meter
m^3	cubic meter

Project Roads map



I. EXECUTIVE SUMMARY

A. Overview

1. The Government of the Socialist Republic of Viet Nam (GOV) has requested the Asian Development Bank (ADB) to provide financing to facilitate investments to support the upgrading of roads proposed in the technical assistance Preparing the Second Northern Greater Mekong Subregion Transport Network Improvement Project TA 6478 - REG (2NGMSTNIP). The 2NGMSTNIP proposes a comprehensive program to upgrade, rehabilitate and maintain the road QL217 in Viet Nam, which links across the border to Lao PDR, and provide upgrading for some adjacent rural roads in the network. The executing agency (EA) for the 2NGMSTNIP in Viet Nam is the Ministry of Transport (MOT); the implementing agency will be Project Management Unit 1 (PMU1) of MOT.

2. The Project is part of the Northeastern economic corridor for the Greater Mekong Subregion (GMS) Economic Cooperation Program. During the feasibility study for TA 6478 REG the project proponent identified a number of bypasses for investigation. This report is the climate change risk assessment (CCRA) for improvement of the relevant sections of road QL217 and construction of three bypasses.

3. The Project site (QL217) is located at Thanh Hoa Province (Figure I.1). The project scope is the fly-over at km 0 and the route from km 59.8 to km 104.475. The key climate change impacts have been assessed.

4. The objectives and scope of this Climate change risk Assessment are to (i) review the international and national climate change modeling and emissions scenarios (ii) assess the existing environment and climate conditions near QL217 (iii) identify potential impacts from climate change in Thanh Hoa province to the proposed road improvement works and bypasses (iv) evaluate and determine the significance of the impacts; (v) develop mitigation measures, monitoring activities, reporting requirements to ensure that such concerns are addressed in the project design and mitigation measures.

5. This Climate change risk Assessment is submitted to ADB by the PMU1 and the final Climate change risk Assessment report will be disclosed to the public through the ADB website and to the public in Viet Nam by PMU1. The Climate change risk Assessment will also be disclosed by PMU1 to Ministry of Natural Resources and Environment (MONRE) and provincial Department of Natural Resources and Environment (DONRE), Ministry of Transport (MOT) and to the local authorities in Thanh Hoa province for review and identification of additional climate change assessment that may be required.

B. Framework for climate change

6. In 2000, the Intergovernmental Panel on Climate Change (IPCC) published a series of projected greenhouse gas emissions scenarios that could be used to assess potential climate change impacts. The Special Report on Emission Scenarios, known as the 'SRES scenarios', grouped scenarios into four families of greenhouse gas emissions (A1, A2, B1, and B2) that explore alternative development pathways, covering a wide range of demographic, economic, and technological driving forces.

7. In 2012, Vietnam Ministry of Natural Resources and Environment published Climate change scenarios and sea level rise for Vietnam, which used PRECIS tool for temperature and precipitation and MAGICC tool for sea level rise forecast. Product model consists of 70 elements in the emission scenario A1B of AR4, IPCC. It is projected that changes in maximum temperature in Vietnam varied in the range from −3 to 3 °C. Changes in minimum temperatures mostly varied in the range from −5 to 5 °C.

Vietnam's temperature and precipitation trends have been greatly different among regions during the last 50 years (1960-2010). Annual average temperature has increased by 0.5 °C nationwide and annual precipitation has decreased in the North and increased in the South (MONRE, 2012).

C. Description of the Project

8. Road QL217 is approximately 196 km from Do Len to the border gate with Lao PDR at Na Meo (Figure I.2). The improvements to QL217 and construction of bypasses should be straightforward but as yet there are no detailed designs for these works. The existing alignment goes through many towns including Vinh Loc and Cam Thuy, where it coincides with the Ho Chi Minh Highway (HCMH) for a distance of approximately 1.3 km. West of HCMH the road presently passes through a long strip of urban development to the west of Cam Thuy followed by road sections that pass through rural and semi-rural settings as well as the town of Cam Thanh and Dien Lu. After Km92 the road enters the town Ba Thuoc and intersects with NH15A, at Thiet Ong, which it follows to Km107.2. West of this point the road moves from the flat and undulating terrain to follow the steeper terrain leading to Quan Son and several smaller settlements and villages up to Na Meo town at the border with Lao PDR. QL217 will be upgraded to Vietnamese Standard 3 (VN3) from the origin to the junction with QL15. The standard will be VN4 from the junction with QL15 to the end at Nam Meo. For purposes of the conceptual design it is assumed that the main QL217 will generally be widened on the uphill side creating a requirement to excavate significant spoil but there are limited opportunities to use this material as fill. Therefore spoil disposal will be significant but other construction impacts should of a scale typical for a road upgrading project.

Table 1: Scope of Project

Section	Location	Description	Length (km)
Section 1	Km0 - Km56+500	- Interchange at start point of Project with NH1A (Km301+500 – NH1A): survey and Basic design.	56
Section 2	Km59+900 - Km104+475	Survey and Basic design	45

9. The rehabilitation and upgrading of QL217 will involve some alterations to the width by <1 m to 5 m in some places on either side to improve road geometry within the RoW of 25 m either side of the centreline. The bypasses will be constructed on land yet to be acquired that is mostly agricultural fields. There will be a need for limited resettlement and the resettlement pans will be accomplished by the Provincial People's Committee of Thanh Hoa (PPCTH) who will also carry out the required social interventions.

10. Bridges will be improved to accommodate vehicles up to 32 tonnes (as per Viet Nam road standards) and constructed as permanent concrete and steel structures. PMU1 will engage a design and supervision consultant (DSC). The target date for completion of reconstruction and upgrading is end 2015.

D. Description of the Environment

11. The climate in the Project area is subtropical and the area is subject to heavy rainfall between April and October. The roads are fairly flat from the origin to Km72 and then undulating with some steeper sections through the westerly hill terrain, especially after

Km90. The minimum altitude of QL217 is 150 meters above sea level (masl) in the east and the maximum 500 masl near Nam Meo. In the surrounding zone, people live at altitudes up to about 800 masl. During rainy periods surface water on the road runs to side drains and across to the adjacent fields and canals and in the hills via crossing drainage structures and culverts. The mountainous area of Thanh Hoa Province feeds the Song Ma river system that runs about 100m from QL21 for most of the way from Cam Thuy to Quan Son. Other smaller rivers Song Buoi, Song Buoi, Song Luong also run alongside the QL217 and there are over seventy bridges for improvement or reconstruction.

12. The average annual temperature of about 23^0C-24^0C in the delta and midland; descending the mountains and about 18^0C-20^0C at the border between Vietnam and Laos. Average annual precipitation ranges from 1600 - 1800 mm. Number of rainy days 130 - 150 days / year. There are 3 hydroelectric powers on Ma River.

E. Climate Change Risk Assessment

13. Annual mean temperature within the QL217 road project area is projected to rise by 1.5 ^{0}C (MONRE, 2012). Maximum absolute temperature is projected to be more than 42 ^{0}C (MONRE, 2012). The temperature of the region plain in Thanh Hoa province tends to be higher than that in the mountain. Thus, the fly-over at km 0 and the section from km 59.8 - Km 90 in region plain will be affected by high temperature more than the section from Km 104.475 of QL217 in the mountain.

14. The fly-over at km 0 is built with the height H = 1.75m beam master the so this section will not be vulnerable sea level rise and projected rainfall increase. Other project sites are prone to the risk of flash floods. Under the B2 scenario, the summer monsoon precipitation is projected to increase by over 3% in 2030. Under the conditions of rising temperature, precipitation is more likely to arrive in the form of heavy rains accompanied by an increase in flood risk. Flood risks are very likely to aggravate in the future.

15. Rainfall would trigger landslides and mudslides could create road blocks. Average rainfall of year for the QL 217 subproject road area is projected for the year 2030 will be medium – high (~1777mm). It is projected that the maximum daily rainfall can reach to 756 mm/day in 2030. Sections which are the mountainous road would be affected by the landslides.

F. Climate Risk Management Response

16. There are several measures to manage the climate change risks. Measures of slope stabilization should be implemented. For flood-prone areas/road sections, incorporation of adequate land drainage, increased clearance of bridges, adequate base height, etc. The design storm for all hydrological features should be calculated based on a large scale, detailed assessment of future climate scenarios within the project areas. Dynamics of soil moisture due to frequent drought/flooding needs to be incorporated into project design. To address the high temperature due to climate change, it is necessary to have the moisture maintenance planning regularly.

II. FRAMEWORK FOR CLIMATE CHANGE

A. International climate change modelling and emissions scenarios

17. In 2000, the IPCC published a series of projected greenhouse gas emissions scenarios that could be used to assess potential climate change impacts. The Special Report on Emission Scenarios, known as the 'SRES scenarios', grouped scenarios into four families of greenhouse gas emissions (A1, A2, B1, and B2) that explore alternative development pathways, covering a wide range of demographic, economic, and technological driving forces:

- A1 – the story line assumes a world of very rapid economic growth, a global population that peaks mid-century and the rapid introduction of new and more efficient technologies. A1 is divided into three groups that describe alternative directions of technological change: fossil intensive (A1Fi), non-fossil energy resources (A1T), and a balance across all sources (A1B).
- B1 – describes a convergent world, with the same global population as A1, but with more rapid changes in economic structures toward a service and information economy.
- B2 – describes a world with intermediate population and economic growth, emphasising local solutions to economic, social, and environmental sustainability.
- A2 – describes a very heterogeneous world with high population growth, slow economic development and slow technological change.

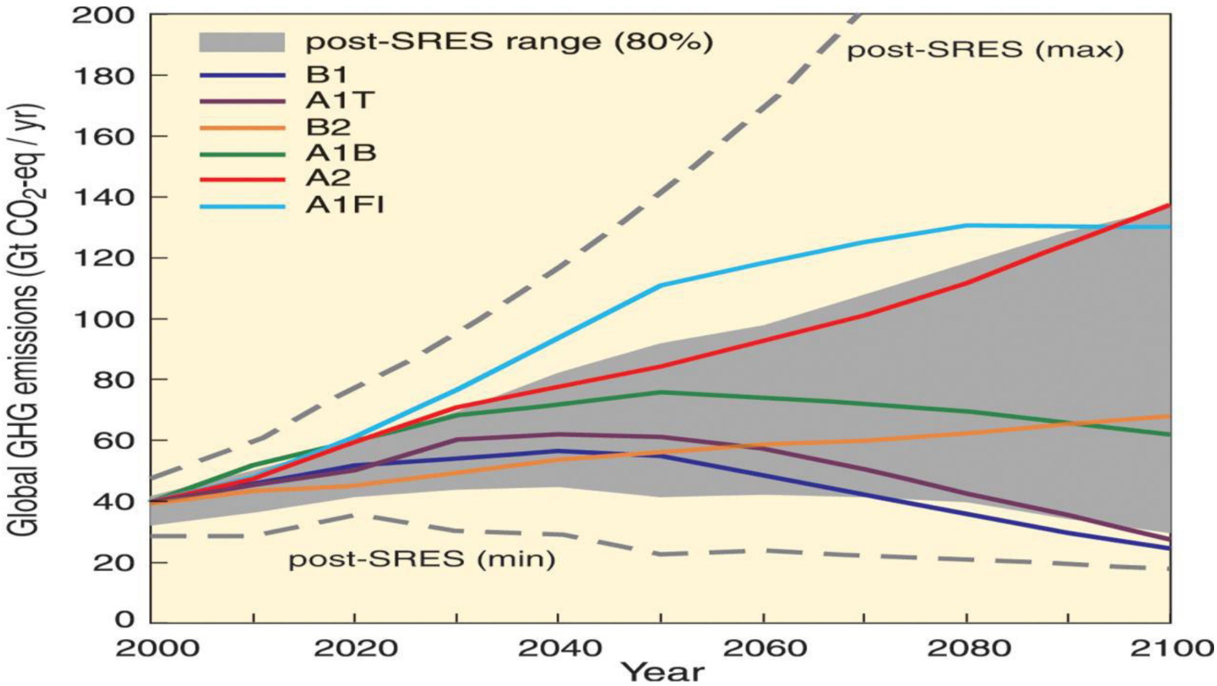


Figure 1: Scenarios for greenhouse gas emissions (source: IPCC, 2007)

18. The IPPC Fourth Assessment Report makes following predictions of climate variability in Asia (Christensen et al., 2007):

i. The increase in temperature will vary from 2.5ºC to 4.3ºC mostly higher than global mean;

ii. Summer heat spells will be longer and more intense and frequent in East Asia;

iii. Precipitation will increase in most of Asia;

iv. The frequency of intense precipitation will increase in parts of South Asia and East Asia;

v. Extreme rainfall and winds due to tropical cyclones will likely increase in East, Southeast and South Asia;

19. In AR5, the IPCC projects sea level rise of between 26 and 82 cm by 2100 (IPCC, 2013)

B. Climate change modelling and emissions scenarios in Vietnam

20. In 2012, Vietnam Ministry of Natural Resources and Environment published Climate change scenarios and sea level rise for Vietnam. In which, Providing Regional Climates for Impacts Studies (PRECIS) model of UK and AGCM/MRI model of Japan were used for temperature and precipitation projection. AGCM/MRI use data of 25 years from 1979 to 2003 to simulate past climate to calculate the typical climate for the baseline period. The near future is described from 2015 to 2039 (25 years) and far future is simulated from 2075 to 2099 (25 years) . Product model consists of 70 elements of the climate change emission scenario A1B of AR4, IPCC. MAGICC tool was applied to forecast sea level rise (MONRE, 2012). The baseline period/BAU to compare the climate change is 1980-1999. The information of climate change information for National Road 217 is basically taken from that source.

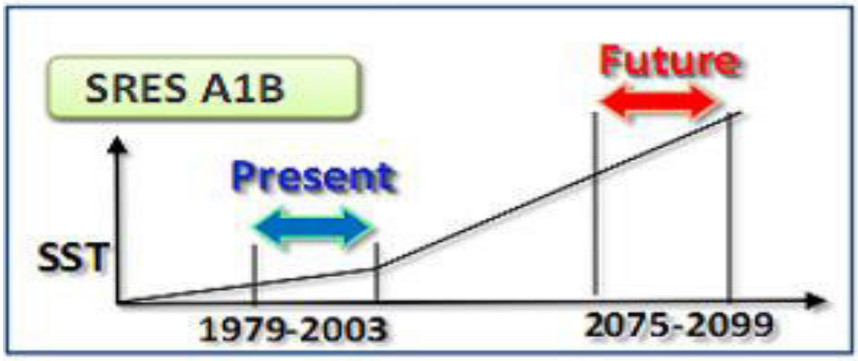


Figure 2: The climate change emission scenario of AGCM/MRI

21. There are some concerns about the climate change projection of MONRE 2012.

i) Regarding the output of AGCM/MRI model: There are still some differences between the calculated data and the measured data in fact. There are also some errors in forecasting the high rain fall in the rain season in South Central.

ii) Regarding the output of PRECIS model: There are some uncertainties in modifying the precipitation in high rainfall season in the Central.

22. Vietnam's temperature and precipitation trends have been greatly different among regions during the last 50 years (1960-2010). Annual average temperature has increased by 0.5 °C nationwide and annual precipitation has decreased in the North and increased in the South (MONRE, 2012):

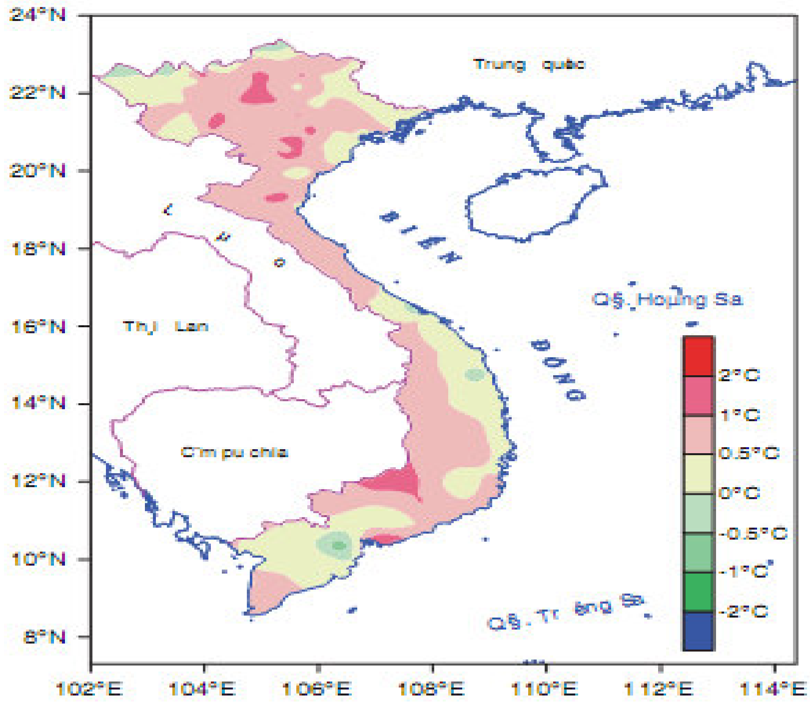


Figure 3: Change in annual average temperature (^{0} C) during the last 50 years in Vietnam (source: MONRE 2012)

23. Changes in maximum temperature in Vietnam varied in the range from −3 to 3 °C. Changes in minimum temperatures mostly varied in the range from −5 to 5 °C. Both maximum and minimum temperatures have tended to increase, with minimum temperatures increasing faster than maximum temperatures, reflecting the trend of global climate warming.

24. Precipitation during dry season (November–April) has increased slightly or is almost unchanged in the northern regions and increased dramatically in the south-ern regions during the last 50 years. Precipitation during the rainy season (May–October) has decreased by 5 to over 10 % in most of Vietnam's northern area and increased by 5–20 % in the southern regions. The pattern of change in annual precipitation is similar to the precipitation during the rainy season, i.e. increasing in the southern climate regions and decreasing in the northern climate regions. Annual precipitation in the South Central Region has increased most dramatically compared with other regions in the country during the last 50 years, even by 20 % in some places.

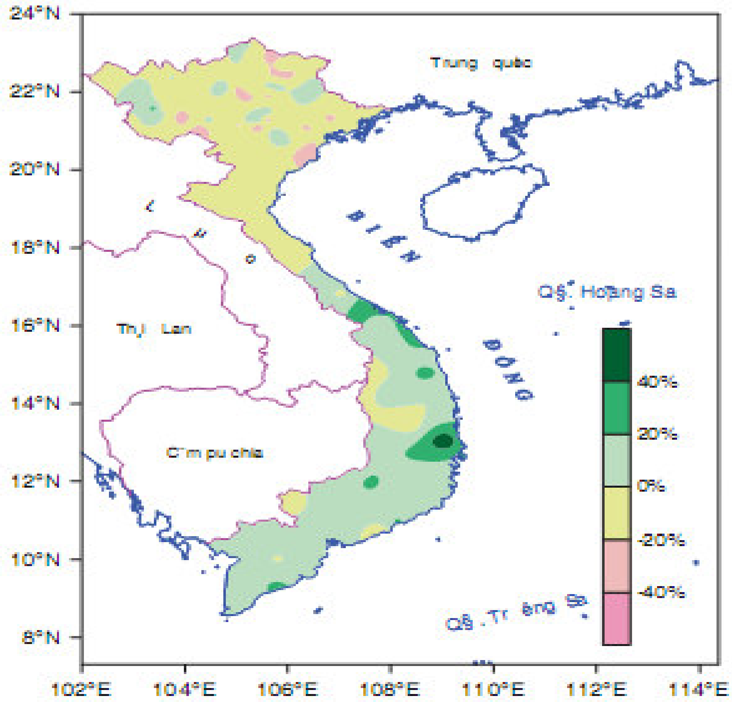


Figure 4: Change in precipitation (%) during the last 50 years in Vietnam (source MONRE, 2012)

It was observed from 1960- 2010 that the annual precipitation decreased in the North and increased in the South. Table 1 will show the increase in temperature and changes in precipitation during the last 50 years in the climate region of Vietnam.

Table 2: Increases in temperature and changes in precipitation during the last 50 years in the climate region of Vietnam

Climate regions	Temperature (°C)			Precipitation (%)		
	January	July	Year	Nov–Apr period	May–Oct period	Year
Northwest	1.4	0.5	0.5	6	−6	−2
Northeast	1.5	0.3	0.6	0	−9	−7
Red river delta	1.4	0.5	0.6	0	−13	−11
North central coast	1.3	0.5	0.5	4	−5	−3
South central coast	0.6	0.5	0.3	20	20	20
Central highlands	0.9	0.4	0.6	19	9	11
South region (southeast and Mekong delta)	0.8	0.4	0.6	27	6	9

Source MONRE (2012a, b)

25. Followed scenarios of IPCC 2007, Vietnam's climate change modeling in 2012 based on 3 main groups of scenarios:

i) Low GHGs emission scenarios (B1)

ii) Medium GHGs emission scenarios (B2, A1B)

iii) High GHGs emission scenarios (A2, A1FI).

26. Climate change scenarios for temperature and precipitation are developed for seven climate regions in Vietnam: North West, North East, Northern Delta, North Central Region (including Thanh Hoa province), South Central Region, Central Highlands, and Southern Region. It is projected that:

i) Temperatures at the end of 21st century in Vietnam (MONRE 2012a, b)

- Low emission scenario (B1): annual average temperature increases by 1.6–2.2 °C.
- Medium emission scenario (B2): annual average temperature increases by 2–3 °C.
- High emission scenario (A2, A1F1): annual average temperature increases by 2.5–3.7 °C.

ii) Precipitation at the end of 21st century in Vietnam (MONRE 2012a, b)

- Low emission scenario (B1): annual precipitation increases 2–6 %.
- Medium emission scenario (B2): annual precipitation increases 2–7 %.
- High emission scenario (A2, A1F1): annual precipitation increases 2–10 %.

iii) Sea level rise at the end of 21st century in Vietnam (MONRE 2012a, b)

- Low emission scenario (B1): average sea level may increase by 49–64 cm.
- Medium emission scenario (B2): average sea level may increase by 57–73 cm.
- High emission scenario (A2, A1FI): average sea level may increase by 78–95 cm

C. Institutional framework for Climate change

27. Climate change risk assessment for road projects has not been referred much in Vietnam‘s regulations and strategy. There are not many strategies and plans relating to climate change impacts on transport. Some of them are the following:

i) National Strategy On Climate Change for 2050 and the Vision to 2100 National Target Program to Respond to Climate Change (2008). In this strategy, Vietnam Government mandates the creation of provincial and other subnational disaster risk management strategies and plans. It also allows establishing subordinate provincial and district committees for flood and storming control.

ii) Decision 199/QD – BGTVT of the Ministry of Transport of Vietnam dated 26 Jan 2011 providing Transport Climate Action Plan 2011 – 2015. The content of this plan are to assess impacts of climate change on transport infrastructure and activities and to identify suitable mitigation and adaptation options for transport projects.

28. There are five Government Standards should be considered when undertaking climate change risk assessment for transport projects.

i) Highway – Specification for survey 22 TCN 263-2000

ii) Calculation of Characteristics of Flood Flows TCVN 9845-2013

iii) Highway – Specification for Design TCVN 4054-05

iv) Bridge – Specification for Design 22 TCN 272-05

v) Handbook for calculation hydrologic, hydraulic bridge and road (Ministry of Transport, publish 2006)

III. DESCRIPTION OF THE PROJECT

A. Background

29. The standards and conditions of many of the roads in Viet Nam are inadequate to meet rapidly growing demand for efficient travel. This situation limits national development and economic growth. The existing road infrastructure needs to be improved, upgraded and maintained on a regular basis.

30. The existing condition of QL 217 is good in the east but only fair to poor in many places further west. The sealed and earthen shoulders are also in poor condition. There are deep ruts and crumbling surface coatings owing to movement of heavy loaded vehicles and little maintenance. The slabs of the bridges have wide holes in places which are repaired improperly from time to time. The culverts are in fair condition but some require major upgrading and repair.

31. The Km 0 fly-over is in the north vicinity of the Do Len River which is a tributary of the Song Ma. This interchange is 2 km far from the Do Len River.

32. Procurement will be using a design and supervision consultant (DSC) who will be responsible for detailed design and project construction supervision. Reconstruction and upgrading will be completed by end 2016. PMU1 will engage the DSC and for purposes of this Climate Change Assessment (CCA), it is assumed that there will be a conventional international competitive bidding (ICB) to secure contractors for upgrading and/or reconstruction of the road. Detailed design, bidding, securing contractors and upgrading works are proposed to take place between 2011 and 2016.

B. Existing Road

33. The existing road connects many parts of Thanh Hoa Province from Route 1 (QL1) in the east, crossing QL45, Ho Chi Minh Highway and QL15 before the border with Lao PDR in the west. The major portion of the traffic on this highway consists of motor bikes, trucks and public motor vehicles with some trucks carrying people and goods in and out of the area. Traffic flows counted in the spring of 2008 resulted in less than 1800 vehicles per day[1] even on the busiest stretches of the road which are towards the east.

34. Road QL217 is approximately 196 km from Do Len to the border gate with Lao PDR at Na Meo (Figure I.2). The existing alignment goes through many towns including Vinh Loc and Cam Thuy, where it coincides with the Ho Chi Minh Highway (HCMH) for a distance of approximately 1.3 km. West of HCMH the road presently passes through a long strip of urban development to the west of Cam Thuy followed by road sections that pass through rural and semi rural settings as well as the towns of Cam Thanh and Dien Lu. After Km 92 the road enters the town Ba Thuoc and intersects with NH15 at Thiet Ong (Km 104.9 to Km 107.2). West of this point the road moves from the flat and undulating terrain to follow the steeper terrain leading to Quan Son and several smaller settlements and villages up to Na Meo Village at the border with Lao PDR.

35. The roads are fairly flat from the origin to Km 72 and then undulating with some steeper sections through the hilly westerly hill terrain especially after Km 90. The minimum altitude is 200 meters above sea level (masl) in the east and the maximum 500 masl near Nam Meo. In the surrounding zone, people live at altitudes up to about 800 masl.

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[1] TA 6478 Final Report June 2010.

C. Scope of work

36. In Phase 2 of The Second Northern GMS Transport Network Improvement Project, the scope of undertaking climate change assessment includes:

- Road number QL 217: 2.5 km from km 0: fly-over and the connection roads. This package is in Ha Trung district, Thanh Hoa province.
- Road number QL 217: from km 0 - 104.475. The route is through existing road and ending point at Km104+900, appertaining Thiet Ong commune, Ba Thuoc district. Total length is approximate 45 km. Almost of package is in Cam Thuy and Ba Thuoc district, Thanh Hoa province.

D. Proposed road upgrading and interchange construction

37. The Km 0 Interchange pass north trumpet shape, radius R = 250m.

i) Intersection trumpet (trumpet) returned north with radius R = 250m. Alignment go intersections surrounding residential areas Ha Ninh and delivered by the National Road 1 at Km is no residential area on the left side.

ii) Speed on the path to reach 60 km / h, while at intersections with turn right towards reaching 40km / h, turn left into the direction 1A speed 15km / h.

iii) Overpass L= 372.0m

iv) Structural flyovers: Structural type of rhythm using reinforced Super-T, height H = 1.75m beam master, 20cm thick reinforced concrete deck. Reinforced concrete abutments on pile foundations.

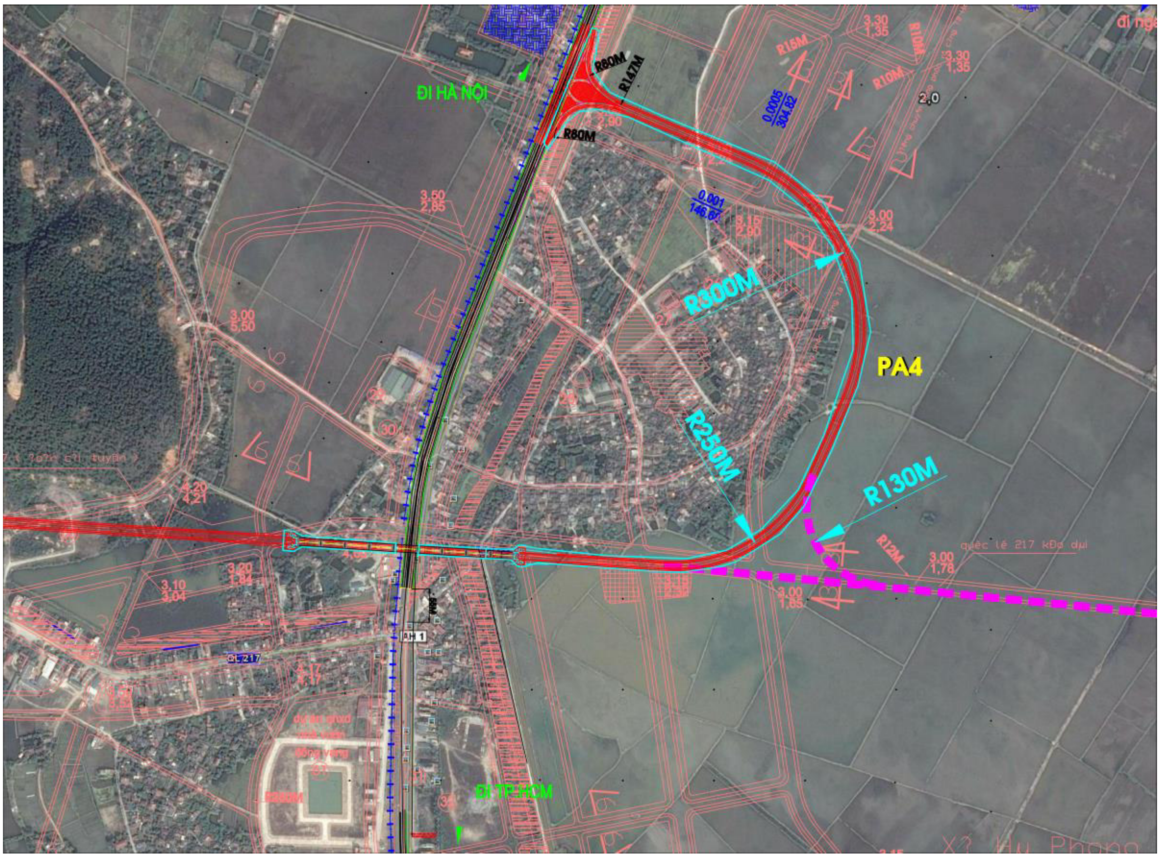
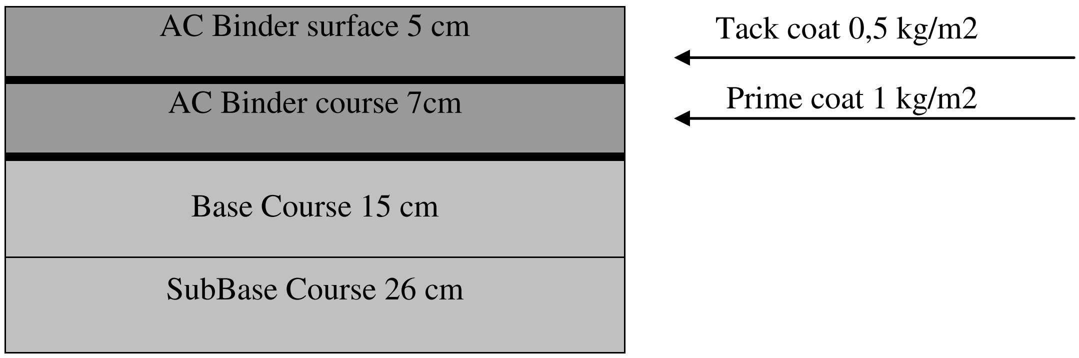


Figure 5: The interchange at Km 0

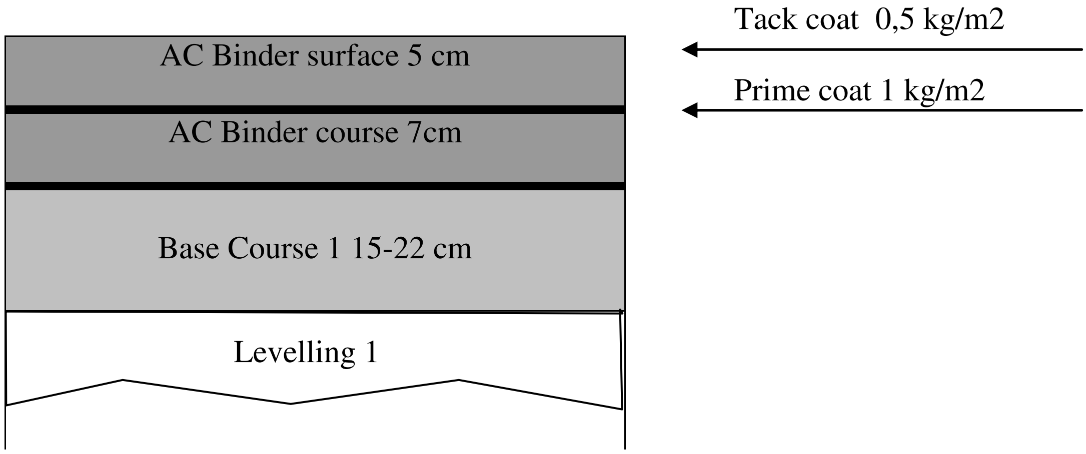
38. The QL217 requires rehabilitation and upgrading that will involve some alterations to the width by 1 m to 5 m in some places (0.5 m to 2.5 m on either side) to improve road geometry. In most places the existing road corridor (RoW of 25 m wide) either side of the centerline, is ample for the proposed rehabilitation works. The QL217 works will therefore take place within the existing road corridor and no significant impacts are expected outside the road corridor. However to get a better road geometry some resettlement and minor land acquisition may be involved in some locations, subject to detailed design.

New Pavement structure



Embankment K98, Eo = 40 Mpa

Pavement structure on existing road



Existing pavement 40Mpa $\leq$ Eo < 96 Mpa

39. The road works will include (i) excavation and reconstruction of the embankment; (ii) reconstruction of one carriageway (5.5 to 7 m wide) plus hard shoulders; (iii) repair and reconstruction of bridges; (iv) ensuring drainage and access near villages and at other key areas is unimpaired by extension of numerous culverts; (v) upgrading road drainage, and; (vii) installing slope stabilization and bioengineering measures, landscaping and accessories. Compensatory planting will also be required for any trees that are removed although this is not expected to be a major task. There will also be large waste disposal issues for the works as there will be a large surplus of cut materials in many areas where these materials cannot be reused on the project. Total cut materials are estimated to amount to more than 4 million m^3. The works are generally expected to take place within

approximately 10 m of the centre line of the alignment subject to detailed design (allowing about 3 m temporary working space either side).

TABLE PAVEMENT STRUCTURE APPLICATION

Eyc=140Mpa

Materials	Unit	New Pavement (KC1)	KC2	KC3	KC4	KC5
AC Binder surface	cm	5	5	5	5	5
AC Binder course	cm	7	7	7	7	7
Base Course	cm	15	15	22	15	
SubBase Course	cm	26	26			
Embankment K98	cm	50				
Requirement elastisc Modulus of existing pavement	Mpa	Eo ≥ 40	40 ≤ Eo < 60	60 ≤ Eo < 80	Eo ≥ 80	Intersection / Nút giao
Total thichkness		103	53	34	27	12

40. The Song Ma River is within 50 m of QL217 at a few locations and this river overflows periodically in some places for several days every year. Specific locations or sections of road are flooded for periods of a few hours to a few days but these could not be identified by the responsible authorities. By observation the consultants identified sections from Km 61 to 63; Km 70 to 73; Km 92 to 96; and Km 135 to 140. Further investigation by the DSC will be required to ensure that the designs for the upgraded road can cope with flooding from a 100 year return rain storm event in all the above areas and any other flood prone areas that are subsequently identified by the DSC, subject to detailed designs.

E. Proposed bridge improvements

41. There are 28 bridges and causeways that require improvements to accommodate vehicles up to 32 tonnes as required by the Viet Nam road standards (Table 3). In phase I, the consultants have recommended that the bridges will be constructed as permanent concrete and steel structures.

Table 3 Assessment of the Bridges and Recommendations

NO.	Name	Location	Span	Width	Load	Assessment
1	Rung lim 1	Km 60+013.	1 – 6.0	7.50	H30	Bridge width is under standard
2	Rung lim 2	Km 60+150.	1 – 5.6	8.10	H30	Bridge width is under standard
3	None	Km 60+495.	1 – 4.5	7.05	H30	Bridge width and railing are under standard
4	Rung lim 3	Km 60+572.	1 – 7.0	4.00	H13	Offset

NO.	Name	Location	Span	Width	Load	Assessment
5	Cam Binh	Km 61+200.	1 – 6.7	4.07	H18	Offset
6	Lang Xam	Km 61+605.	1 – 5.0	3.50	H13	Offset
7	None	Km 61+950.	1 – 4.4	7.10	H30	Bridge width is under standard
8	Dat	Km 62+264.	1 – 15.0	7.55	H30	Bridge width is under standard
9	Cam Binh 2	Km 63+650.	1 – 6.6	7.10	H30	Bridge width and railing are under standard
10	Khuoi Gao	Km 64+870.	1 – 4.0	6.95	H30	Bridge width and railing are under standard
11	Lang To	Km 66+600.	1 – 15.0	7.55	H30	Bridge width is under standard
12	Lang Chon	Km 68+866.	1 – 24.0	7.50	H30	Bridge width is under standard
13	Lang Chen	Km 69+970.	1 – 6.0	7.00	H30	Bridge width and railing are under standard
14	Vac 1	Km 70+920.	1 – 6.0	7.00	H30	Bridge width and railing are under standard
15	Vac 2	Km 71+250.	1 – 6.6	7.60	H30	Bridge width and railing are under standard
16	Chieng Tram	Km 72+315.	2 – 12.1	6.00	H30	Bridge width and railing are under standard
17	Cam Thanh	Km 73+338.	1 – 15.0	7.50	H30	Bridge width is under standard
18	Bong	Km 74+050.	1 – 6.1	7.00	H30	Bridge width and railing are under standard.
19	Tra Nua	Km74+545.9	1 – 15.1	7.40	H30	Bridge width is under standard
20	Hon Ngang	Km 75+215.	1 – 5.0	5.90	H18	Offset
21	None	Km 76+230.	1 cell	5.80		Box-culvert length and railing are under standard
22	None	Km 81+285.	1 – 4.1	7.00	H18	Bridge width and railing are under standard.
23	Dai Lan	Km 82+240.	1 – 22.0	7.00	H18	Offset
24	Hon La	Km 91+259.9	1 – 33.0	7.50	H30	Repair expansion joint. Carriage width is lacked
25	None	Km 92+070.	1 – 6.0	7.30	H18	Bridge width and railing are under standard.
26	Mun	Km 92+700.	1 – 18.0	7.50	H30	Bridge width is under standard
27	La Han	Km 95+850.	1 – 6.0	10.90	H30	Bridge width is under standard
28	Vom Da	Km 102+021.	1 – 12.0	7.30	H13	Offset
	Border	border				

Source: TA6348 Final Report Supplementary Appendix 2 Bridge Engineering. Span and Width in metres, Load in Tonnes. Span indicates the spacing between piers of the bridges

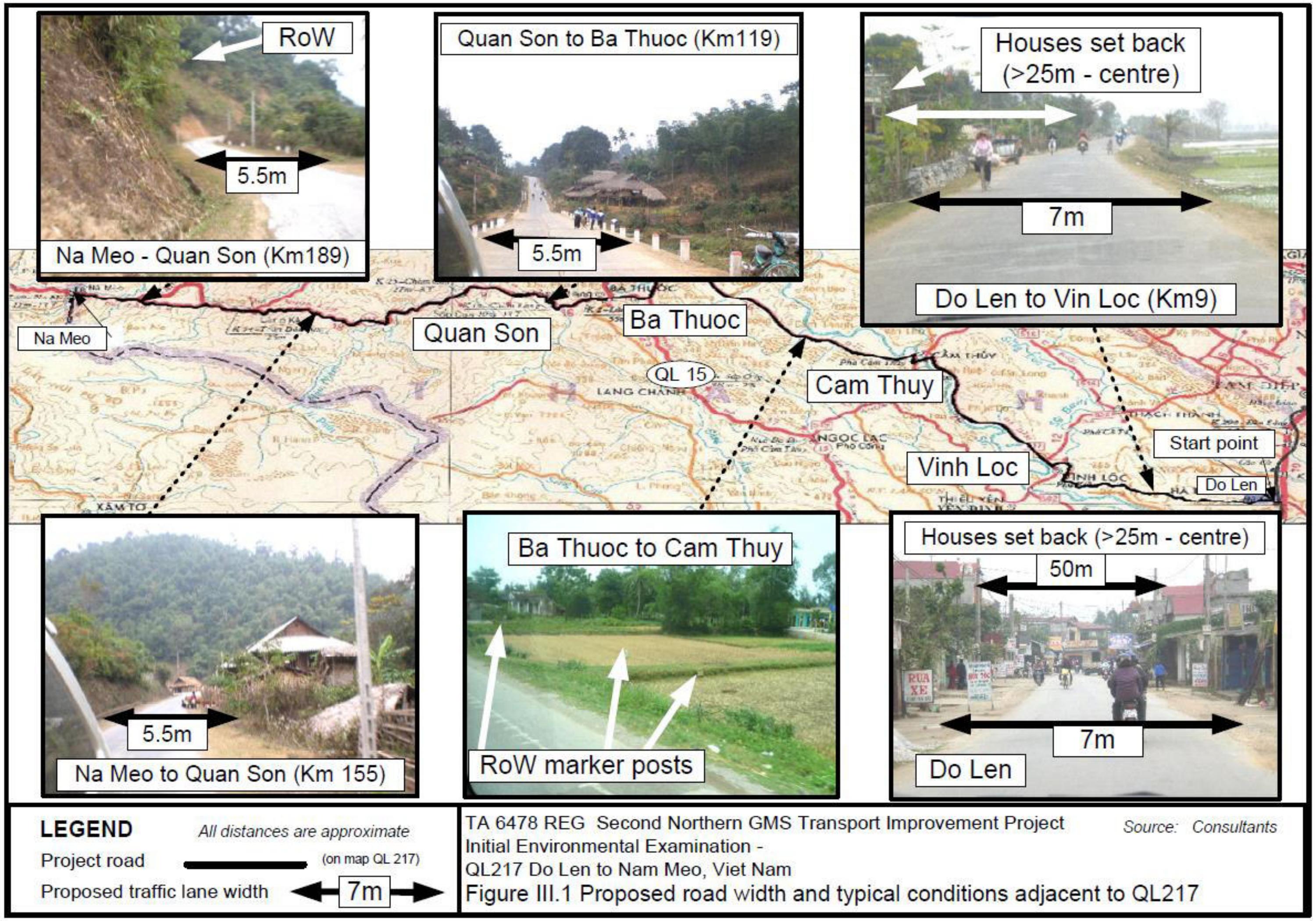


Figure 6 Proposed road width and typical conditions adjacent to QL217

IV. DESCRIPTION OF ENVIRONMENT AND CLIMATE IN PROJECT AREA

A. Meteorology and Climate

42. Thanh Hoa province is a province in the north of medium area, where has all the most common features of the climate of North Vietnam. It is kind of a tropical monsoon climate, with cold winters and unique form special type of weather. The climate above is as a result of interference and resonance of a cyclic process temperature, humidity in tropical latitudes, with the monsoon mechanism complexity of Southeast Asia, on the terrain of northern Vietnam.

43. Climate has two seasons, the summer season coincides with the rainy season and winter season coincides with the dry season. Especially in the summer season the presence of the West wind in the early summer.

44. Located in the tropics, Thanh Hoa has two suns zenith before and after the summer solstice 22/6. Total annual average radiation 100kcal/cm2/year and many places get 125kcal/cm2/year.

45. The average annual temperature of about 23^0C-24^0C in the delta and midland; descending the mountains and about 18^0C-20^0C at the border between Vietnam and Laos. There are 04 months the average temperature to below 20^0C (from December to March the following year), the coldest month is January with an average temperature of about 17^0C -18^0C (higher than the Northern Plains around 10C).

46. Average annual precipitation ranges from 1600 - 1800 mm. Number of rainy days 130 - 150 days / year. The rainy season usually lasts 06 months, starting from May and ends in October. The rainy months are August, September, October. Rainy season has 60 - 80% of the year's rainfall so easy to cause flooding.

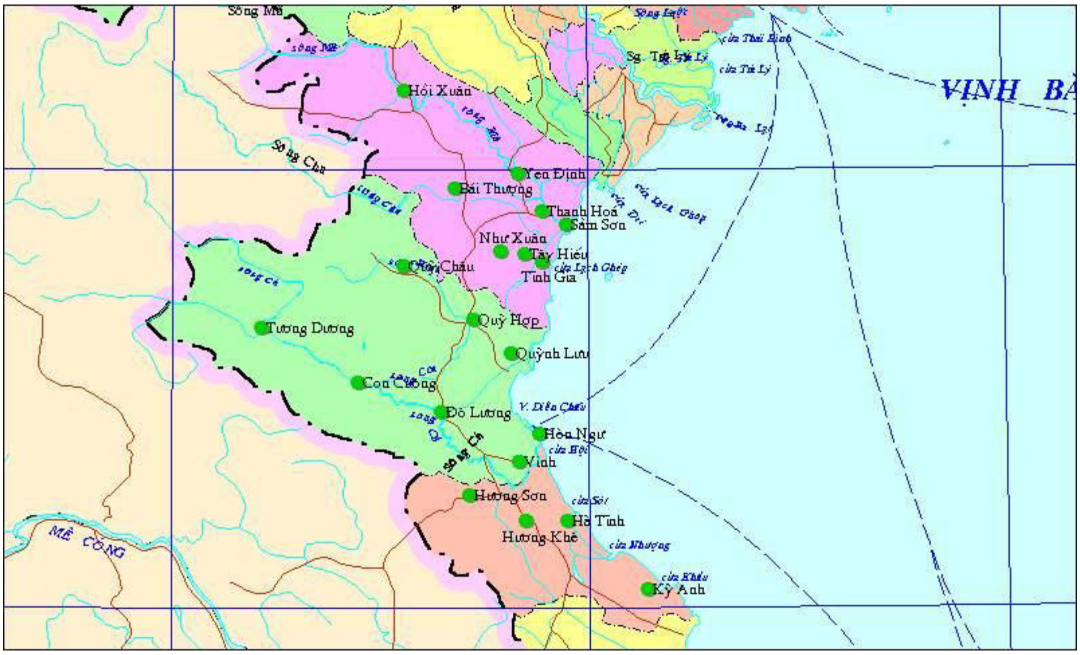


Figure 7: **Location map of the North Central Meteorological Station**

Table 4 Meteorological characteristics at Thanh Hoa station

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Direction and maximum velocity of wind in month and year (m/s)													
Value	12	12	12	37	35	35	28	32	27	20	12	>15	37
Direction	NH	SE	NH	SW	W	W	W	NW	E	W	NH	N	SW
Maximum absolute temperature of month and year (^oC)													
Value	33	35.8	35.9	41.5	41.9	41.3	42.0	41.8	38.3	37.2	35.2	31.4	42.0
Average temperature of month and year (^oC)													
Value	17.0	17.5	19.8	23.6	27.3	28.9	29.3	28.4	27.0	24.7	21.6	18.5	23.6
Minimum absolute temperature of month and year (^oC)													
Value	5.4	6.6	7.7	12.2	15.2	19.5	20.0	18.9	16.3	13.2	6.7	5.6	5.4
Average rainfall of month and year (mm)													
Value	22	27	40	56	137	193	187	275	409	288	87	27	1747
Maximum rainfall daily of month and year (mm)													
Value	83	87	96	113	217	191	219	240	731	457	229	82	731
Average number of rainfall daily of month and year (day)													
Value	9.8	12.0	14.4	11.5	12.2	12.4	11.0	15.1	15.2	12.6	8.0	5.6	139.8
Average relative humidity of month and year (%)													
Value	85.3	88.2	90.3	89.3	83.8	80.9	80.2	84.4	85.4	83.8	81.7	81.7	84.6

Table 5: Meteorological characteristics at Hoi Xuan station

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Direction and maximum velocity of wind in month and year (m/s)													
Value	12	12	20	>20	28	>20	>20	20	>20	20	14	18	28
Direction	N	W	NW	NH	SW	NH	NH	W	NH	WNW	NH	W	SW
Maximum absolute temperature of month and year (^oC)													
Value	33.8	36.2	38.4	40.8	41.4	41.6	40.3	38.7	37.1	37.8	34.6	32.8	41.6
Average temperature of month and year (^oC)													
Value	16.6	18.0	20.7	24.5	26.9	27.6	27.6	27.0	25.6	23.5	20.5	17.6	23.0

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Minimum absolute temperature of month and year (°C)													
Value	2.5	6.1	7.0	12.9	16.3	17.0	20.2	21.7	16.7	10.9	6.4	2.1	2.1
Average rainfall of month and year (mm)													
Value	11.5	15.0	28.7	87.0	213.0	248.6	337.2	318.0	271.0	129.2	36.9	11.2	1707.3
Maximum rainfall daily of month and year (mm)													
Value	44.9	43.9	41.0	88.0	111.7	118.6	306.9	152.2	316.0	165.7	94.1	31.8	316.0
Average number of rainfall daily of month and year (day)													
Value	7.0	8.1	10.6	13.9	16.8	18.0	18.8	19.0	15.5	11.2	8.1	5.0	152.0
Average relative humidity of month and year (%)													
Value	86	85	85	84	83	85	86	88	88	87	87	88	86

Notes: N - North direction E - East direction NN - Many days
S - South direction W - West direction NH - Many directions

B. Topography, Geology, and Soils

47. The topography of Thanh Hoa is largely below 300 meters above sea level (masl) in the east with mountainous areas in the west, with elevations above 500 masl typically characterized by steep terrain, narrow river valleys, and lower agricultural potential. Together, the alluvial plains and river terraces cover about 60% of the land area served by QL217; mostly in the east. The hills and steeper landscape extends across most of the west of Thanh Hoa Province beyond Km 90 on QL217 with the most mountainous area west of Ba Thuoc after Km 107.

48. The QL217 areas in the western highlands are more biophysically diverse than the east. The Thanh Hoa area is tectonically active and northern parts of Viet Nam have encountered major earthquakes. Cam Thuy was subject to a moderate earthquake in 2005 but the seismic activity was not significant. There is no record of recent volcanic activity in the mountains. The steep slopes, with moderately thin soil layers are prone to erosion when vegetation is removed and soils are exposed to rainfall and surface water flows. Thus, water quality in the mountain streams and rivers can be rapidly degraded when soils are eroded and flushed out, resulting in increased turbidity that reduces water quality for aquatic life and domestic and livestock consumption. Heavy rainfall is responsible for deteriorated sections of national and rural roads. The QL217 road passes through sedimentary limestone with karst ridges and slopes on either side with recently deposited gravels and silts in narrow river valleys.

C. Surface and Groundwater

49. The route through and close to the Ma River. Terrain of river basin was is mountain and low mountains interspersed plateau. Total basin area of Ma River was 28400km^2, in which was 17600 km^2 of Viet Nam. The main stream was 512 km, which was 102 km in Laos.

50. The mountainous area of Thanh Hoa Province provides the catchment for the Song Ma river system and QL217 runs alongside the Song Ma at a distance of at least 50 m for most of the way from Cam Thuy to Quan Son. Other smaller rivers Song Buoi, and Song Luong also run alongside QL217.

51. The rainfall is irregular distributed and topography on the Ma River basin has a direct impact on the flow distribution. Upstream and middle class in the lee position for moist wind, strong wind affected Laos cause hot dry weather, little rain has led to river flow is less. Modular flow where only about 10 -: - 20 $l/s/km^2$. From Hoi Xuan, so rain should increase the flow was significant increase; the flow module reaches $35l/s/km^2$ kind of relatively many countries in the North. South-West of Hoi Xuan, Cam Thach can achieve $40l/s/km^2$ is the most water basins.

52. The regulation of Ma River is divides into two distinct seasons. Flood season starts from the months of June and ended on October. Flood season is slowly from northwest to southeast. The largest floods of the north-west of the basin is appears into August, the months remaining is September. The dry season starts from November and ends in May, the month most shallow is March.

53. The largest flow in the Ma River is quite fierce. Largest amplitude of water level in the middle and downstream is from 9 to more 11m. The time up of flood is relatively short, most of the major floods of 2 -: - 2.5 days. There are 03 months is the largest flow which are July, August, September, occupy to 54 -: - 55% of the annual flow.

54. During the wet season several stretches and some of the bridges and culverts are regularly inundated, cutting off roads and villages. Sections of road that are flooded for periods of a few hours to a few days are by observation as follows: Km 61 to 63; Km 70 to 73 and Km 92 to 96.

55. There are 3 hydroelectric powers on Ma River. Table 6 will shoe some specification these hydro power as below:

Table 6: Specification of hydro powers in project area

Hydro power's name	Class	Design Frequency	Basin Area (Km2)	Design Discharge (m3/s)	Retention level (m)	Pay-load Capacity (m3)
Trung Son	I	P = 0.5%	13,175	10,440	160	112x106
Hoi Xuan	II	P = 1.0%	13,595	10,500	80	7,73x106
Thanh Son	III	P = 1.0%	13,222	6,817	89	-
Ba Thuoc 1	IV	P = 0.5%	16,570	11,450	54	3,26x106
Ba Thuoc 2	V	P = 0.5%	17,150	11,600	41	12,68x106

56. After checking position, basic specifications of hydroelectric power system on Ma River, it is realized that so long as water levels do not exceed design elevations of retention ponds. Even in the historic flood 2007 together with the heavy rain, the water levels still under the retention level. Thus, it could be said that the hydroelectric power system on Ma River cause little risks to the whole alignment Km0+000 -:- Km104+900.

V. CLIMATE CHANGE RISK ASSESSMENT

57. This part assesses the climate risks of the proposed upgrading of QL217 road and identifies sections can be vulnerable by these climate events.

A. Temperature

58. In 2012, The Ministry of Natural Resources and Environment (MONRE, 2012) projected the changes in temperature, precipitation and sea level raise for Vietnam. Under medium emission scenario (B2), the average temperature increase of Thanh Hoa province till the end of 21st century comparing to the period 1980-1999 as below:

Table 7 The projected average temperature increase of Thanh Hoa province till the end of 21st century comparing to the period 1980-1999 under B2 scenario

Year	Projected annual mean temperature increase (C degree)	Increase in Winter (Dec-Feb) (C degree)	Increase in Summer (Jun-Aug) (C degree)	Maximum absolute temperature 42 °C	Average Absolute Temperature 23.6 °C
2020	0.5	0.5	0.4	42.4	24.5
2030	0.7	0.7	0.6	42.6	32.5
2040	1.0	1.0	0.8	42.8	24.5
2050	1.2 (1.0 – 1.4)	1.3	1.1	43.1	24.8
2060	1.5	1.6	1.3	43.3	25
2070	1.7	1.8	1.5	43.5	25.2
2080	2.0	2.1	1.7	43.7	25.5
2090	2.2	2.3	1.9	43.9	25.7
2100	2.4 (2.2 – 2.8)	2.5	2.1	44.1	25.9

Source: MONRE, 2012

59. Annual mean temperature within the QL217 road project area is projected to rise by 1.5 ^{0}C. Maximum absolute temperature is projected to be more than 42 ^{0}C. The extended warm weather would affect pavement deterioration due to melting of bitumen, heating and thermal expansion of bridges and buckling of joints of steel structures.

60. The temperature of the region plain in Thanh Hoa province tends to be higher than that in the mountain. Thus, the fly-over at km 0 and the section from km 0 - Km 90 in region plain will be affected by high temperature more than the section from Km 90 - Km 104.475 of QL217 in the mountain. There should have the soil moisture and maintenance planning for the pavement of the fly-over and the section from km 0 - Km 90.

B. Flood

61. The annual average rainfall in Thanh Hoa province is projected to increase from 2%-4% till the end of 21st century when comparing to the period 1980-1999 under B2 scenario. However, in the spring, the average precipitation is projected to decrease about 2% - 6%.

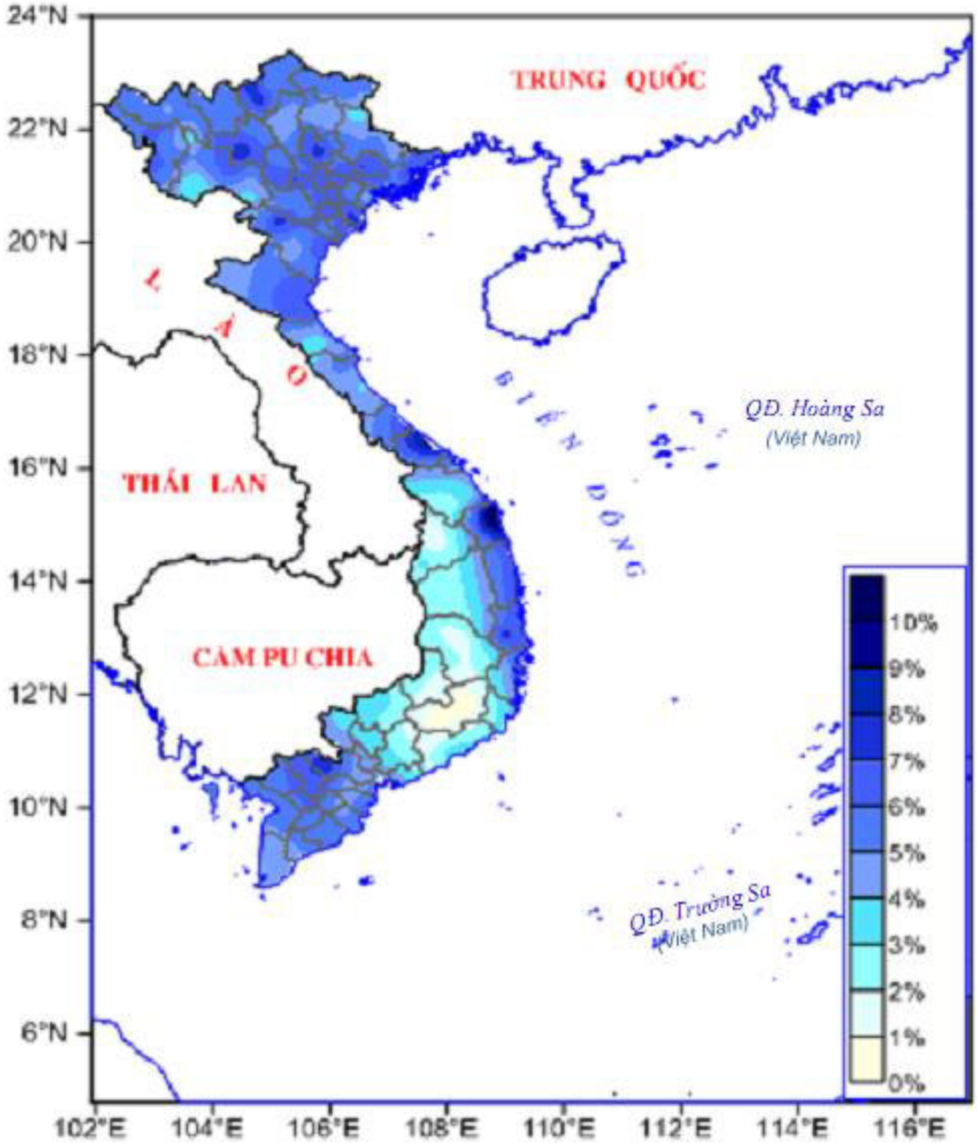


Figure 8 The annual average rainfall in Thanh Hoa province

62. Average annual precipitation within the project area is projected to increase by 30mm (or 1.7%) in 2030 comparing to 1980-1999. Summer rainfall (June-August) is projected to increase by 3.4%. Table 8 will show the change in precipitation of Thanh Hoa province till the end of 21st century comparing to the period 1980-1999 under B2 scenario.

Table 8: Change in precipitation of Thanh Hoa province till the end of 21st century comparing to the period 1980-1999 under B2 scenario.

Year	The projected average rainfalls increase of the whole year (%)	Increase in Spring (Mar-May) (%)	Increase in Summer (Jun-Aug) (%)	Maximum daily rainfall 731 mm	Average Rainfall of year 1747 mm
2020	1.1	-1.0	2.3	748	1766
2030	1.7	-1.4	3.4	756	1777
2040	2.3	-2.0	4.8	766	1787
2050	3.0 (2.0-4.0)	-2.6	6.2	776	1799
2060	3.7	-3.1	7.5	786	1812
2070	4.3	-3.6	8.7	795	1822
2080	4.8	-4.1	9.8	803	1831
2090	5.3	-4.5	10.9	811	1840
2100	5.8 (4.0 – 8.0)	-4.9	11.8	817	1848

Source: MONRE, 2012

63. The increase in summer precipitation would affect drainage capacities, road pavement, driving condition and visibility. Increase in intensity of summer precipitation would create floods; affect drainage, bridges affecting waterways and clearance, damage pavement and affect road, damage bridges foundation due to scoring.

64. The fly-over at km 0 is built with the height H = 1.75m beam master so this section will not be vulnerable by sea level rise and projected rainfall increase.

65. Other project sites are prone to the risk of flash floods. Under the B2 scenario, the summer monsoon precipitation is projected to increase by over 3% in 2030. Under the conditions of rising temperature, precipitation is more likely to arrive in the form of heavy rains accompanied by an increase in flood risk. Flood risks are likely to aggravate in the future.

66. The maximum flood occurred in 2007, 1975 and 1996 maximum flood occurred flooded several sections, the most to 2.5 m deep section, after a period of about 1 to 2 days of water drained. It is caused by heavy rain caused the river Ma to rise Code flooded roads. Along inadequate investigation about 1km per cluster level total 45 clusters along the water level investigation.

67. Sections of road which are flooded for periods of a few hours to a few days are by observation as follows: Km 25 to 27; Km 38 to 39; Km 41 to 42; Km 50 to51; Km 54 to 56. Table 9 showed 5 sections with high risk of flood from km 0 to km 59.

Table 9: sections with high risk of flood from km 0 to km 59

No.	Station	
	From Km	To Km
1	Km 25	Km 27
2	Km 38	Km 39
3	Km 41	Km 42
4	Km 50	Km 51
5	Km 54	Km 56

68. There are 28 sections which were prone to the effect of Ma river and the flood 2007.

Hn: The highest observed local flood stage (with reference to local topography).

Hmax 2007: The high flood level in the flood 2007 comparing with the sea level

$H_{4\%}$: The high flood level which is projected to happen each 25 year comparing with the sea level.

Table 10 summarized 23 sections affected by Ma river and the flood 2007 below

Table 10 Summary section affected by Ma River

No.	***Station***		Length (m)	Location and depth of flooding (m)		**Hmax 2007** (m)		**$H_{4\%}$** (m)	The depth of flooding Hn compares with
	From Km…	To Km....		Location	depth Hn				
1	km59+920	km60+140	220	km59+979	7,60	24,18	25,04	23,55	The deepest point of the existing ground where will be replaced by new culverts
2	km60+340	km62+500	2160	km60+873	8,40	24,58	25,44	23,95	
3	km62+730	km63+020	290	km62+900	2,49	26,31	27,17	25,68	
4	km63+239	km63+700	461	km63+485	4,00	26,64	27,50	26,01	
5	km63+700	Km66+000	2300	Km64+770	1,70	27,39	28,25	26,76	Existing road
6	km67+475	km67+768	293	km67+568	0,24	28,39	29,25	27,76	Existing road
7	km70+428	km71+487	1059	km70+889	8,00	29,93		29,30	The deepest point of the existing ground where will be replaced by new culverts
8	km72+195	km72+579	384	km72+204	8,27	30,29		29,66	
9	km92+000	km92+145	145	km92+115	5,69	45,28	46,68	43,73	Existing road
10	km92+665	km92+736	71	km92+715	2,06	45,71	47,11	44,16	Existing road
11	km93+355	km93+440	85	km93+425	1,26	45,71	47,11	44,16	Existing road
12	km93+525	km93+581	56	km93+534	1,36	45,71		44,16	Existing road

No.	Station		Length (m)	Location and depth of flooding (m)		**Hmax 2007** (m)		**H4%** (m)	The depth of flooding Hn compares with
	From Km…	To Km....		Location	depth Hn				
13	km95+385	km95+425	40	km95+408	1,00	47,76		46,21	Existing road
14	km95+550	km95+583	33	km95+550	0,75	47,76		46,21	Existing road
15	km95+746	km95+789	43	km95+754	1,20	47,79		46,24	Existing road
16	km97+122	km97+246	124	km97+154	0,50	47,81	49,21	46,26	Existing road
17	km98+811	km98+885	74	km98+885	0,34	49,11	50,51	47,56	Existing road
18	km99+708	km99+980	272	km99+872	1,32	49,76	51,16	48,21	Existing road
19	km100+186	km100+249	63	km100+236	1,14	50,04	51,44	48,49	Existing road
20	km100+329	km100+535	206	km100+450	2,20	50,07		48,52	Existing road
21	km100+857	km101+000	143	km100+934	0,42	50,09		48,54	Existing road
22	km102+015	km102+127	112	km102+086	0,90	50,19		48,64	Existing road
23	km102+461	km102+609	148	km102+528	1,35	50,31		48,76	Existing road

C. Landslides triggered by precipitation

69. Rainfall would trigger landslides and mudslides could create road blocks. Average annual precipitation for the QL 217 subproject road area is projected for the year 2030 will be medium – high (~1777mm). It is projected that the maximum daily rainfall can reach to 756 mm/day in 2030. Slopes in the country are susceptible to landslides especially in the rainy season. Landslides mostly occur where the terrain is steep and rocks underlying the soil are highly fractured thus allowing easy seepage of water. In addition to direct damages, landslides can also create temporary blockages across stream/river courses and have resulted in huge floods when the blockages are breached.

70. Table 11 will show which sections may have landslides due to high rainfall.

Table 10: Sections with risk of landslides

Order	Station	Length (m)	Notes
1	Km76+100 - Km76+700	600	The Local Improvement Route divert the old road to the right to ensure supply lines
3	Km 99 +510 - Km 104+475	4965	Mountainous road .

D. Sea level rise

71. The section from km 59.8 – km 104.475 of National road 217 is mainly on the high terrain so this project component is not sensitive to the sea level rise.

72. The fly-over at Km 0 of national road 217 which is at Ha Trung district is far from the sea. From figure 9 below, Ha Trung is near the area where is projected to be affected by the sea level rise 1 meter comparing to 1980-1999. The red area show the region could be flooded by the sea level rise 1 meter comparing to 1980-1999.

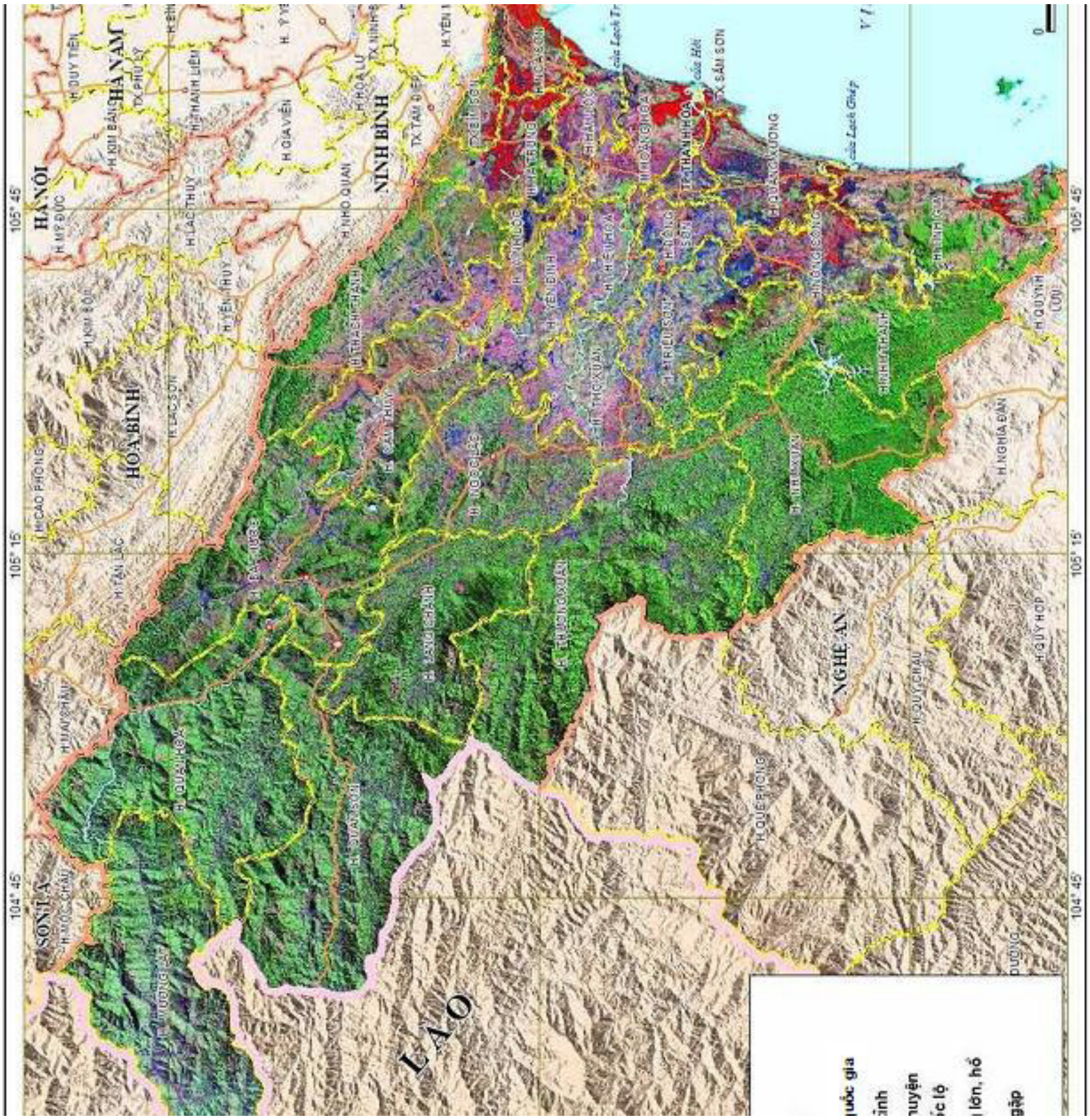


Figure 9: The projected area affected by the sea level rise 1 meter comparing to 1980-1999

73. However, the risk of sea level rise for the sea level rise at km 0 is still not high until 2100. It is projected that in 2030 the sea level rise in Thanh Hoa province area may be 11-13cm. In 2100, the sea level rise is forecasted to be about 42-58cm. The red area in figure 9 show the fly-over is still not in the flooded area when the sea level rise to 1m

comparing to the period 1980-1999. Table 11 provides detail information about the sea level rise of Thanh Hoa province area from the period from 2020-2100.

Table 11 Sea level rise of Thanh Hoa from 2020-2100

Year	2020	2030	2040	2050	2060	2070	2080	2090	2100
Sea level rise (cm)	8-9	11-13	15-17	19-23	24-30	29-37	34-44	38-51	42-58

74. Based on table 11, it could be said that the section from km 0- km 59.8 will not be affected by the sea level rise.

VI. CLIMATE RISK MANAGEMENT RESPONSE

A. Due diligence

75. Conducted a stand-alone climate change vulnerability assessment for the QL 217.

76. Reviewed climate change projections for Vietnam in general, and project area in detail based on Ministry of Natural Resources and Environment, Vietnam –“Climate Change and Sea level rise scenarios for Vietnam, 2012” which used PRECIS, AGCM/MRI for temperature and precipitation and MAGICC for sea level rise. Product model consists of 70 elements of the climate change emission scenario A1B of AR4, IPCC.

77. Conducted hydrological assessment including modelling of the major watersheds crossed by QL 217. Description of local climate surrounding the QL 217. The climate baseline was established using and processing precipitation, and temperature data from the Rainfall, Meteorology Section of Hoi Xuan and Thanh Hoa Hydro and Meteorology station.

78. Identified specific sections vulnerable to climate change risk.

79. Reviewed current road design, construction, and maintenance practices in in Thanh Hoa and identified areas of improvements. The climate risk assessment looked into the proposed pavement, slope protection, drainage, and bridge design construction practices and recommended adaptation measures.

B. Conclusions

80. The specific sections of the QL 217 road which are vulnerable to climate change risks are summarized in the table 12 below:

Table 12 Climate change vulnerable Road sections

Climate events	**Climate change vulnerable Road sections**	
Temperature	Fly-over at Km 0 Km 0 - Km 90	
Flood due to Rainfall 23 sections	***From Km***	***To Km***
	Km 25	Km 27
	Km 38	Km 39
	Km 41	Km 42
	Km 50	Km 51
	Km 54	Km 56
	km59+920	km60+140
	km60+340	km62+500
	km62+730	km63+020
	km63+239	km63+700
	km63+700	Km66+000
	km67+475	km67+768
	km70+428	km71+487
	km72+195	km72+579
	km92+000	km92+145
	km92+665	km92+736
	km93+355	km93+440
	km93+525	km93+581
	km95+385	km95+425
	km95+550	km95+583
	km95+746	km95+789
	km97+122	km97+246

Climate events	Climate change vulnerable Road sections	
	km98+811	km98+885
	km99+708	km99+980
	km100+186	km100+249
	km100+329	km100+535
	km100+857	km101+000
	km102+015	km102+127
	km102+461	km102+609
Landslide due to rainfall	Km76+100 - Km76+700 Km 99 +510 - Km 104+475	
Sea level rise	Fly-over at Km 0 if sea level rises to 1m comparing to the period 1980-1999. (However, it is projected that sea level rises to about 42-58cm in 2100)	

C. Climate change risk management response

81. Thermal expansion of bridge joints, liquidation of asphalt pavements and increase in maintenance requirement of the pavement due to high temperature, overflow of side drains and cross drainage works, submerged bridges due to floods induced by intense precipitation, inundation of coastal roads due to sea level rise, and road blocks due to landslides are some anticipated impacts of climate change on the road transport. Key design parameters corresponding to climate change vulnerable infrastructure are shown in table 13

Table 13: Design parameters of climate change vulnerable infrastructure

Infrastructure component	Design parameters needing consideration
Bridge	- Flood estimation, return period, design discharge - High flood level - Free board (clearance above High flood level) - Length of water way - Design load, wind load - Foundation, river and bank protection - Corrosion protection
Drains	- Discharge estimation (return period) - Size and shape of drain - Drain slope
Road and Pavement	- Camber to quickly remove surface water - Stiff bitumen to withstand heat or workable in winter - Soil moisture and maintenance planning
Culvert	- Discharge estimation (flood return period) - Size and discharge capacity - Cross slope - Free board (clearance)

Infrastructure component	Design parameters needing consideration
Side slope Mountainous road	- Slope protection work - Subsurface drains - Catch drains
Road signs	- Wind load - Structural design - Foundation - Corrosion protection

82. More specific recommendations were drawn as below.

i) Measures of slope stabilization should be implemented.

ii) For flood-prone areas/road sections, incorporation of adequate land drainage, increased clearance of bridges, adequate base height, etc. The design storm for all hydrological features and sea level rise should be calculated based on a large scale, detailed assessment of future climate scenarios within the project areas.

iii) Dynamics of soil moisture due to frequent drought/flooding needs to be incorporated into project design. The extended warm weather would affect pavement deterioration due to melting of bitumen, heating and thermal expansion of bridges and buckling of joints of steel structures. To address the high temperature due to climate change, it is necessary to have the moisture maintenance planning regularly.

83. There should have Erosion Control Plan which could include consideration of the following:

i) Climate and rainfall for the area and checking weather forecasts.
ii) Terrain and typical locations susceptible to erosion and runoff.
iii) Protection of the works and potential impacts to the environment.
iv) Erosion control methods to be employed, locations and installation timing.
v) Limits to stockpiling on sites near waterways and irrigation channels.
vi) Discussion of the DSC/PMU inspection/monitoring role.
vii) Agreement on publicity/public consultation requirements.

84. Mitigation measures for cut slopes will be required by the contractors to prevent slope collapse. These will include but not necessarily be limited to:

(i) Stockpile topsoil for immediate replanting after cutting.
(ii) Minimize damage and cutting of surrounding vegetation during slope formation.
(iii) Protect the cut slope with planted vegetation, bioengineering or conventional civil engineering structures as soon as practicable after cutting.
(iv) Prevent erosion and protect the cut slope with temporary or permanent drainage as soon as practicable after cutting.
(v) If new erosion occurs accidentally, back fill immediately to restore original contours.

85. In order to preserve the constructed slopes and other works and embankments from soil erosion and runoff.

i) Low embankments will be protected from erosion by seeding and planting indigenous grasses that can flourish under local conditions.

ii) High embankments, i.e. 2m high and above, will be considered for protection by constructing stone pitching or a riprap across the embankment immediately after the works are completed. This practice will also be applied along cross-drainage structures where embankments are more susceptible to erosion by water runoff.

iii) The contractors will also be required to include appropriate measures for slope protection, i.e. vegetation cover and stone pitching, as required in the detailed construction drawings and implement them accordingly.

86. Measures will also be taken during the operational phase to ensure that storm drains and highway drainage systems are periodically cleared to maintain clear drainage to allow rapid dispersal of storm water flow. An adequate system of monitoring, reporting and maintenance will be developed.

87. Four bridges on QL 217 from km 59+979 to km 104 that were found to be without adequate hydraulic capacity are proposed for reconstruction. 23 culverts are proposed on QL 217 from km 59+979 to km 104 to facilitate proper drainage and avoid stagnation of water and flooding problems. These culverts are mostly replaced for old slab bridge. Table 2 and table 4 show how these slab bridge are under the Standard of Vietnam or lack of width. Also, the aperture design of these new culverts will improve the capacity of drainage to ensure that high flood level Hn will be lower than the finished grade/elevation of new road pavement and bridges. Due to climate change, the rainfall will be higher so the proposed culverts will help to mitigate the effect of climate change. Table 15 propose bridges and culverts should be alternate to adapt with climate change.

Table 14 Proposed Bridges and Culverts

No	Name of bridge	Aperture current	Current Width (m)	Station	Alternate	Aperture design			Width (m)
1	Rung Lim 1	4.3x3	8.5	Km59+979.00	new culvert	1x	4.0x	4.0	22.2
2	Rung Lim 2	5x3	9.0	Km60+120.00	new culvert	1x	4.0x	4.0	10.2
3	Rung Lim 3	6x2.5	8.0	Km60+423.30	new culvert	1x	4.0x	4.0	12.6
4	Cam Binh 1	6x3	4.1	Km60+873.00	new culvert	1x	4.0x	4.0	21.3
5	Lang Xam	4x2.5	5.0	Km61+533.70	new culvert	1x	4.0x	4.0	17.9
6	slab bridge	3.8x2	8.0	Km61+793.00	new culvert	1x	4.0x	4.0	26.1
7	Dat bridge	1x15	8.5	Km62+090.00	new bridge	1x		15.0	9.0
8	slab bridge	5.8x2.5		Km63+529.96	new culvert	1x	5.0x	3.0	10.9
9	Khuoi gao	3.5x3	7.93	Km64+772.44	Lengthen	1x	3.5x	3.0	14.6
10	Lang To	1x15	8.50	Km66+603.10	No change	1x		15.0	
11	Lang Chon	2x24	7.70	Km68+789.80	No change	2x		24.0	
12	Lang Chen	5.2x4.5	8.0	Km69+960.05	No change	1x	5.2x	4.5	
13	Vac 1		8.0	Km70+860.49	new culvert	1x	5.0x	4.0	13.2

No	Name of bridge	Aperture current	Current Width (m)	Station	Alternate	Aperture design			Width (m)
14	*Vac 2*		*8.0*	*Km71+186.31*	*new culvert*	*1x*	*5.0x*	*5.0*	*11.2*
15	Chieng cham	2x12	7.0	Km72+204.69	new bridge	1x		33.0	9.6
16	Cam Thanh	1x15	8.3	Km73+340.18	No change	1x		15.0	
17	Bong	5.5x3	8.0	Km74+030.87	No change	1x	5.5x	3.0	
18	Tra Nua	1x15	7.7	Km74+368.48	No change	1x		15.0	
19	Hon Ngang	1x4x3	7.7	Km75+210.23	Lengthen	1x	4.0x	3.0	13.3
20	slab bridge	*3x2.5*		*Km76+223.72*	*New culvert*	*1x*	*3.0x*	*2.5*	*22.2*
21	slab bridge	*1.1x1*	*6.50*	*Km81+257.49*	*New culvert*	*1x*	*3.0x*	*3.0*	*9.0*
22	slab bridge	3.4x5.5	7.0	Km81+284.56	No change	1x	3.4x	5.5	
23	Dai Lan	1x21	7.8	Km82+227.18	*New culvert*	1x		22.0	9.0
24	Hon La	1x33	9.4	Km91+304.04	No change	1x		33.0	
25	slab bridge	*6x4.5*		*Km92+115.20*	*New culvert*	*1x*	*6.0x*	*4.5*	*11.5*
26	*No name*			*Km93+363.10*	*New culvert*	*1x*	*2.5x*	*2.5*	*18.9*
27	*No name*			*Km93+533.74*	*New culvert*	*1x*	*3.0x*	*3.0*	*12.0*
28	*No name*			*Km94+201.63*	*New culvert*	*1x*	*2.5x*	*2.5*	*11.0*
29	arch bridge	2.5x2.5	7.9	Km98+885.47	Lengthen	1x	2.5x	2.5	18.1
30	*No name*			*Km98+885.47*	*New culvert*	*1x*	*4.0x*	*4.0*	*18.1*
31	arch bridge	4x3	8.02	Km100+465.0	New culvert	1x	4.0x	3.0	22.3
32	*No name*			*Km101+533.9*	*New culvert*	*1x*	*2.5x*	*2.5*	*12.9*
33	arch bridge	2.5x2.5	6.7	Km102+087.7	*New culvert*	1x	2.5x	2.5	16.6
34	arch bridge	2.5x2.5	7.7	Km102+528.7	*New culvert*	1x	2.5x	2.5	21.8
35	Hon nga	1x12		Km104+000	*New culvert*	1x		18.0	9.0

The contract agreement will require the contractor to design drainage systems that are adequate to drain future increases in rainfall. It is necessary to have protection measures and drainage systems that can withstand debris flows and future increases in rainfall respectively will be recommended in the detailed design.

88. The main climate-sensitive components of the project are protection walls, bridges and drainage structures. Specific adjustments made in the design to withstand future climate extremes for the Ql 217 Road subprojects are:

89. Cement Mortar for all concrete works including drainage structures: Normally a ratio of 1:6 (cement: sand) is used. This ratio has now been revised to 1:4 in order to increase the strength of the mortar.

90. Random Rubble Masonry (RRM) wall: Normally only the top and bottom section of the wall is made of cement, the middle section is made of stones stacked on top of each other. Now the entire wall is made of cement in order to improve the strength of the wall to hold debris and material falling on the hillside and support the road embankment on the valley side of the road. (Extensive bioengineering for slope protection is already a normal practice in Vietnam, hence thought it is an adaptation activity it is not mentioned separately here)

91. Hume pipes: Hume pipes are one of two types of common cross drain types. Normally the diameter of the hume pipes used are 750mm or 1000mm. Now a 1200mm hume pipe has been introduced and only 1000mm and 1200mm are included in the design in order to facilitate proper flow of water and avoid frequent blockages due to debris being washed down.

92. Bridge protection: Normally provision for wing walls to protect the bridge foundation and abutment from scouring is done on ad hoc and on a reactive basis. Now a provision has been made to have wing walls for all bridges on a proactive basis. (The normal bridge height design already provides adequate clearance for discharging increased quantities of rainfall/water).

93. It is necessary to have these above considerations in the Detail Design to mitigate the climate change impacts to the life span of road pavement and bridge.

Appendix A: Selected Photographs

Photograph 1
QL217 Typical section through settlement

Photograph 2
QL217 -Typical embankment

Photograph 3
QL217 –Typical bridge

Appendix B: Data for Climate Change modelling of MONRE 2012

The projected average temperature increase of Thanh Hoa province till the end of 21st century comparing to the period 1980-1999 under B2 scenario

Year	The projected average rainfalls increase of the whole year (%)	Increase in Spring (Mar-May) (%)	Increase in Summer (Jun-Aug) (%)
2020	1.1	-1.0	2.3
2030	1.7	-1.4	3.4
2040	2.3	-2.0	4.8
2050	3.0 (2.0-4.0)	-2.6	6.2
2060	3.7	-3.1	7.5
2070	4.3	-3.6	8.7
2080	4.8	-4.1	9.8
2090	5.3	-4.5	10.9
2100	5.8 (4.0 – 8.0)	-4.9	11.8

Source: MONRE, 2012

Change in precipitation of Thanh Hoa province till the end of 21st century comparing to the period 1980-1999 under B2 scenario.

Year	Projected annual mean temperature increase (C degree)	Increase in Winter (Dec-Feb) (C degree)	Increase in Summer (Jun-Aug) (C degree)
2020	0.5	0.5	0.4
2030	0.7	0.7	0.6
2040	1.0	1.0	0.8
2050	1.2 (1.0 – 1.4)	1.3	1.1
2060	1.5	1.6	1.3
2070	1.7	1.8	1.5
2080	2.0	2.1	1.7
2090	2.2	2.3	1.9
2100	2.4 (2.2 – 2.8)	2.5	2.1

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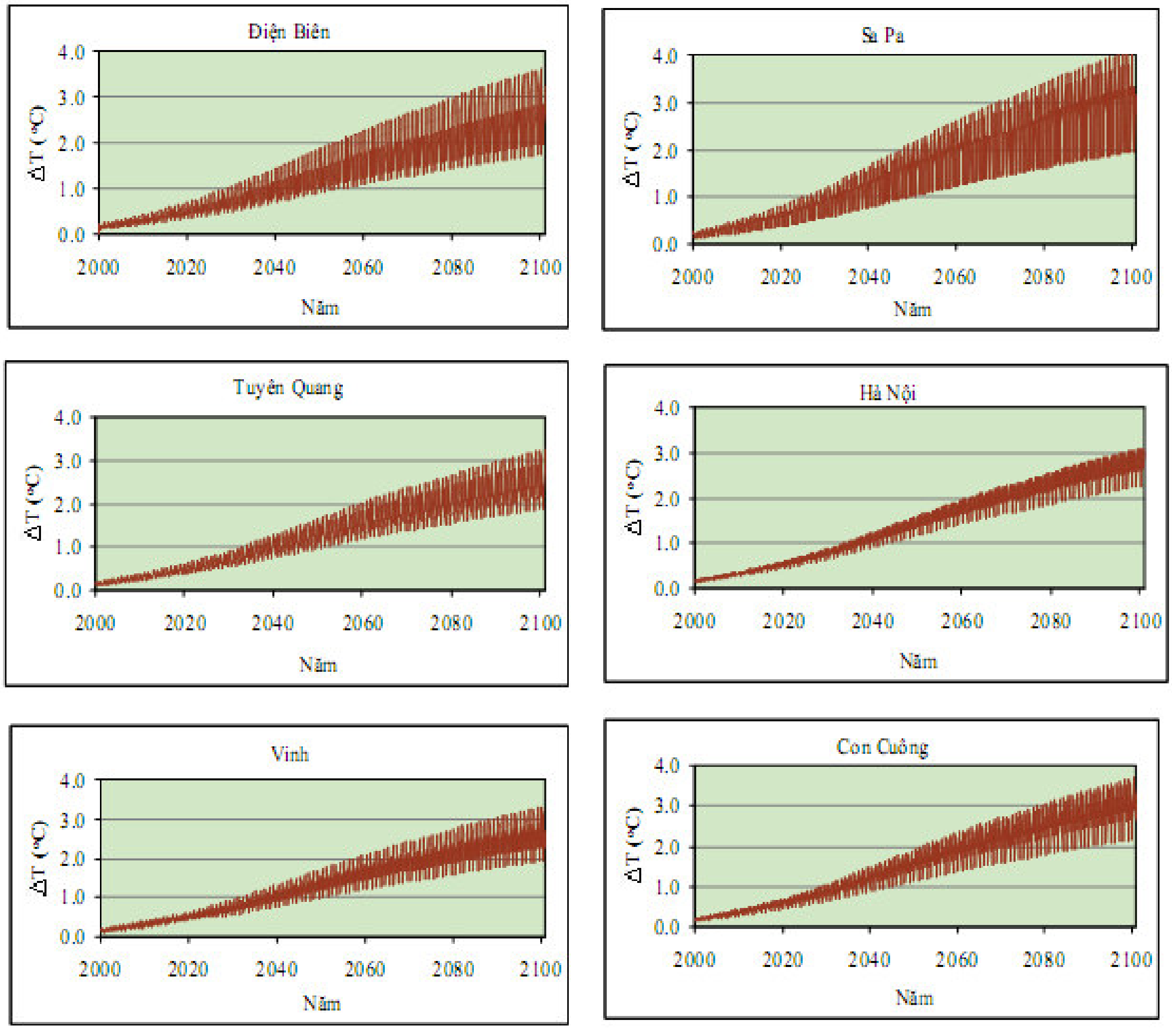
Mean temperature increase in the 21st century for some areas in Vietnam



Source: MONRE, 2012

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