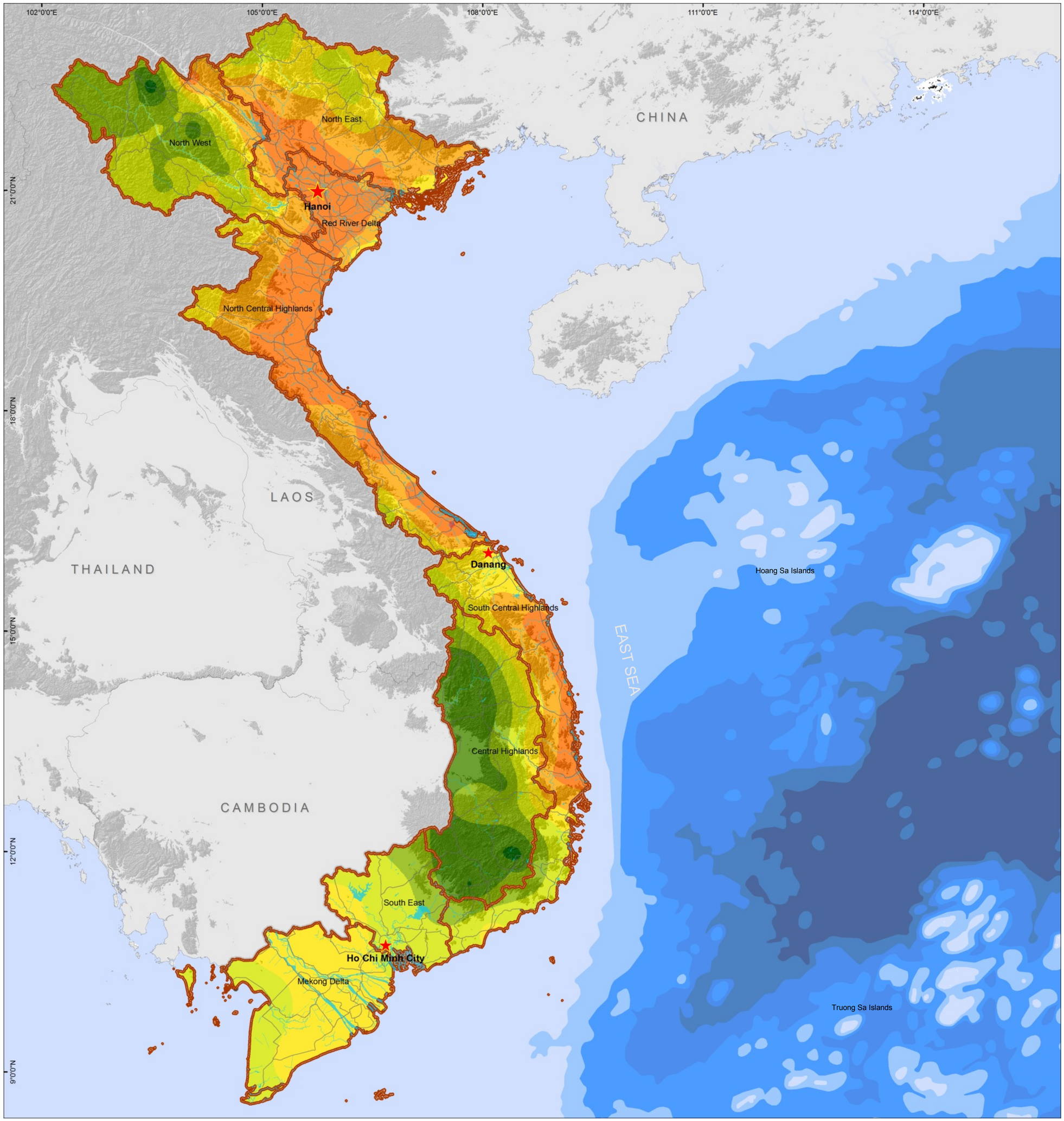
NATIONAL TARGET PROGRAM ON CLIMATE WITH A FOCUS ON ENERGY AND TRANSPORT

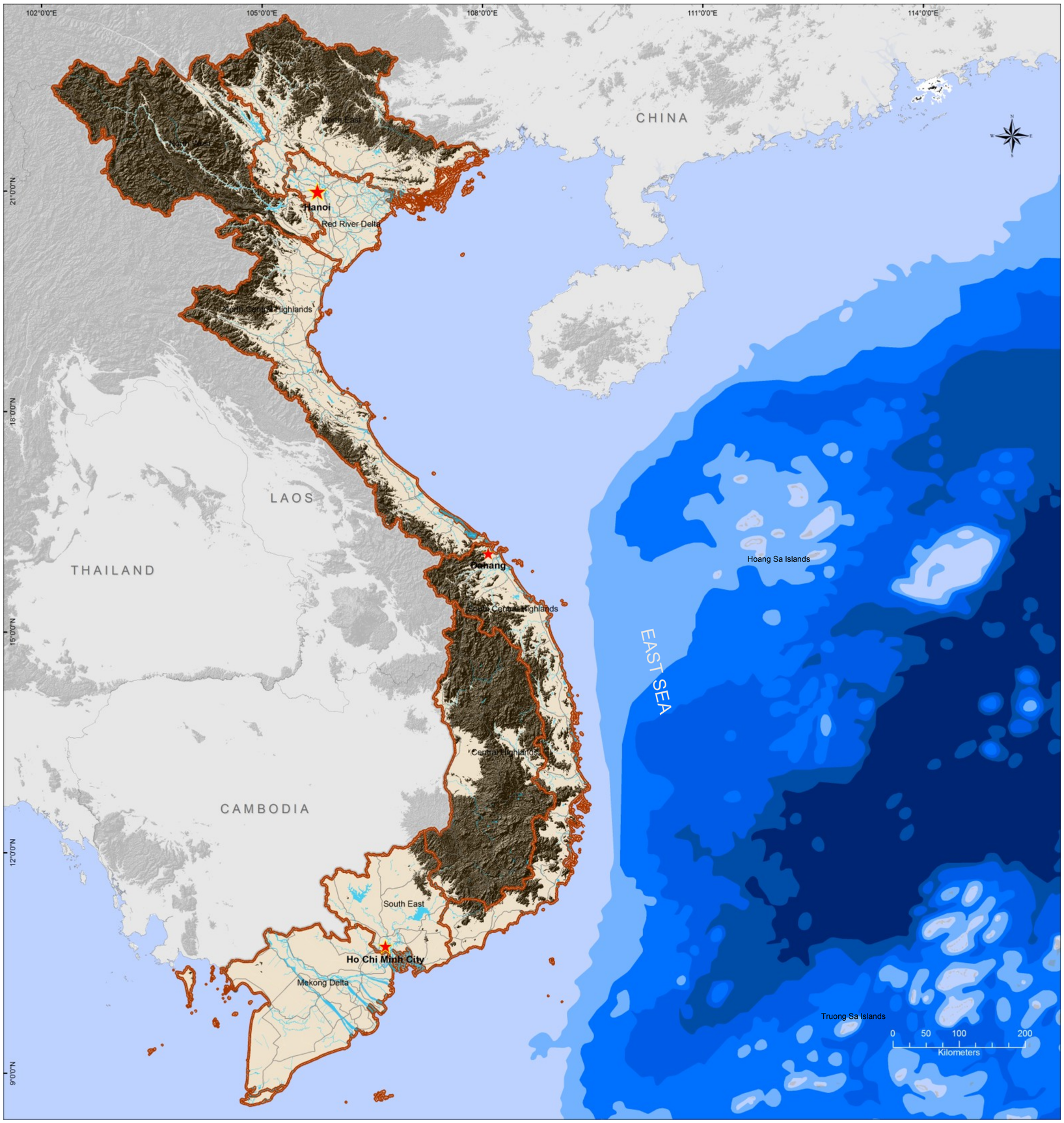


FUNDING AGENCIES

PARTNERS

COMPANIES

FOREWORD



The Climate Change Atlas is the culmination of activities under the *ADB TA7779-VIE: Support for the National Target Program with a Focus on Energy and Transport* and represents an important part of the scientific evidence base for climate vulnerability and adaptation. The CC Atlas is a visualization aide that brings complex technical information on climate change into a practical reality for transportation and energy assets.

The CC Atlas was developed through a collaborative effort between the project team and various partner agencies including, the Institute for Meteorology, Hydrology and Environment (IMHEN) which provided the information on the CC scenarios, the Transport Development and Strategy Institute (TDSI) providing information on the current and proposed transportation assets, and finally, the Institute of Energy Viet Nam (IE) which provided information on the energy assets.

As a geospatial representation of climate change data the Atlas makes information easily available to review and share, supporting a better understanding of technical aspects of climate change, and the possible impacts on existing and proposed transportation systems and energy systems across Vietnam. The Atlas is also designed to communicate this information at a national, regional, and provincial level, albeit the current work is limited to provinces of Thanh Hoa and Da Nang.

Designed as a product for use by the general user, not a technical expert, the atlas is also complemented with a digital data set that enables further review, inquiry, and analysis using technological tools and GIS software and Atlas layers can be opened directly in GoogleEarth™ as a series of overlays. In this way national, provincial and district stakeholders can explore climate risks by overlaying them onto satellite imagery showing terrain and land use to understand the implications of future changes on their area and systems of interest.

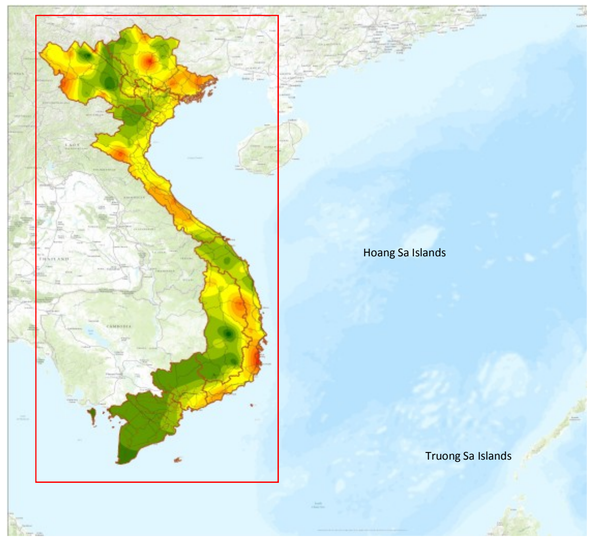
The focus of national maps is to put attention toward the key climate indicators and projected future. A series of climate indicators are mapped for baseline period (1980-1999) and projections for year 2050 at a scale of 1:3,000,000. The climate scenario selected for representation include either B2 (Conservation and Environmental protection at local levels) or A1B (Business as usual). B2 scenario was used to represent average cases of climate while extreme climate changes were represented using A1B scenario. In order to view the changes a Change map is also provided along with descriptive text.

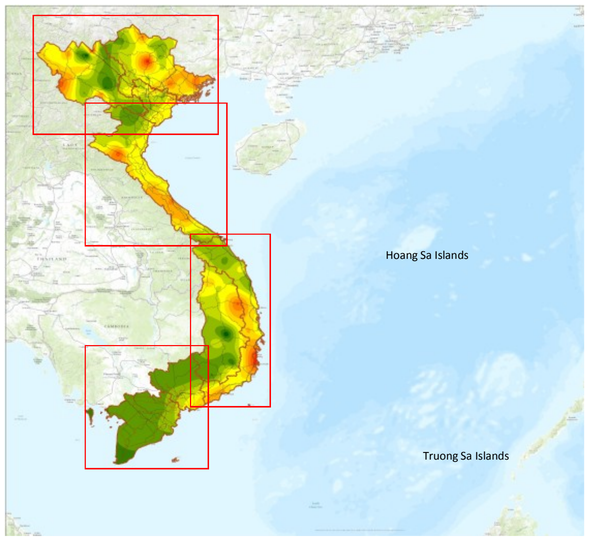
Regional Atlas has similar layout which presents the entire country in 4 regional clusters: (i) Northern Mountains Region; (ii) North-Central Region; (iii) Central Region; and (iv) Southern Mekong Region. The 4 regions are an aggregation of one or more than one climate region of Vietnam. Region 1 consists of North East, North West and Red River Delta. Region 2 consists of Northern Central Highlands, Region 3 consist of South Central Highlands and Central Highlands. Region 4 consists of South East and Mekong Delta.

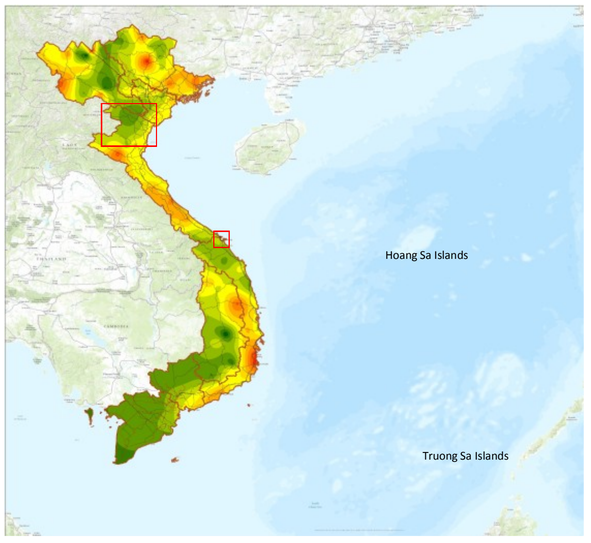
These regional maps provide comparative graphics of the baseline climate conditions, 2050 projected climate change conditions, and the relative change between baseline and 2050 projections. Overlaid on these maps are the Transportation and Energy assets at a 1:120,000 scale mapping. At this scale it is useful to see asset data juxtaposed to the climate data to make useful analysis. For purposes of consistency in representation across the Atlas, all the regional maps use national level climate change scenario.

At a provincial level, the CC Atlas is focussed on two provinces as key demonstration provinces namely Thanh Hoa and Da Nang. The Atlas provides the information about these two provinces at a 1:400,000 scale using the same CC scenario as used at the national level. The analytical result however includes maps on more detailed parameters representing landslide risk, riverine flooding and maximum discharge. More detailed representation of national and provincial Transportation and Energy assets were also available on these provincial maps for improved review and analysis.

This atlas is a first key step to enable end user in application of spatially enabled climate change information for decision making toward adaptation of Transportation and Energy Infrastructure. It is also a pioneering work in Viet Nam to an Atlas beyond changes in climate parameters towards an expression of the risk experienced by the assets that characterise the transport and energy system. We hope, that this Atlas will facilitate dialogue, discussion, decision making through this quick and easy to use, highly informative map product.







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REGIONAL - TRANSPORTATION

AVERAGE MAXIMUM DAILY TEMPERATURE

REGION - 1

1 TRANSPORTATION - ROADS AND BRIDGES
2 TRANSPORTATION - OTHER

REGION - 2

3 TRANSPORTATION - ROADS AND BRIDGES
4 TRANSPORTATION - OTHER

REGION - 3

5 TRANSPORTATION - ROADS AND BRIDGES
6 TRANSPORTATION - OTHER

REGION - 4

7 TRANSPORTATION - ROADS AND BRIDGES
8 TRANSPORTATION - OTHER

RAINFALL ASSOCIATED LANDSLIDES

REGION - 1

9 TRANSPORTATION - ROADS AND BRIDGES
10 TRANSPORTATION - OTHER

REGION - 2

11 TRANSPORTATION - ROADS AND BRIDGES
12 TRANSPORTATION - OTHER

REGION - 3

13 TRANSPORTATION - ROADS AND BRIDGES
14 TRANSPORTATION - OTHER

REGION - 4

15 TRANSPORTATION - ROADS AND BRIDGES
16 TRANSPORTATION - OTHER

WET SEASON CATCHMENT YIELD

REGION - 1

17 TRANSPORTATION - ROADS AND BRIDGES
18 TRANSPORTATION - OTHER

REGION - 2

19 TRANSPORTATION - ROADS AND BRIDGES
20 TRANSPORTATION - OTHER

REGION - 3

21 TRANSPORTATION - ROADS AND BRIDGES
22 TRANSPORTATION - OTHER

REGION - 4

23 TRANSPORTATION - ROADS AND BRIDGES
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REGIONAL - ENERGY

WET SEASON CATCHMENT YIELD

REGION - 1

1 TRANSMISSION LINES AND SUBSTATIONS
2 POWER PLANTS AND OTHER

REGION - 2

3 TRANSMISSION LINES AND SUBSTATIONS
4 POWER PLANTS AND OTHER

REGION - 3

5 TRANSMISSION LINES AND SUBSTATIONS
6 POWER PLANTS AND OTHER

REGION - 4

7 TRANSMISSION LINES AND SUBSTATIONS
8 POWER PLANTS AND OTHER

AVERAGE MAXIMUM TEMPERATURE JUNE - AUGUST

REGION - 1

9 TRANSMISSION LINES AND SUBSTATIONS
10 POWER PLANTS AND OTHER

REGION - 2

11 TRANSMISSION LINES AND SUBSTATIONS
12 POWER PLANTS AND OTHER

REGION - 3

13 TRANSMISSION LINES AND SUBSTATIONS
14 POWER PLANTS AND OTHER

REGION - 4

15 TRANSMISSION LINES AND SUBSTATIONS
16 POWER PLANTS AND OTHER

NUMBER OF HOT DAYS

REGION - 1

17 TRANSMISSION LINES AND SUBSTATIONS
18 POWER PLANTS AND OTHER

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19 TRANSMISSION LINES AND SUBSTATIONS
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REGION - 4

23 TRANSMISSION LINES AND SUBSTATIONS
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TRANSPORTATION

1 AVERAGE MAXIMUM TEMPERATURE JUNE - AUGUST
2 RAINFALL ASSOCIATED LANDSLIDE RISK
3 RIVERINE FLOODING 100 YEAR

ENERGY

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PROVINCIAL - DANANG

TRANSPORTATION

1 AVERAGE MAXIMUM TEMPERATURE JUNE - AUGUST
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3 RIVERINE FLOODING 100 YEAR

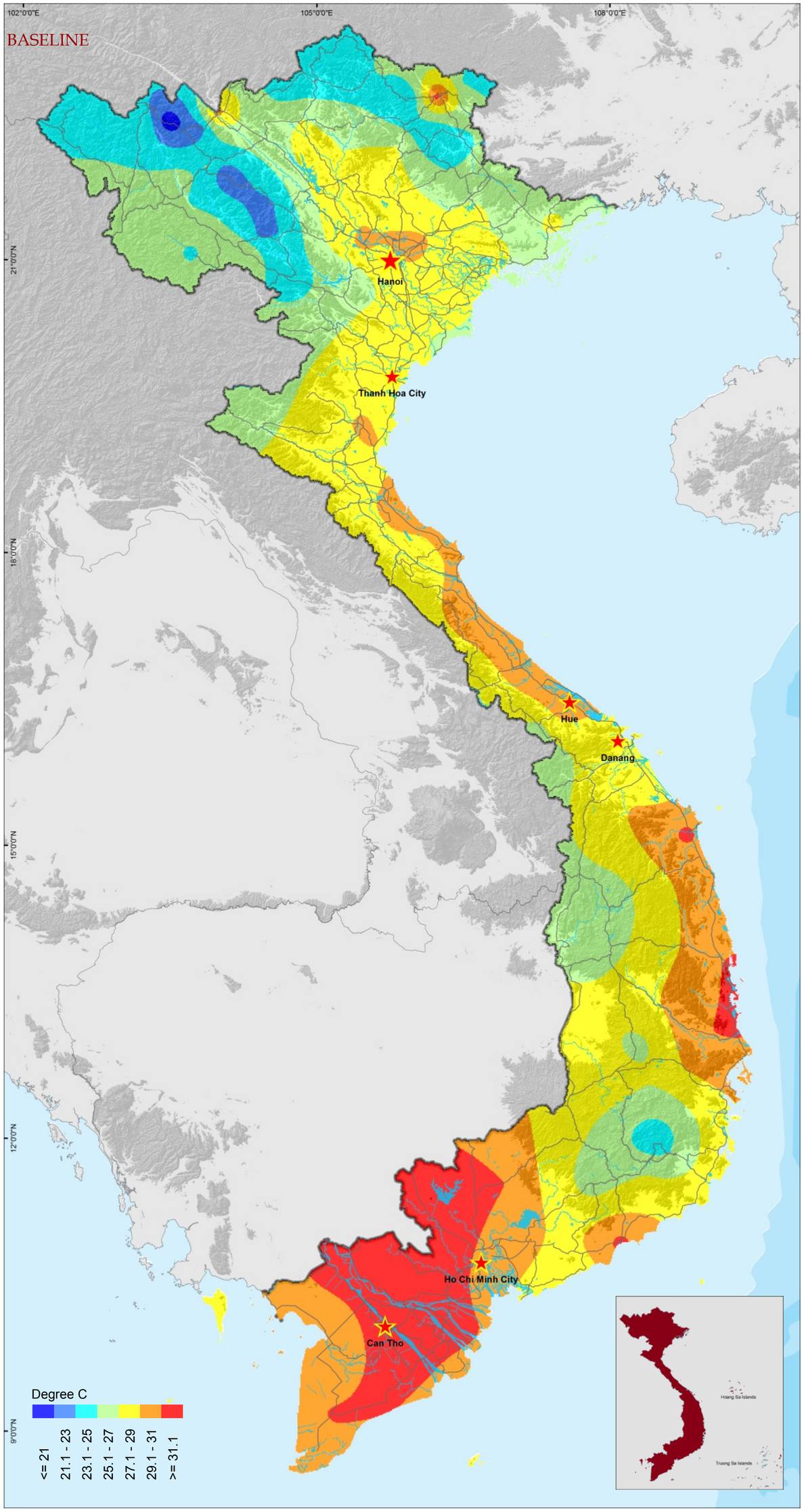
ENERGY

4 AVERAGE MAXIMUM TEMPERATURE JUNE - AUGUST
5 NUMBER OF HOT DAYS
6 RIVERINE FLOODING 100 YEAR
7 SEA LEVEL RISE (1M)

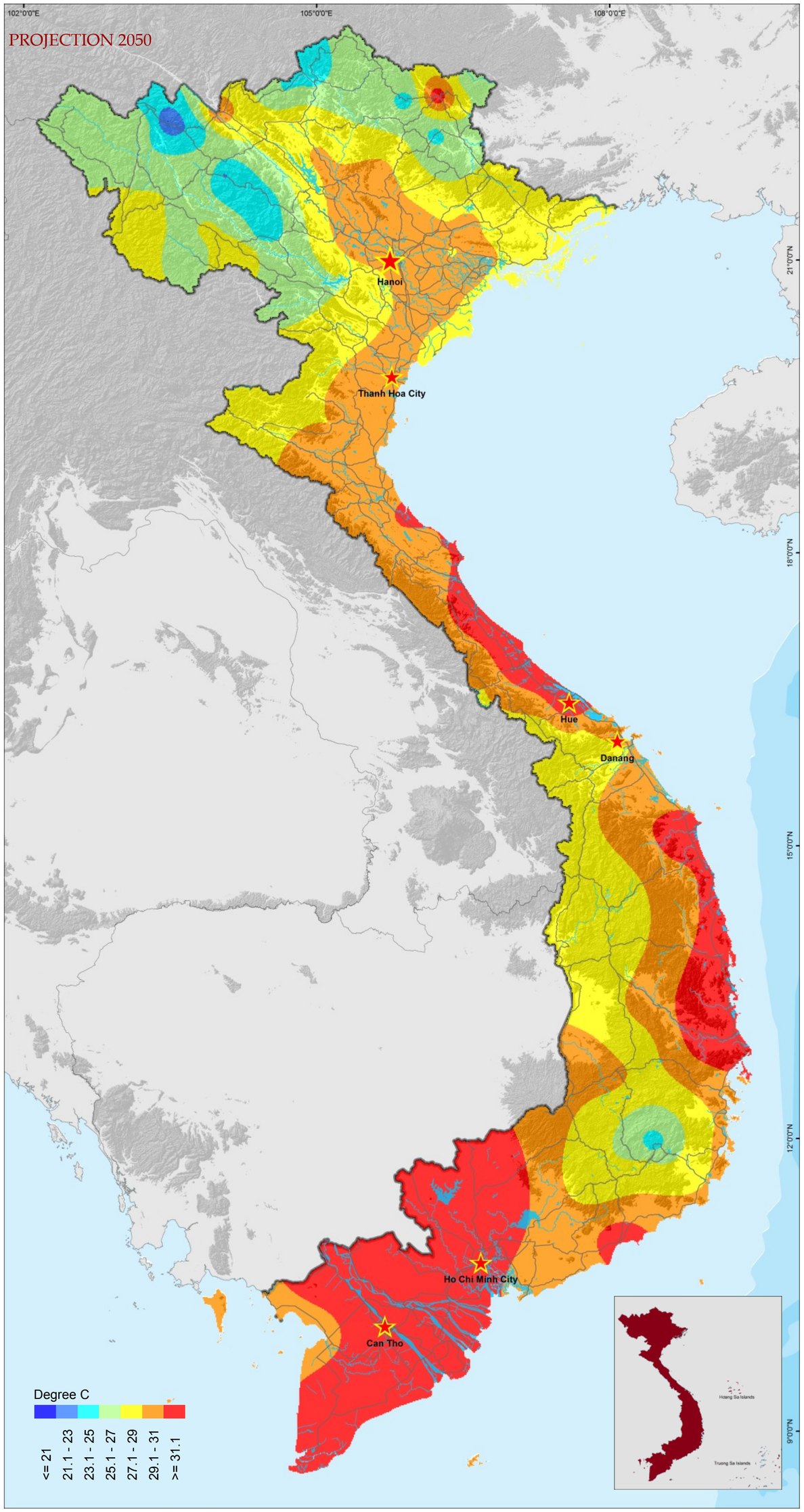
NATIONAL

TEMPERATURE - AVERAGE ANNUAL MAXIMUM

BASELINE



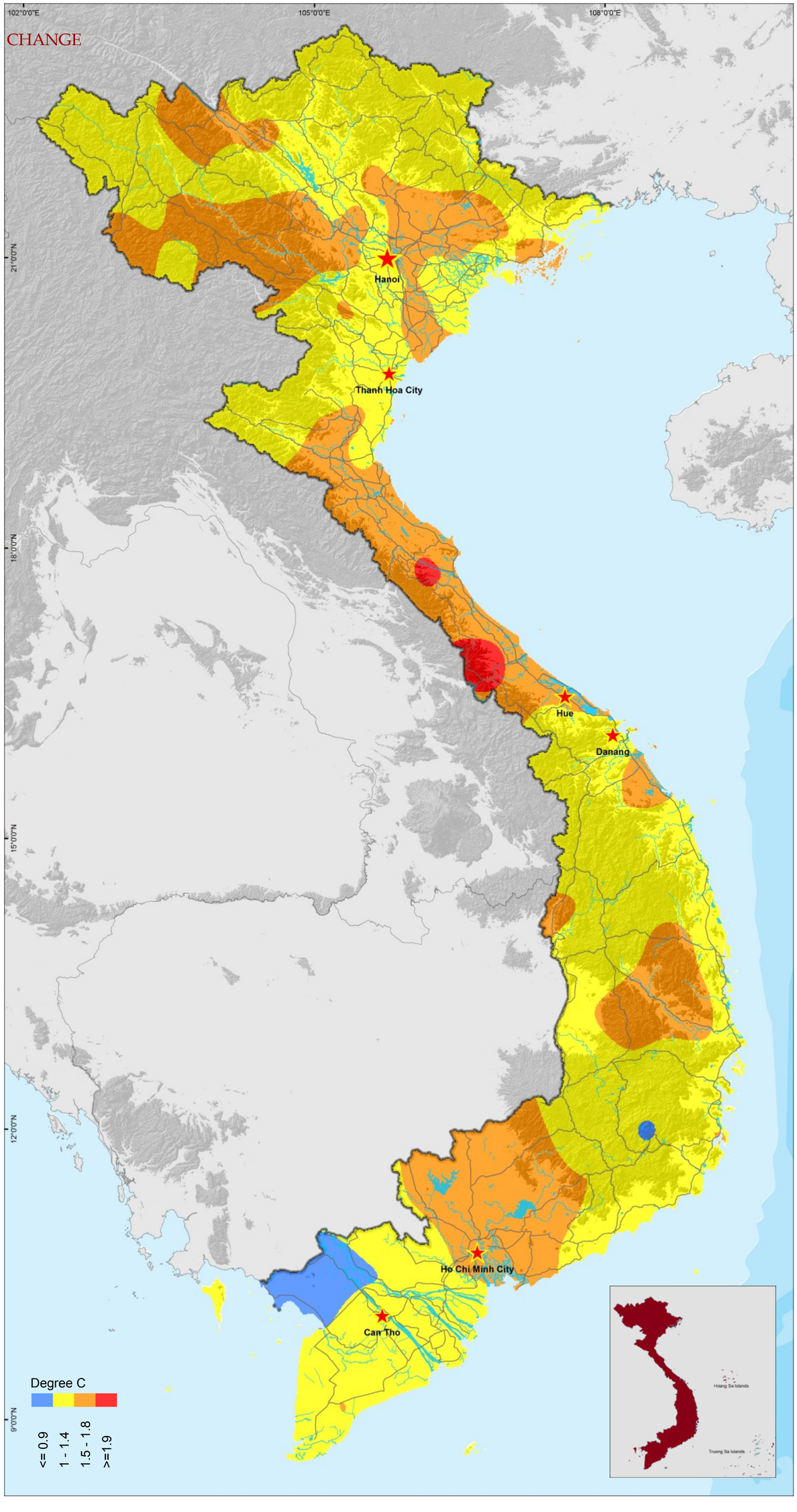
PROJECTION 2050



FUNDING AGENCIES

PARTNERS

COMPANIES



BASELINE

Average annual maximum temperature for the period 1980-1999 (baseline) ranged between 18 to 32°C with cooler temperatures experienced in the mountainous areas near the borders with China and Lao PDR and warmer temperatures centred on the large floodplains of southern Viet Nam and the smaller floodplains of central Viet Nam. Drawing on the seven climate zones established for the country, the annual maximum temperature distribution can be characterised as follows:

1) Northwest: Overall, the average maximum temperature ranges mainly between 21 to 26°C in the Northwest region, however, it can reach as low as 10°C at Hoang Lien Peak. Thie highest temperatures in this zone are located in Southwest reaching about 26°C.

2) Northeast: the average maximum temperature in this area is higher than the Northwest region, mainly in the range of 20 to 26° C, the northern mountainous region has lower temperature and central region has higher temperature.

3) Northern Delta: the average maximum temperature is mainly between 26 to 30°C, the central is the hottest area and the coastal area is the coolest.

4) North Central: the average maximum temperature ranged from 27 to 32°C, the mountainous area exprience cooler temperature and the coastal area is hot.

5) South Central: The average maximum temperature in the region is mainly from 27 to 34°C; Quang Nam to Khanh Hoa and Binh Thuan are the hottest areas with the main temperature between 29 to 32°C.

6) The Central Highlands: The average maximum temperature in the area ranges between 25 and 30°C; only Lam Dong has lower temperature with 20°C as the maximum temperature.

7) Southern: Spatial distribution of maximum temperature in this region is the most uniform of the seven zones with the average maximum temperature consistentlyfrom 29 to 32°C.

2050 SCENARIO

By 2050 the average maximum temperature will significantly increase in comparison with the baseline period (1980-1999) specifically in following areas:

1) Northwest: the average maximum temperature has increased by about 0.5 to 1°C from the baseline. The average maximum temperature is expected to range between 21 to 30°C. The lowest temperature is still at Hoang Lien Peak, at approximately 10°C, while higher temperatures are in the Southwest, between 27 to 28°C. Some areas in the east of the region will for the first time experience average maximum temperatures of 30°C confirming a shift in temperature regime.

2) Northeast: a similar shift in temperature regime is projected, with the overall average maximum temperature is expected to increase between 0.5 to 1°C as compared to baseline period (1980-1999). The average maximum temperature will range between 21 to 32°C, though the spatial gradient of lower temperatures in the northern mountainous region and higher temperatures in the midland region will persist.

3) Northern Delta: This region has the more significant increase in maximum temperature as compared to the baseline. Generally, the average maximum temperature in the mid-century will range from 29 to 32°C, notably in Hanoi and neighboring provinces, the average maximum temperature may reach 31 to 32°C.

4) North Central: Compared with the past, this area has a high increase on maximum temperature by 2050. Overall, the average maximum temperature varies from 29 to 32°C; some northern mountainous areas have lower maximum temperature, around 27 to 28°C; in coastal areas, the average maximum temperature is mainly from 31 to 32°C.

5) South Central: Compared with the baseline, the average maximum temperature in mid-century in this region has increased significantly. The average maximum temperature is from 29 to 34°C. Notably, the area from Quang Ngai to Nha Trang has average maximum high temperature from 31 to 34°C and this hot-zone has expanded significantly as compared to the baseline.

6) Central Highlands: Average maximum temperature in the Central Highlands region has significantly increased compared to the baseline. Areas with low maximum temperature has been narrowed, areas with high maximum temperature has been widened. In most of the area of the region, average maximum temperature is from 25 to 32°C.

7) Southern: Average maximum temperatures in the Southern region are projected to remain high and range from 31 to 34°C. Compared with the baseline, the average maximum temperature in the mid-century has increased dramatically with the regions

SUMMARY OF PROJECTED CHANGES

In the mid 21st century, climate change scenarios for average greenhouse gas emission project an increase of 1 to 2.5°C in average maximum temperatures throughout Viet Nam, with the exception of a small decreasing trend in the western areas of the Southern Zone. Temperature shifts are greatest in the North Central Zone where increases of more than 2°C are projected, followed by the Central Highlands and mid-elevation areas of the Northwest and Northeast regions.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

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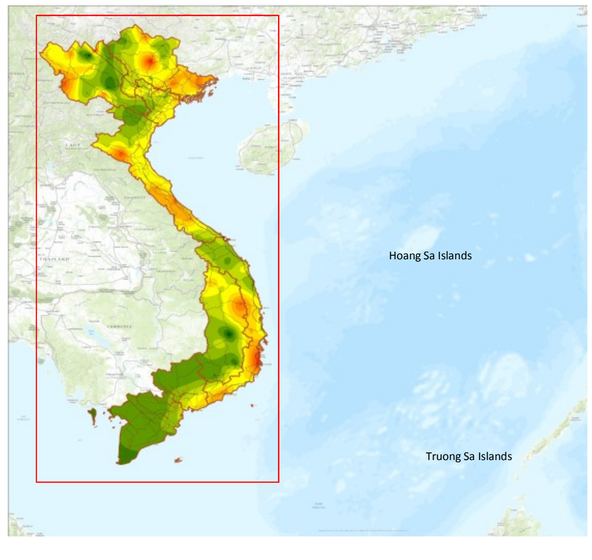
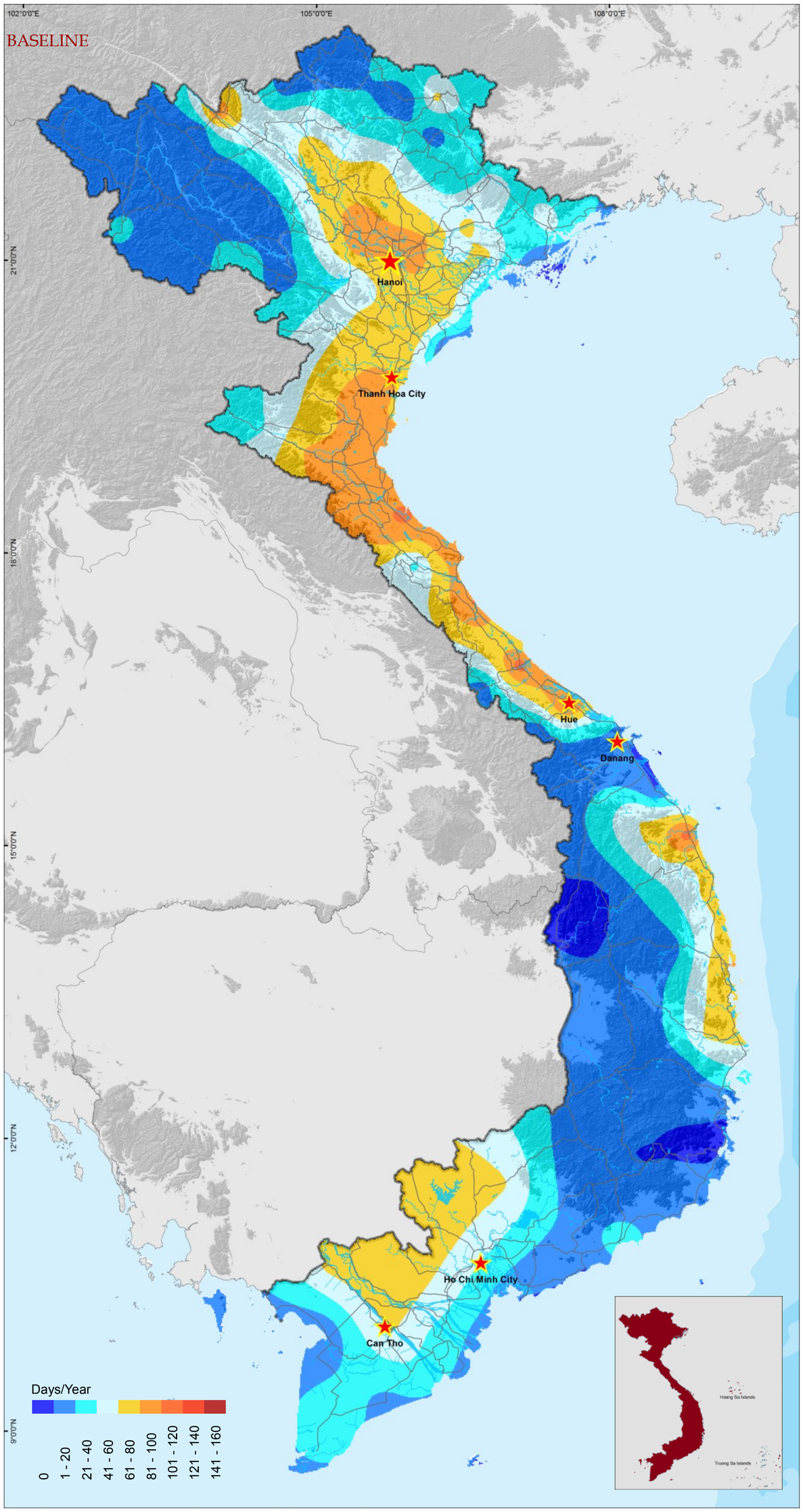
MAP SCALE - 1: 3,000,000

INDEX MAP

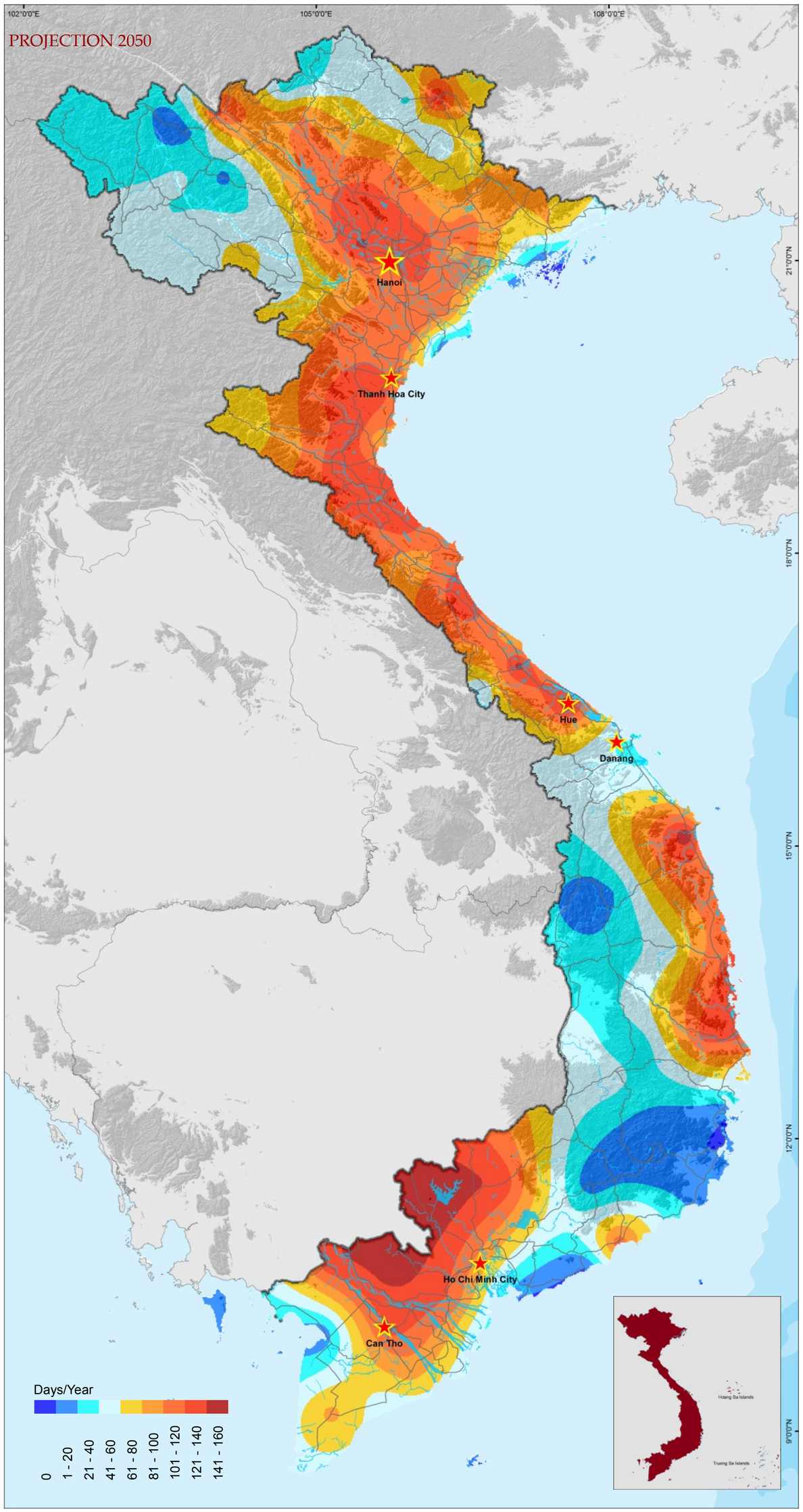


TEMPERATURE - NUMBER OF HOT DAYS

BASELINE



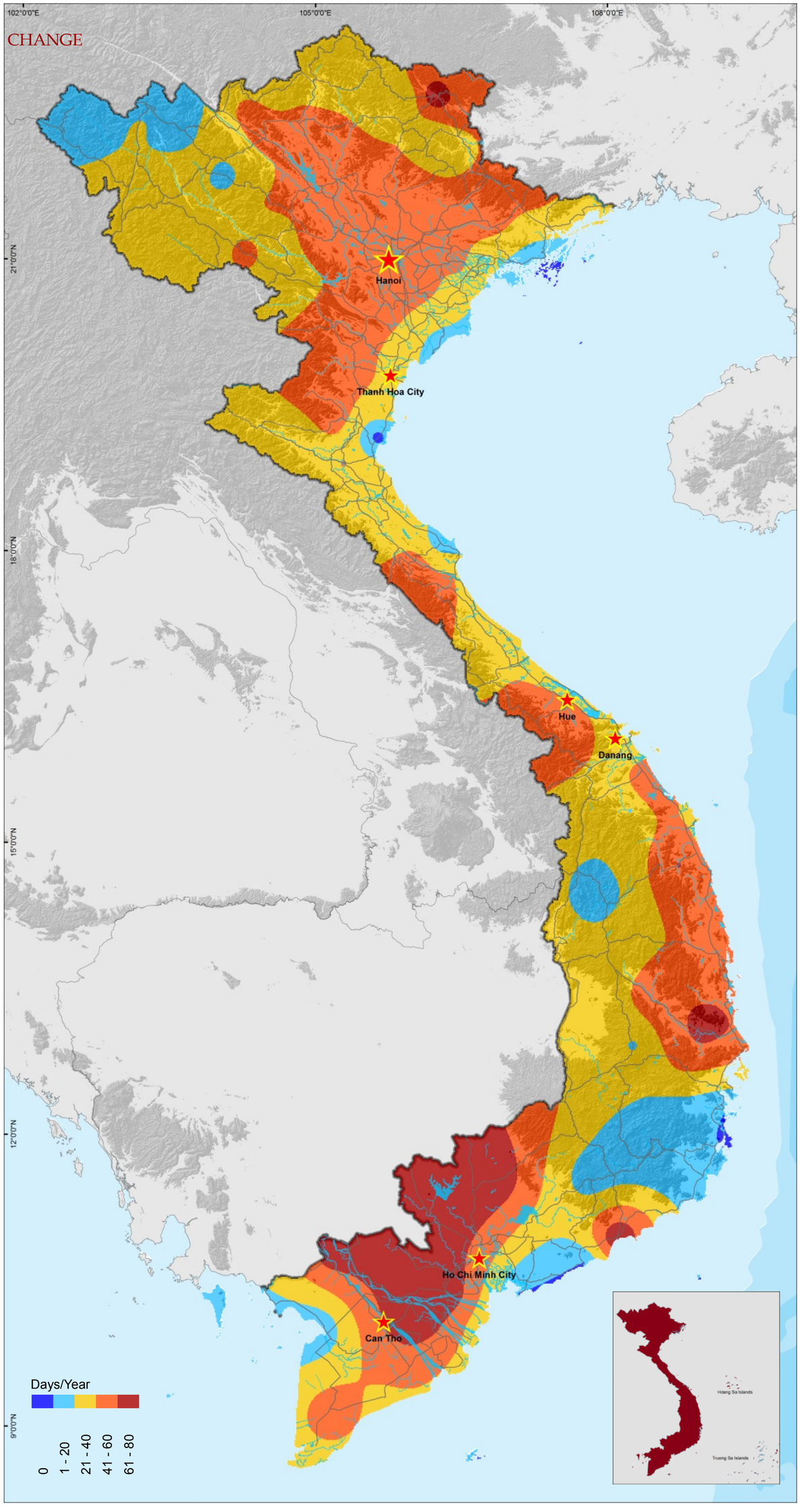
PROJECTION 2050



FUNDING AGENCIES

PARTNERS

COMPANIES



BASELINE

The number of hot days is measured as the number of days when maximum daily temperature exceeds 35°C. In general, hot weather prevails in most areas of the country; except in some mountainous areas of Northwest, Northeast and Central Highlands. These mountainous areas typically experience less than 20 hot days per year. The North Central region and the low elevation flood plains of the Northeast historically experience the greatest number of hot days in the country with more than 60 days per year and over 100 days per year in the vicinity of Ha Noi, Nghe An, Ha Tien and southern Thanh Hoa.

2050 SCENARIO

By mid of 21st century, there will be a consistent and dramatic increase in hot days throughout the country. Cooler mountainous regions of Northern Viet Nam and the Central highlands will now experience up-to 60 hot days/year. The areas experiencing more than 100 hot days/year will expand significantly encompassing mid-elevation areas of the two Northern zones, as well as the entire North Central zone and coastal areas of the South Central Zone – in some areas reaching 150 hot days/year. By 2050, the southern zone will experience the highest frequency of hot days in the country, representing the most dramatic increase in ho t spells for Viet Nam.

SUMMARY OF PROJECTED CHANGES

By mid-century the frequency of hot days will increase dramatically throughout Viet Nam representing a consistent increasing shift in the temperature regime. The number of hot days has increased by between 27 to 60 days on average compared to the period 1980-1999. The biggest increases in number of hot days will be experienced in the delta regions of the Mekong (Southern zone) and Red Rivers (Northeast zone). These increases will see the Southern zone emerge as the most consistently hot region in the country with up to 80 additional hot days compared to the baseline. The North Delta area from Quang Ngai to Phu Yen will also experience an increase of up-to 60 additional hot days/year compared to the period 1980-1999.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

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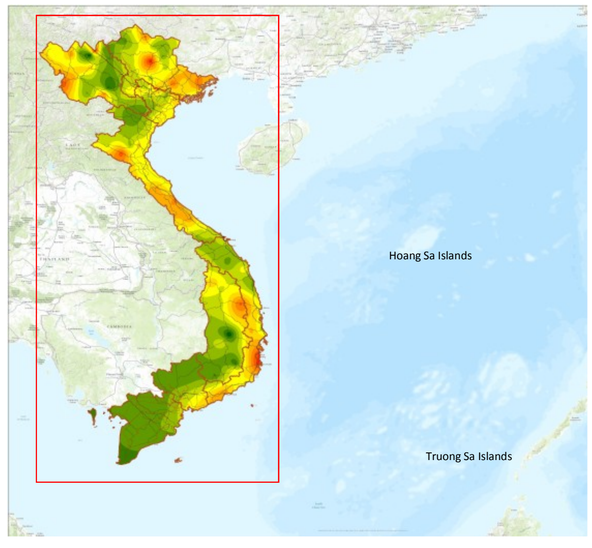
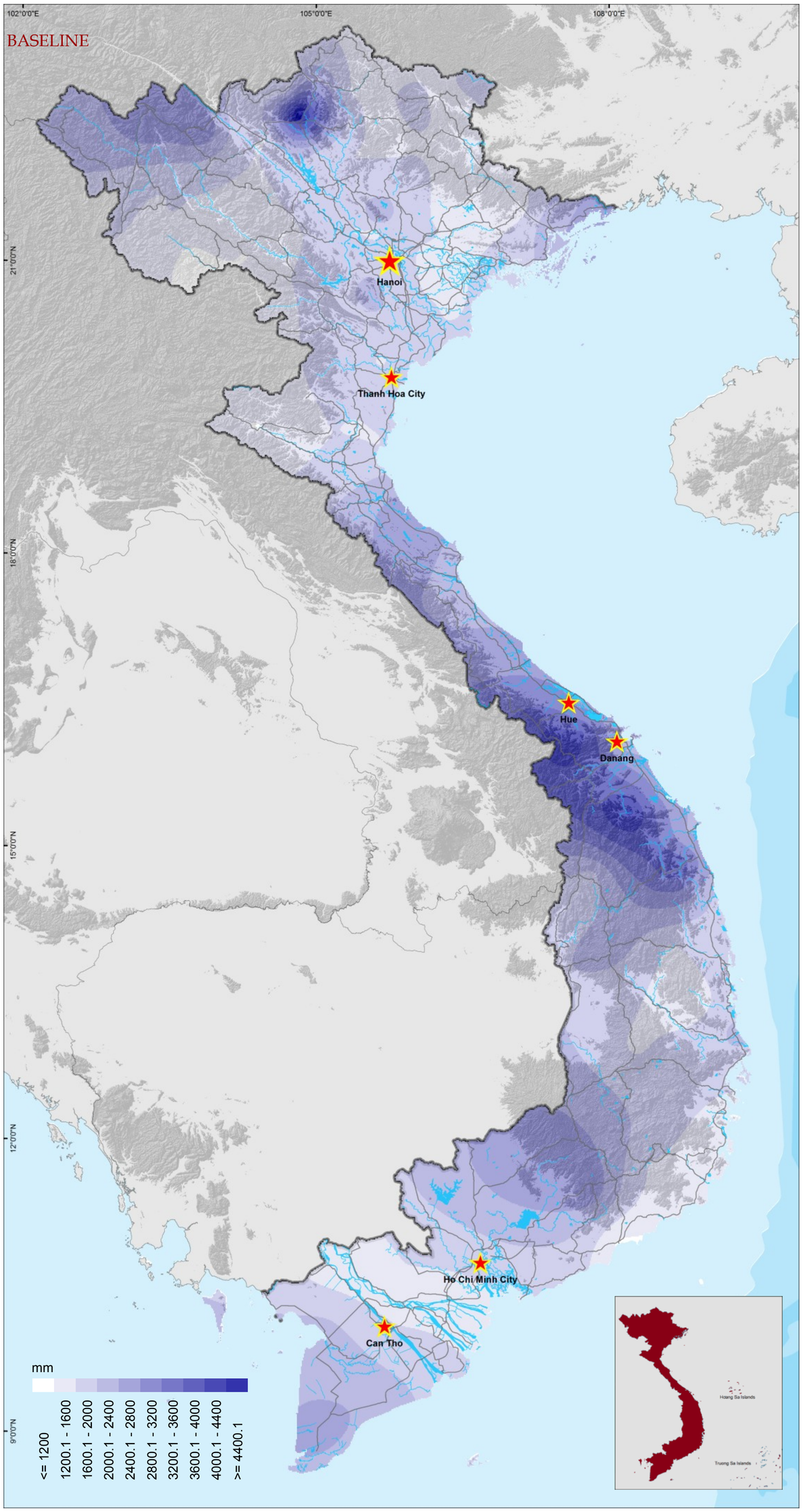
MAP SCALE - 1: 3,000,000

INDEX MAP

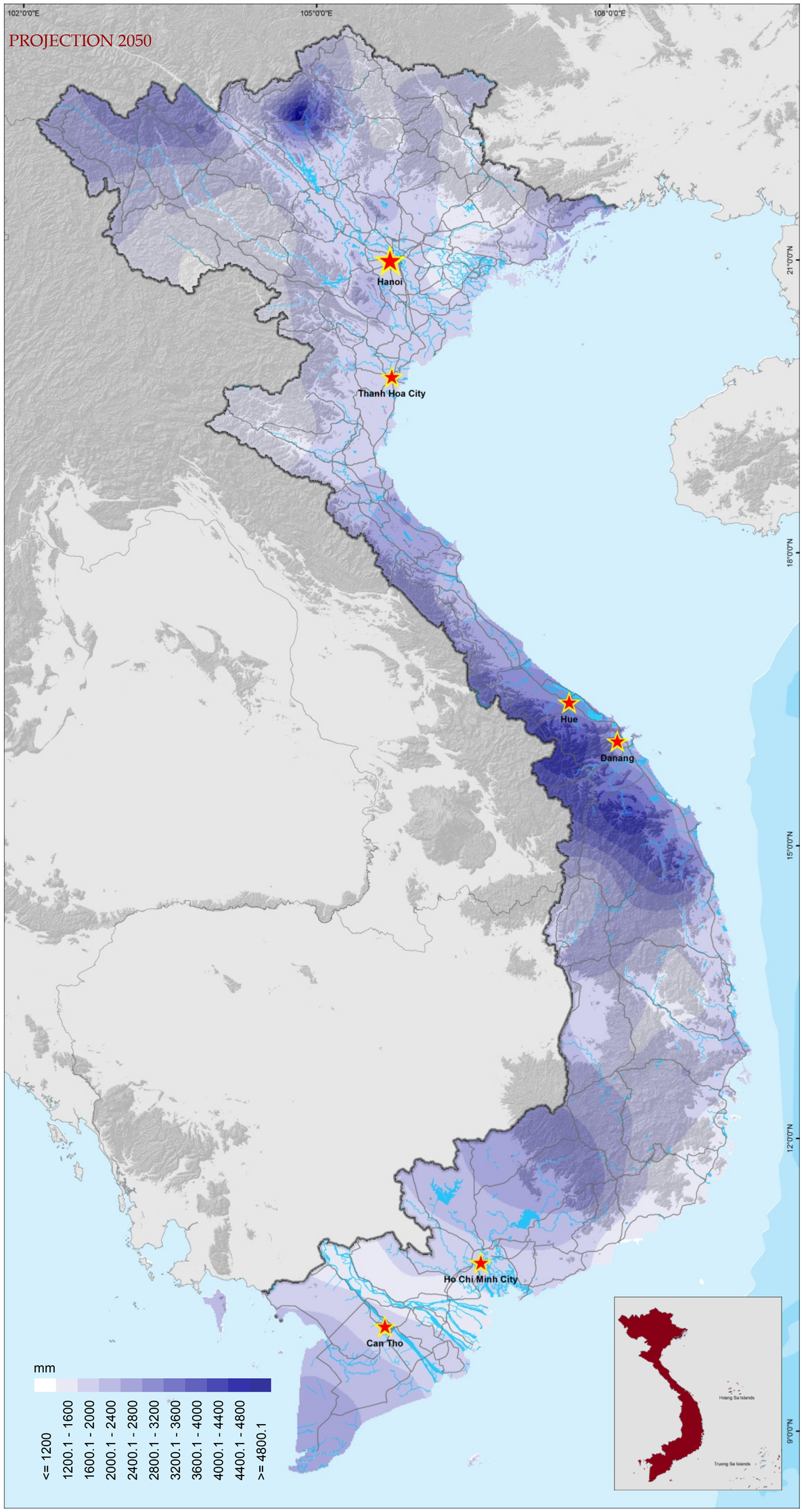


RAINFALL - AVERAGE ANNUAL

BASELINE



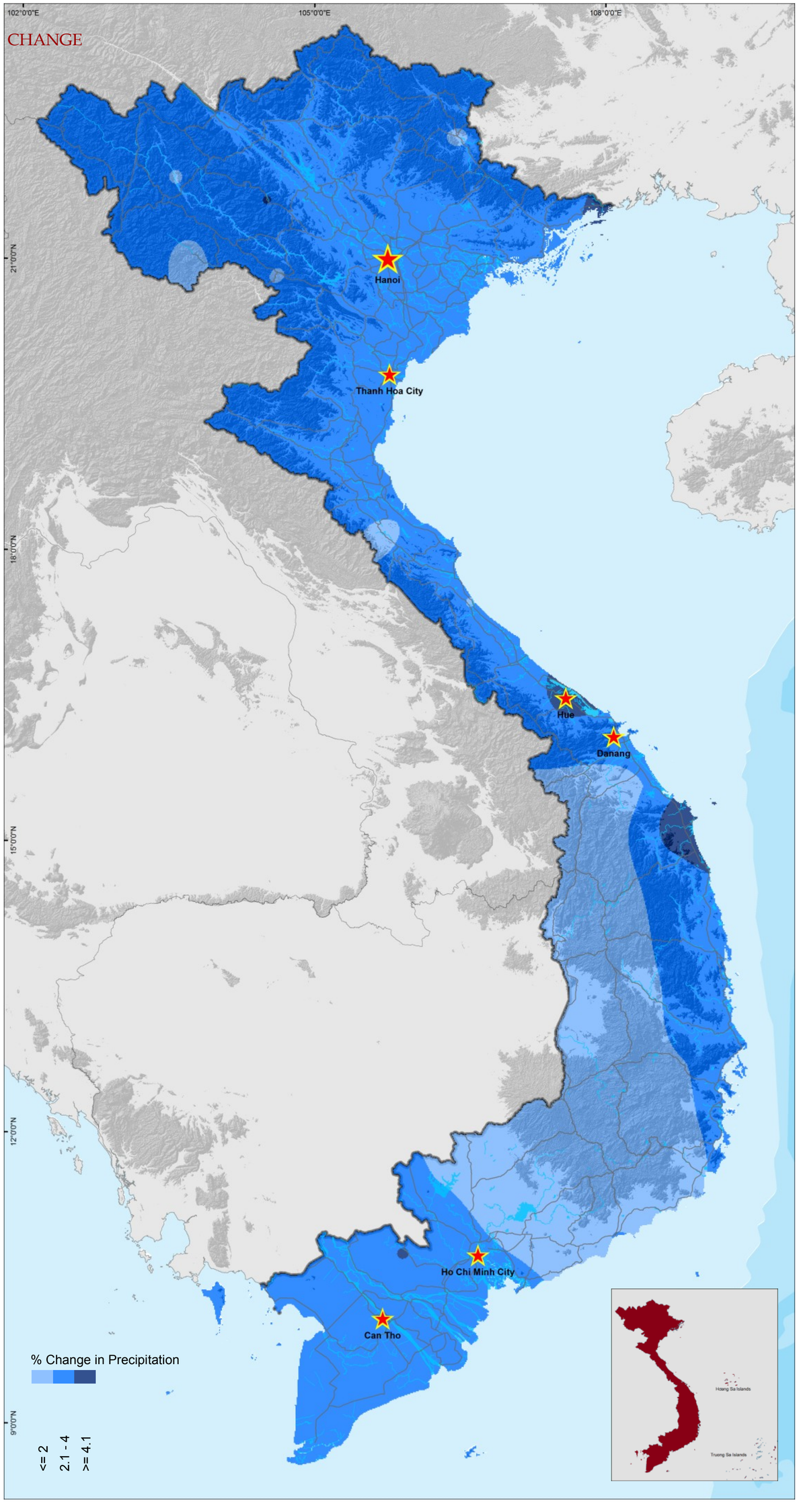
PROJECTION 2050



FUNDING AGENCIES

PARTNERS

COMPANIES



BASELINE

Rainfall in Viet Nam is driven by the complex interaction of two monsoon regimes and a regular cyclone system originating in the East Sea. These factors combine to produce large spatial variability in annual rainfall ranging from 1,000mm to 5,000mm.

The northern region has total annual rainfall ranging from 1000 - 2500mm. Specifically, the Northern Delta received rainfall between 2000 - 2500mm, the Northeast with total annual rainfall ranging from 1000 - 2000mm. The largest rain center is at Bac Quang station in the Northern region with annual rainfall measured up to 5000mm. The Northwest has the total annual rainfall increasing to the North. The rainfall ranges from 1000 - 1500mm in Son La, from 1500 to 200 mm in Dien Bien and from 2000 - 3000mm in Lai Chau. Rainfall in North Central increases to the South. Between Thanh Hoa to Nghe An rainfall ranges from 1500 - 2500mm, from Ha Tinh to Danang, rainfall ranges from 2500 - 4500mm. The largest rain center is in Thua Thien Hue, with the two provinces of Quang Nam, Quang Ngai in South Central also receive high annual rainfall ranging from 3000 - 4500mm. The rest of the South Central, Central Highlands and Southern, the rainfall is recorded in the range of 1000 - 2500mm, however rainfall reaches 3000 mm in some parts of Dak Nong and Lam Dong.

2050 SCENARIO

Distribution patterns for average annual rainfall will remain consistent with the baseline distribution, though average annual rainfall volumes will increase throughout the country. Areas experiencing heavy rainfall (greater than 3,500mm/year) will expand – especially in central coastal areas surrounding Da Nang. In addition, the areas experiencing less than 1,500mm/year **will reduce significantly.**

SUMMARY OF PROJECTED CHANGES

Based on the comparison of the rainfall pattern between two time periods (the baseline and 2050), the Central Highlands is projected to experience the least change (from 0-2%). The majority of the Northern areas will have rainfall increases varying between 4-5%, this represents some of the largest rainfall increases in Viet Nam. In some provinces such as Cao Bang, Bac Kan, Lai Chau, Dien Bien, Son La and Thanh Hoa, rainfall increases from 2-3%. From Ha Tinh to Quang Tri, rainfall increases from 2-3%, of which a small part of Ha Tinh province will have 4-5% rainfall increased. The region including coastal areas of Thua Thien Hue, Quang Nam to Binh Dinh and the Mekong Delta, has the largest rainfall increase from 4-7%.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

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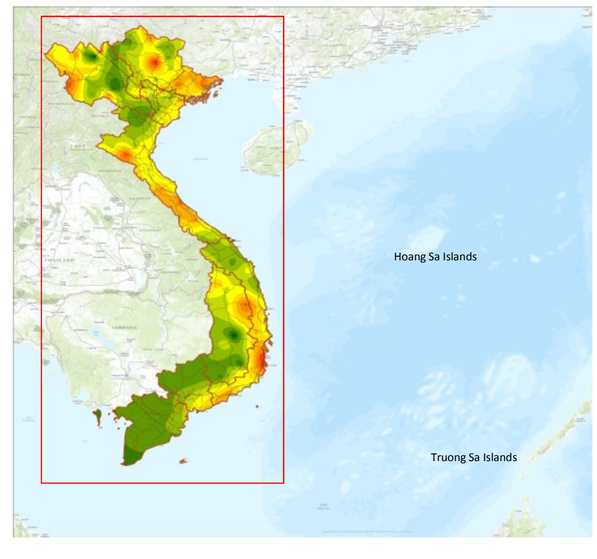
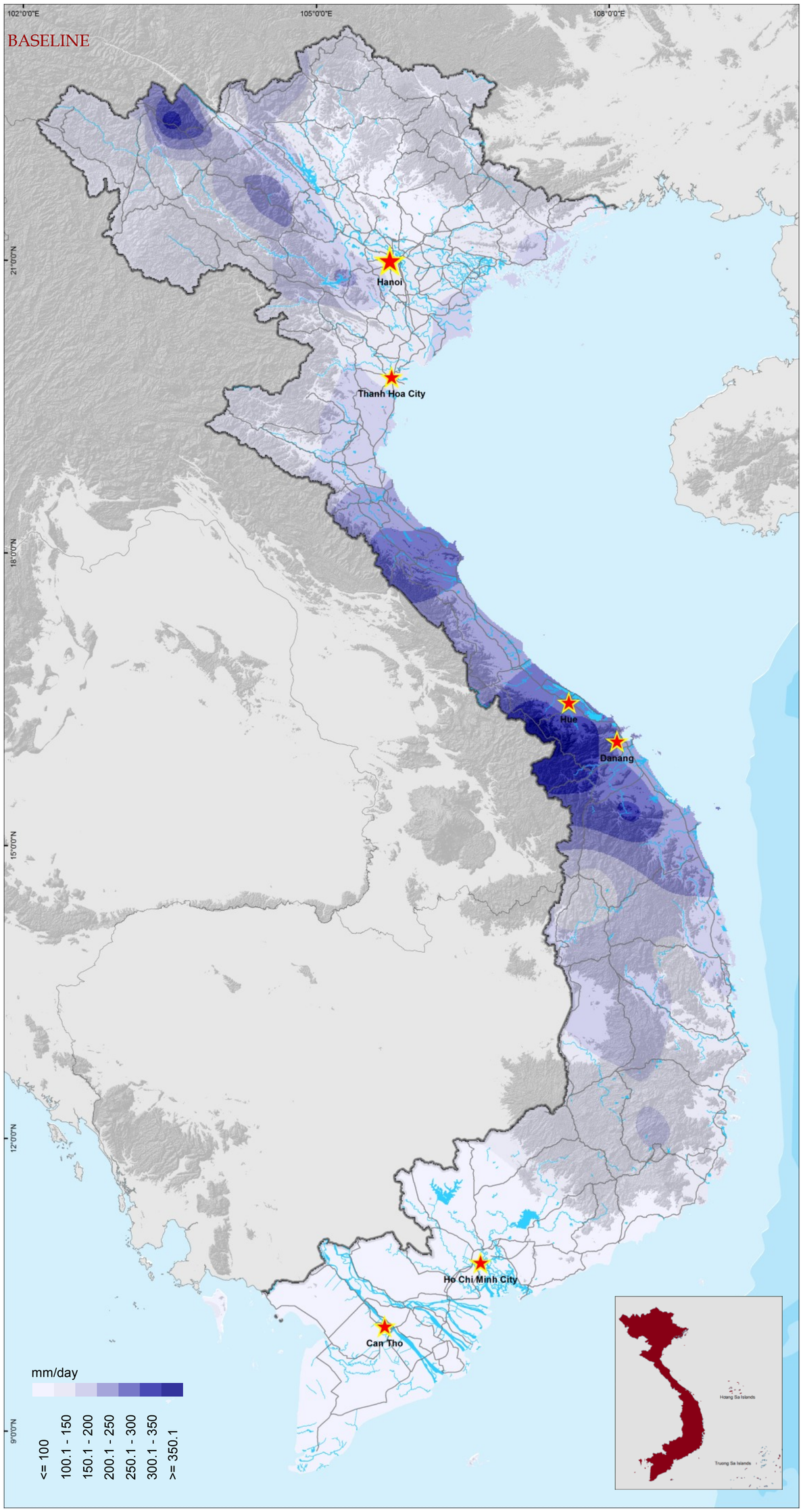
MAP SCALE - 1: 3,000,000

INDEX MAP

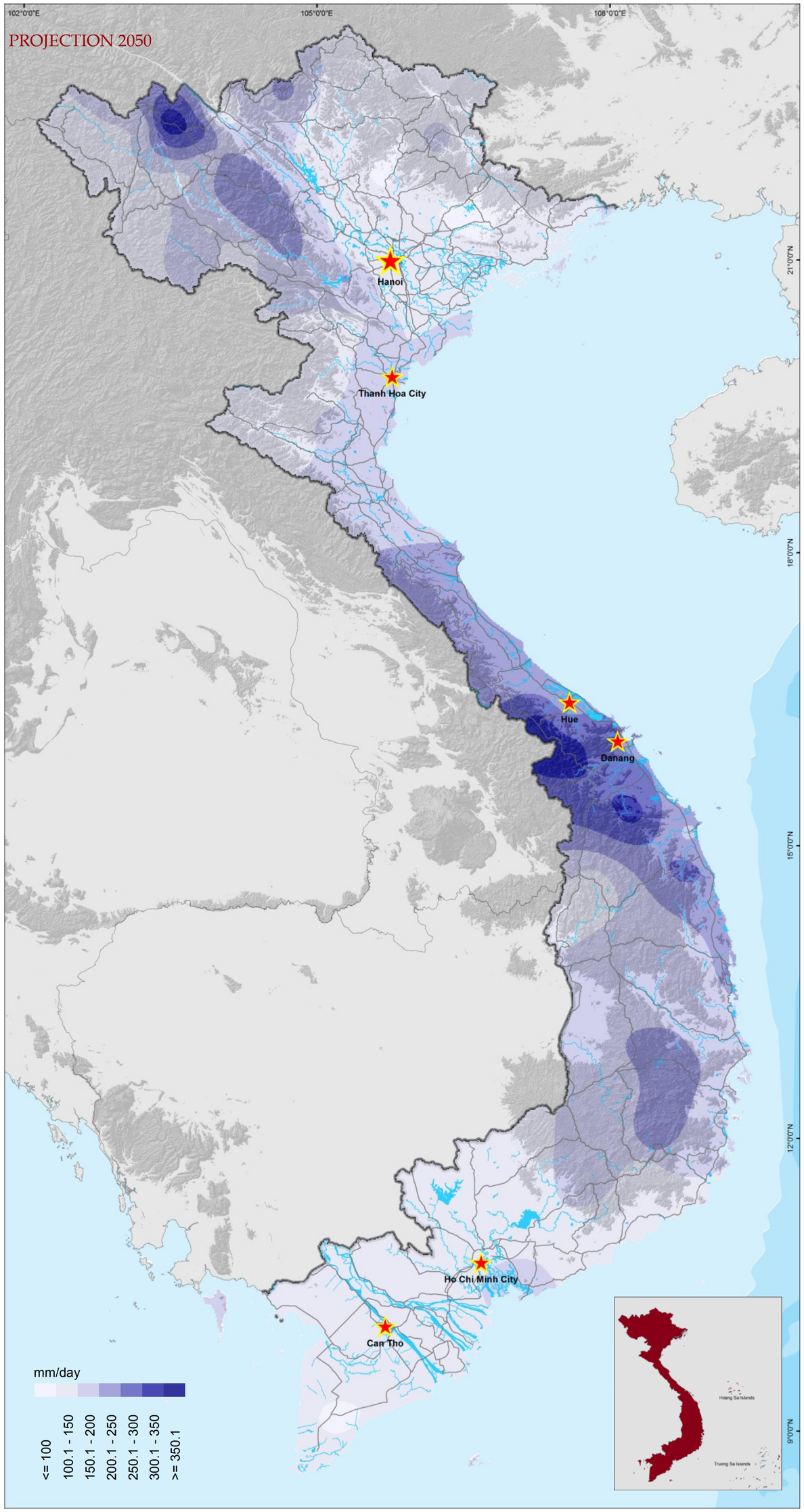


RAINFALL - DAILY MAXIMUM ANNUAL

BASELINE



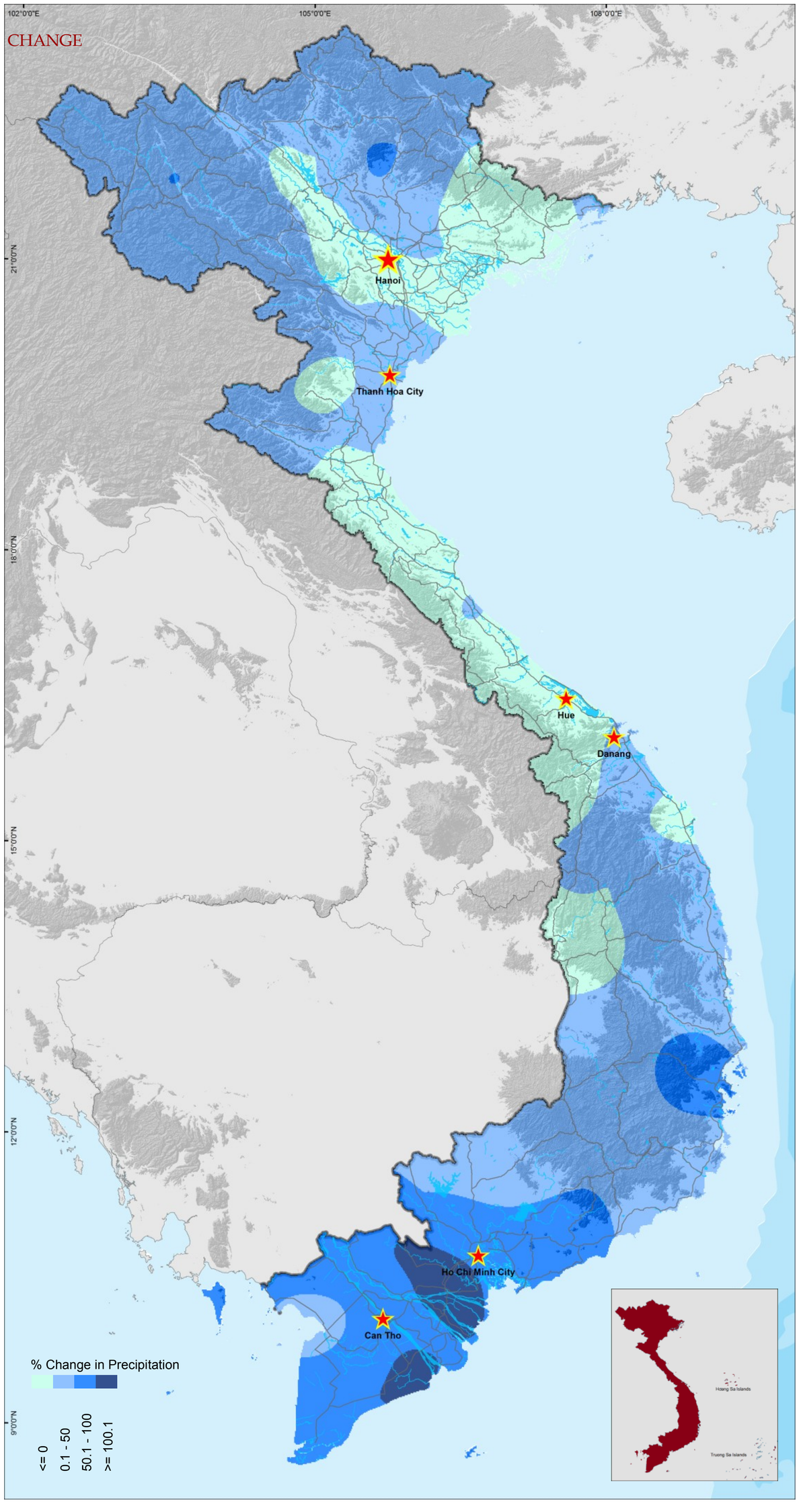
PROJECTION 2050



FUNDING AGENCIES

PARTNERS

COMPANIES



BASELINE

The spatial distribution of peak daily rainfall matches that of average annual rainfall with the highest totals of 200 to 400 mm / day mainly in the area from Ha Tinh to Quang Nam. In particular, the highest rainfall per day mainly concentrates in the area of Thua Thien Hue - Quang Nam. These high peak daily rainfall levels reflect the concentration of cyclone activity in central Viet Nam with the majority of cyclones and tropical storms making land fall in this region.

Most of northern Viet Nam experiences lower peak daily rainfall totals in the order of 100 – 200 mm with similar levels in the South Central region and Central Highlands. The Mekong Delta of Southern Vietnam with its flat terrain experiences some of the lowest levels of peak rainfall in the country.

2050 SCENARIO

By 2050, peak rainfall will increase throughout most of Viet Nam. Hot spots for peak rainfall (>200mm/day) in Central coastal areas will expand with Thua Thien Hue - Quang Nam remaining the area of most intensive rainfall. In addition, the areas experiencing daily peak rainfall of more than 100mm/day is projected to expand and cover most of the country.

SUMMARY OF PROJECTED CHANGES

By 2050, peak rainfall is expected to increase throughout the country but the distribution of increases means that it will also become more uniform. High rainfall areas in the central coast areas of Viet Nam will experience the smallest increases though they will still remain as areas of the highest totals. The biggest increases are projected for the Mekong and northern mountainous area where peak daily rainfall values will increase by more than 50%, and especially in the Sai Gon delta area where increases will amount to more than 100%.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

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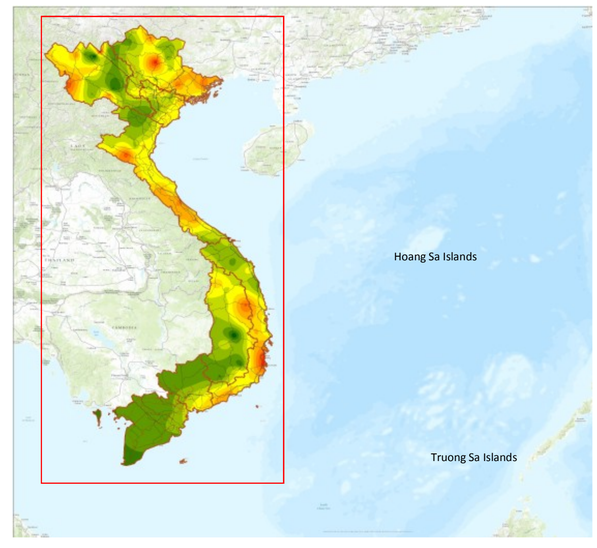
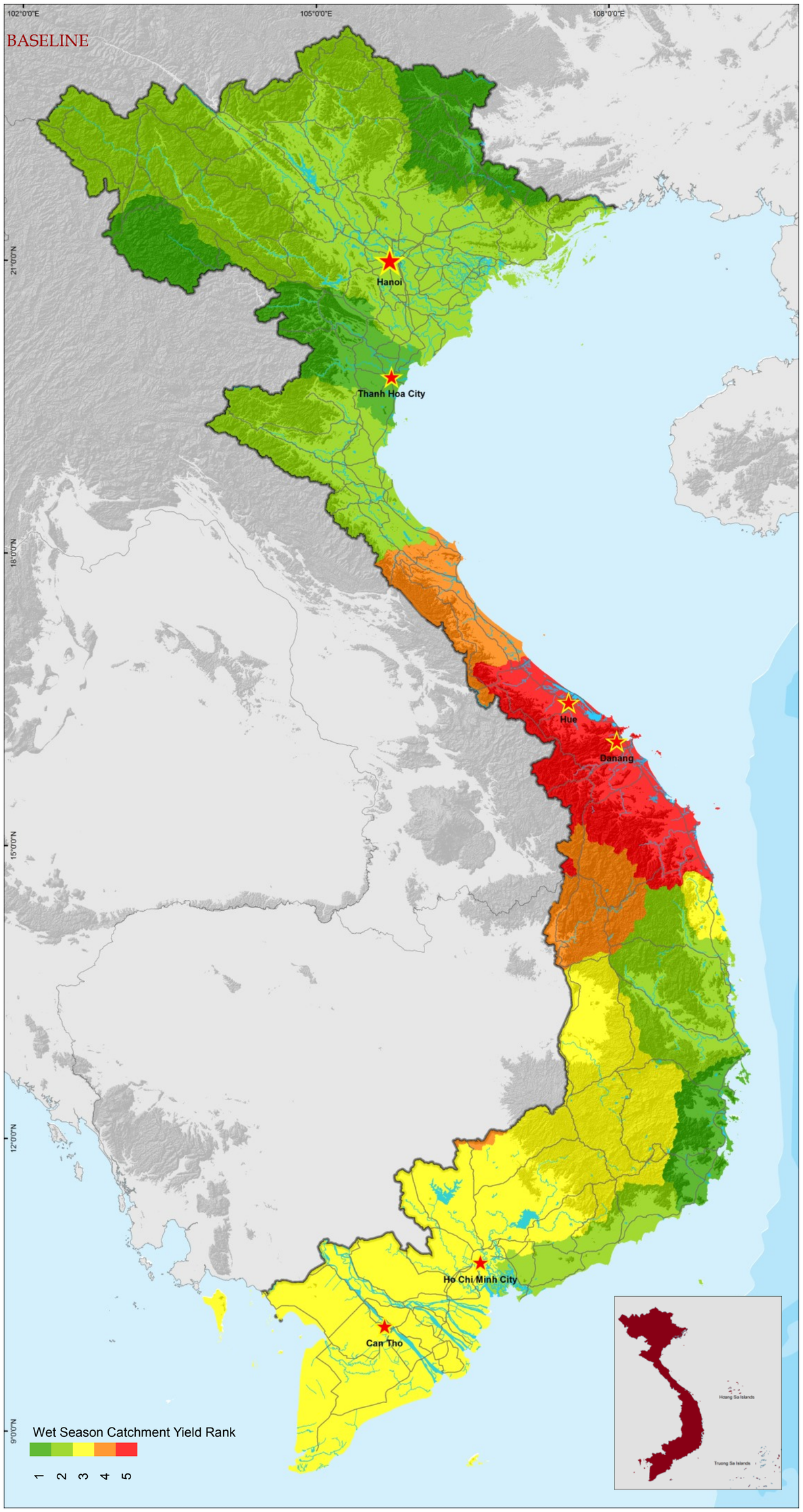
MAP SCALE - 1: 3,000,000

INDEX MAP

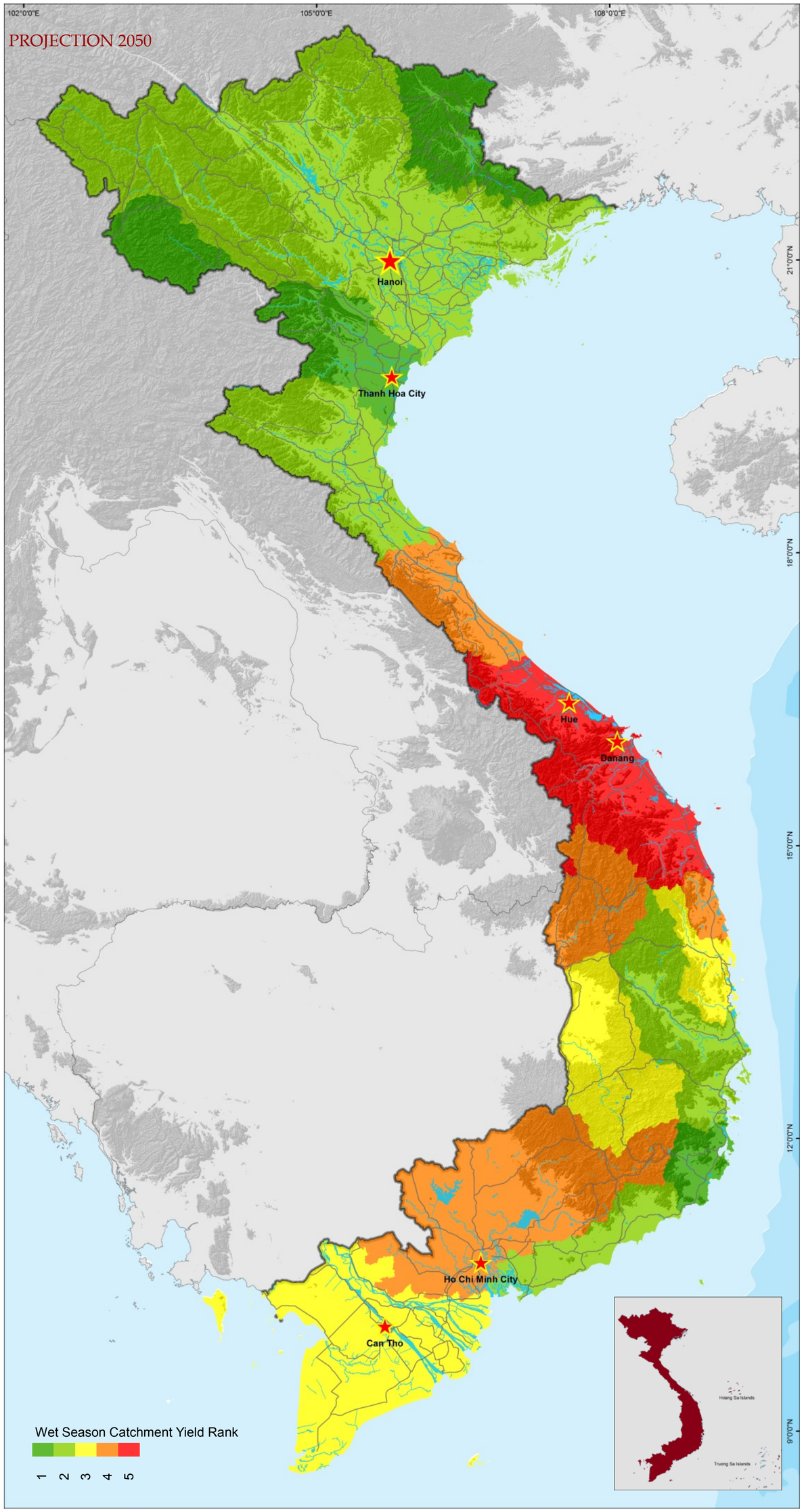


FLOOD RISK

BASELINE



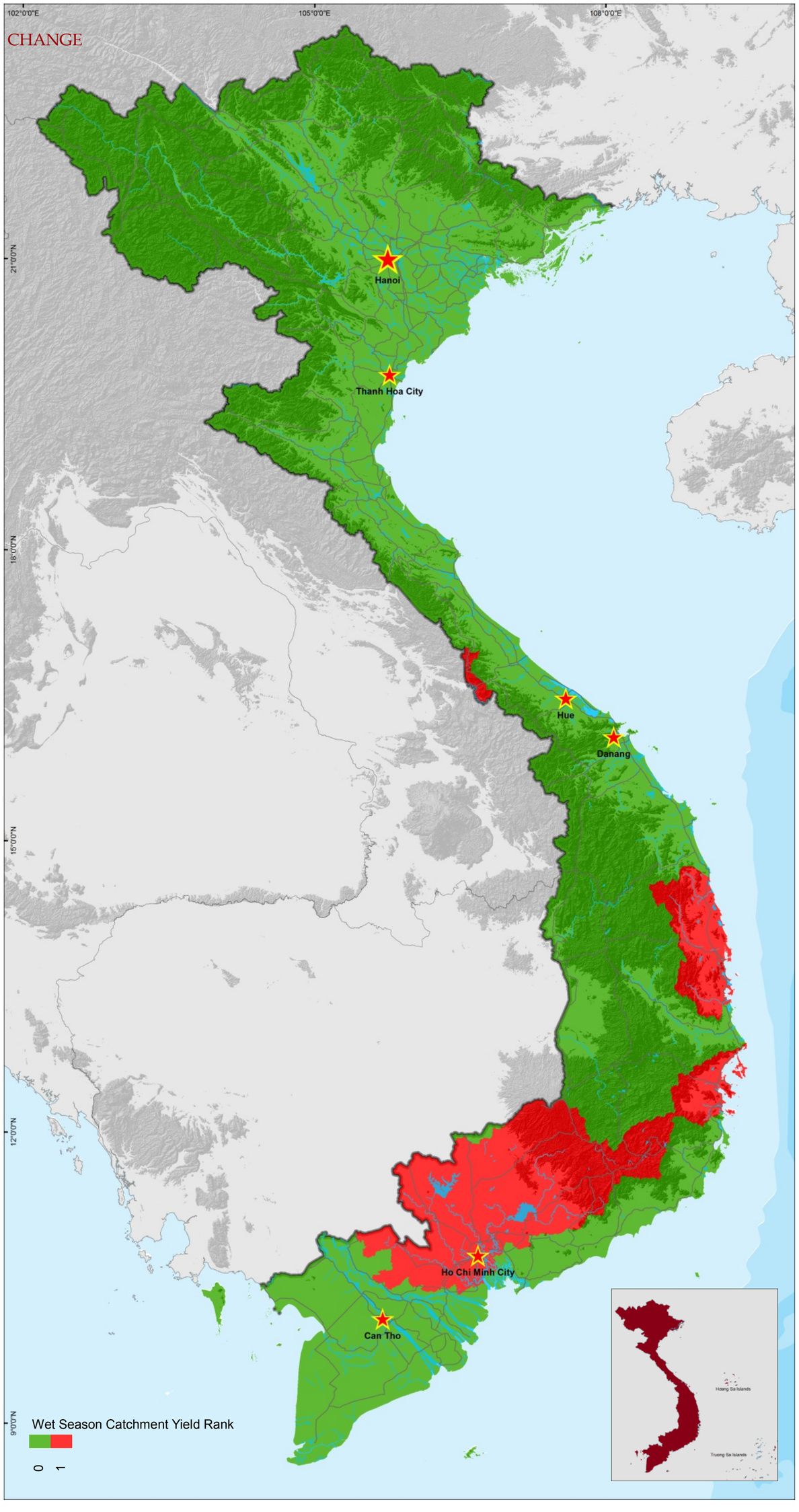
PROJECTION 2050



FUNDING AGENCIES

PARTNERS

COMPANIES



BASELINE

This indicator is intended to link the climate parameter of rainfall, for which national level projections were available, to the risk of flooding at a national scale. The assessment uses the total water yield of each catchment within Viet Nam as a proxy for riverine flooding.

To determine the wet season basin yield, Viet Nam was split into 25 major river basins, using official boundaries from the National Atlas of Viet Nam. The basin area influences the time that it takes for water to drain through the upper to the lower reaches of the basin. Therefore, it gives a good indication of ranking of priorities at this level of geographical scope. For each basin, the baseline and 2050 total average maximum wet season rainfall from June to November was calculated using IMHEN's climate modelling results.

The worst effected regions for the risk of flooding include the central coastal provinces (Thua Thien Hue, Da Nang, Quang Nam). This is because the central basins are small, short and steep catchments that are annually impacted by many tropical storms. Relative to the central regions of Viet Nam, the Mekong Delta has a medium flood risk whilst the North West, North East and Red River Delta face a low risk.

2050 SCENARIO

The projected wet season catchment yield parameter indicates an increase in flood risk in the south east and south central highlands. This includes the Dong Nai, Song Con and Song Ve river basins. The relative level of risk for all other basins in the country remains unchanged, although the total water yield in the wet season is projected to increase for all basins.

SUMMARY OF PROJECTED CHANGES

The level of risk of flooding in Dong Nai, Song Con and Song Ve Basins will increase due to a projected increase in rainfall in these regions.

Of the three basins, the most significant impact from this changing flood risk is likely to be felt in the Dong Nai basin, which is the second largest in the country. It has a large urban and rural population, including the major center of Ho Chi Minh City, many industrial centers and important infrastructure links.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

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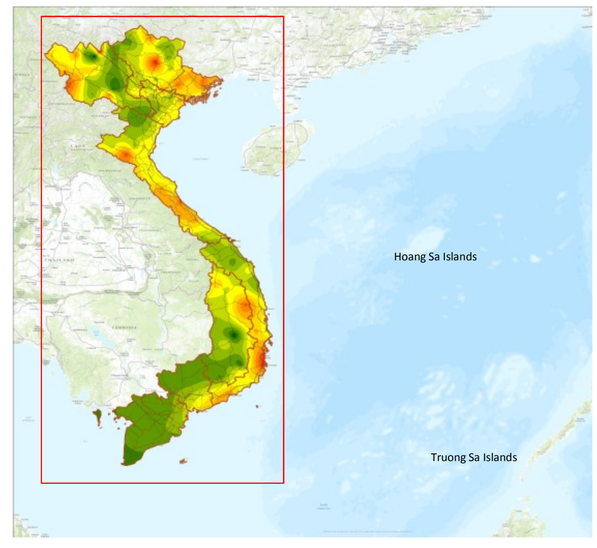
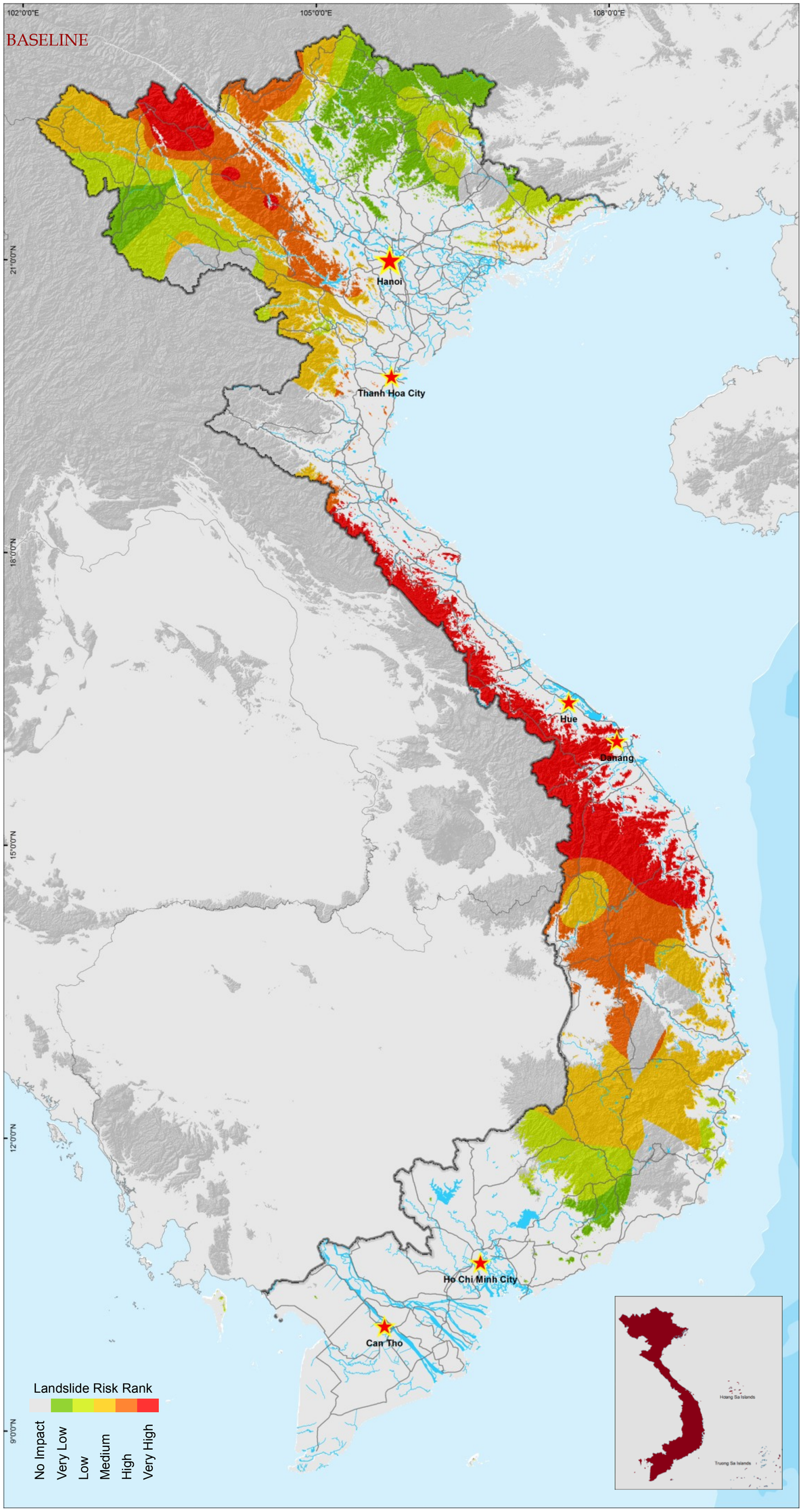
MAP SCALE - 1: 3,000,000

INDEX MAP



LANDSLIDE RISK

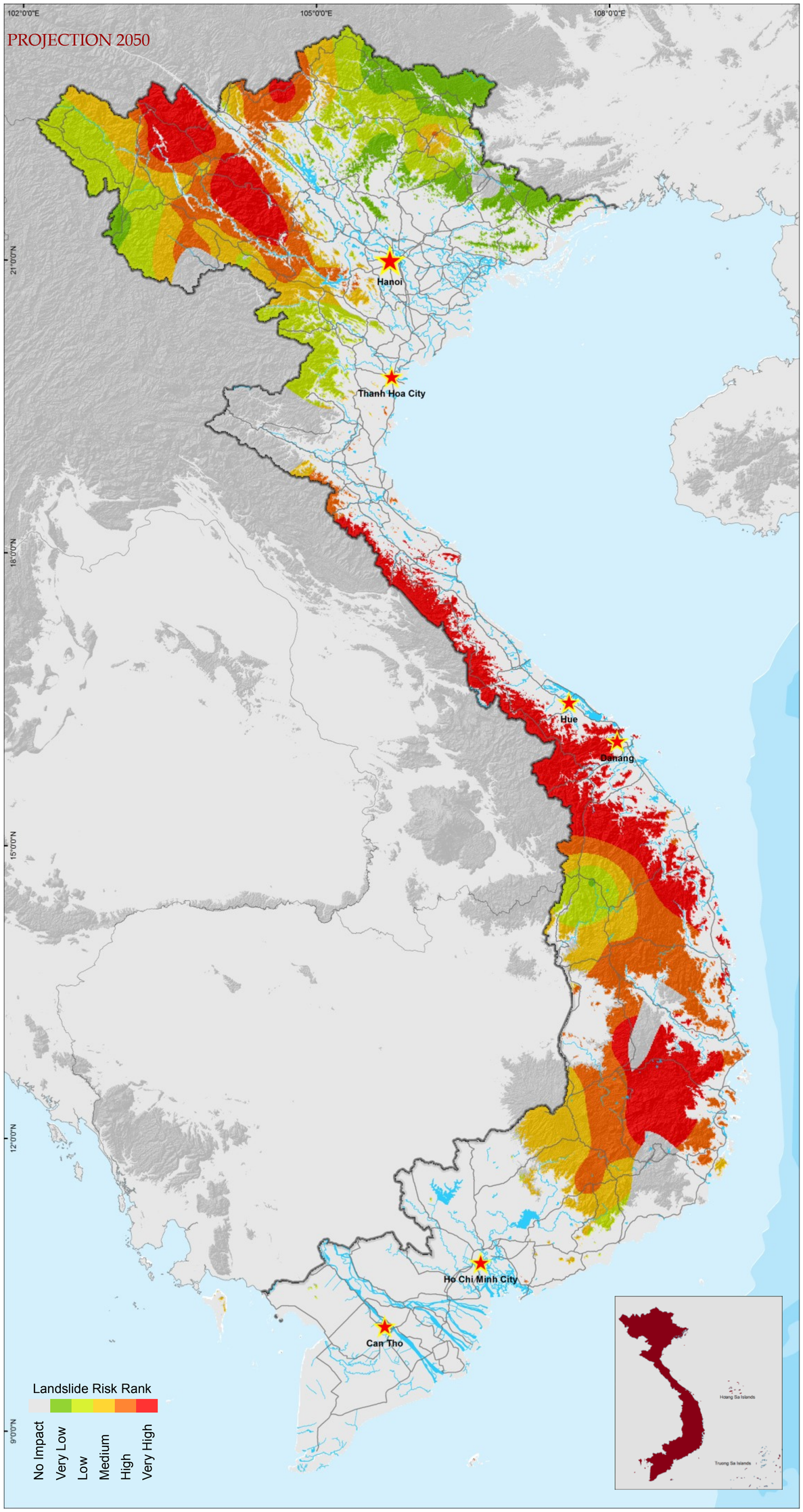


BASELINE

Projections for potential landslide exposure show some changes. The West Central highlands will experience a decrease in landslide risk whilst the south central highlands show an increase from medium potential to high and very high potential.

The conditions in Mekong delta are unchanged with no potential for landslides.

In the northern west regions there are pockets of increased potential of landslides. This includes Son La, Yen Bai and Phu Tho. In the north central highlands Nghe An shows decrease in potential for landslide.



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Projections for potential landslide exposure show some changes. The West Central highlands will experience a decrease in landslide risk whilst the south central highlands show an increase from medium potential to high and very high potential.

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In the northern west regions there are pockets of increased potential of landslides. This includes Son La, Yen Bai and Phu Tho. In the North Central highlands Nghe An shows a decrease in potential for landslide.

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GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

MAP SCALE - 1: 3,000,000

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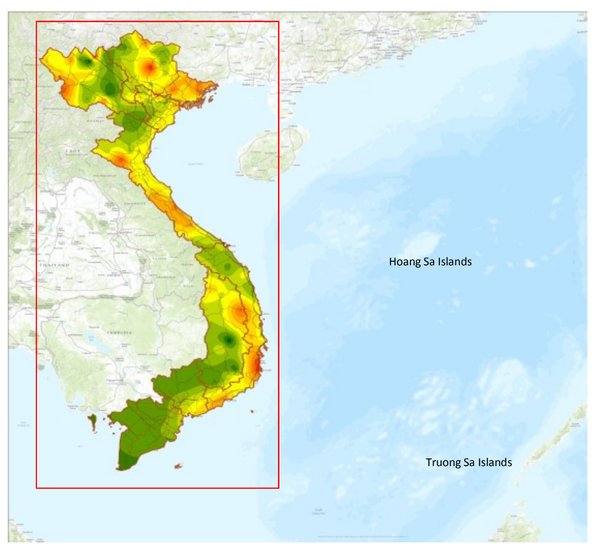
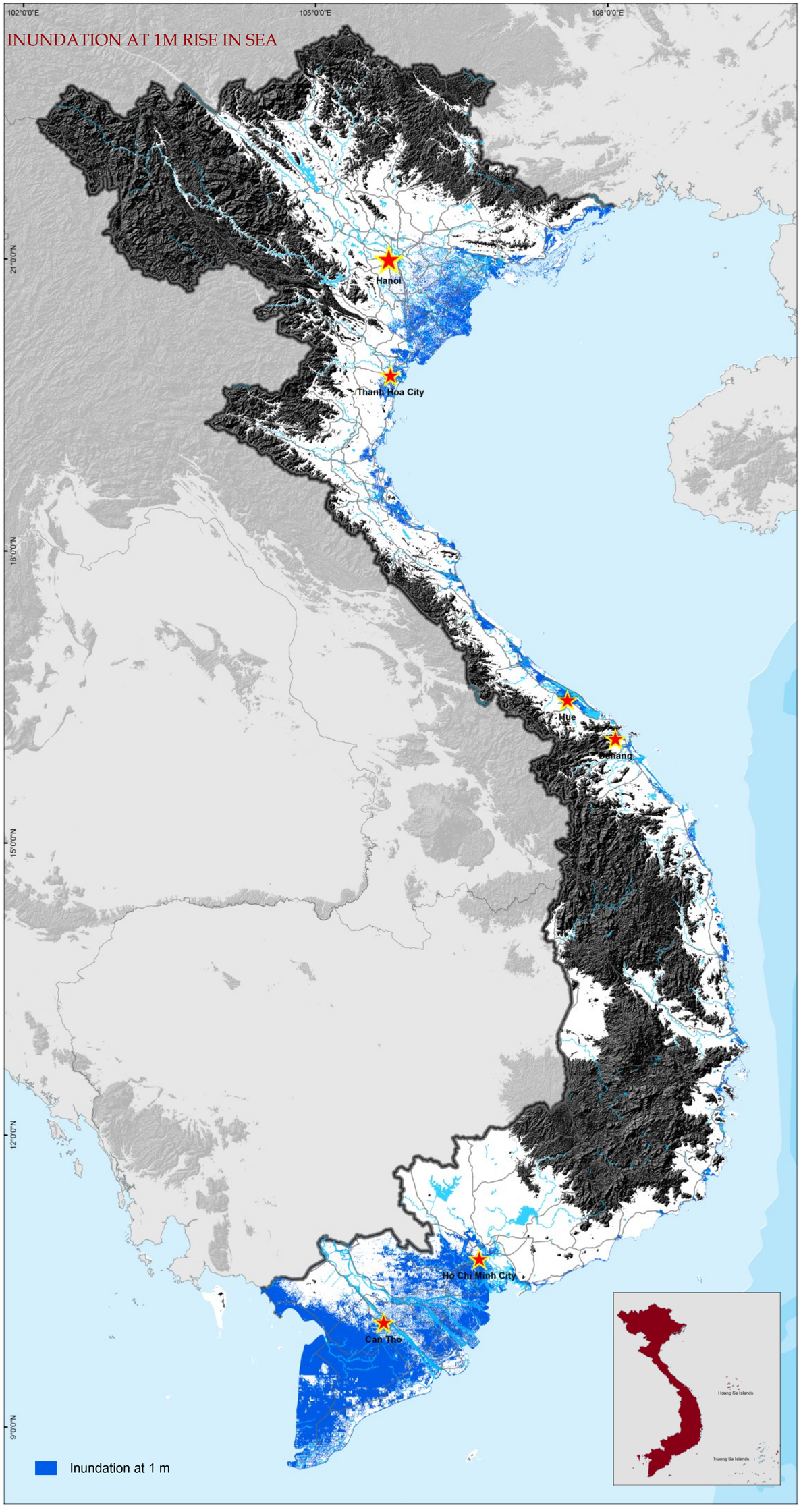


SEA LEVEL RISE & STORMS



INUNDATION AT 1M RISE IN SEA LEVEL

1) Baseline time period

Methods on data sources to make climate change, sea level rise scenarios for Vietnam are adopted from previous researches and had been updated by the year of 2010. 1980-1999 is selected as the baseline period to compare changes of sea level rise.

In Vietnam, observed data from Tidal gauges in coastal regions of Vietnam shows difference in changing trends of average sea level. Most gauges indicate an increasing trend, while some of them do not. The average rate of sea level rise in coastal regions of Vietnam is approximately 2.8mm/year. Data of sea levels from satellites in the period of 1993-2010 demonstrates that the rate of sea level rise in the whole area of East Sea is 4.7mm/year; the rise tends to happen faster in the Eastern part of the sea than the West, which is relatively much lesser in extent. Along the coast of Vietnam, the trend is higher in Mid-central and South West seas. The Sea level rise estimations are almost similar between in-situ data based approach and satellite data based approach. The compared result shows high similarity of phase and oscillation amplitude of average sea level as well as correlation among the levels.

The methods applied to establish sea level rise scenarios consist of the following: Statistical down-scaling elaboration methods (MAGICC, SIMCLIM, SLRPP) and application of numerical modeling results. Plenty of numerical models were developed to create sea level rise scenarios, utilizing the combination between climate models and ocean models for different greenhouse gas emission scenarios. Generally, when sea level rise scenarios are set up for small regions, local factors are normally used in international researches, such as speed of sea level change in the past and geological shift in the regions so that sea level rise scenarios at global scale can be edited from statistical methods or numerical models.

Maps for inundation risk which is based on sea level rise are created to address risk regions which are directly affected by the rise. The methodology involves raising sea surface by a selected value which is related to a specific sea level in a scenario.

2) Scenarios time period

Greenhouse gas emission scenarios selected to build up sea level rise scenario for Vietnam are the low emission scenario (B1), medium emission scenario of medium emission scenarios group (B2) and high emission scenario of high emission scenarios group (A1FI). Sea level rise scenarios are made for seven coastal regions in Vietnam including: (1) Coastal area from Mong Cai to Hon Dau; (2) From Hon Dau to Ngang Pass; (3) From Ngang Pass to Hai Van Pass; (4) From Hai Van Pass to Dai Lanh Cape; (5) From Dai Lanh Cape to Ke Ga Cape; (6) From Ke Ga Cape to Ca Mau Cape; and (7) From Ca Mau Cape to Ha Tien.

- According to low emission scenario (B1): By 2050, the average sea level rise is from 18 to 25cm in the whole Vietnam. By the end of 21st century, the highest sea level rise happens in the area from Ca Mau to Kien Giang, which is around 54-72cm; lowest rise happens from Mong Cai to Hon Dau, which is from 42 to 57cm. The average sea level rise in Vietnam is from 49 to 64cm.

- According to medium emission scenario (B2): By mid of 21st century, the average sea level rise is from 24 to 27cm in the whole Vietnam. By the end of 21st century, the highest sea level rise happens in the area from Ca Mau to Kien Giang, which is around 62-82cm; lowest rise happens from Mong Cai to Hon Dau, which is from 49 to 64cm. The average sea level rise in Vietnam is from 57 to 73cm.

- According to high emission scenario (A1FI): By mid of 21st century, the average sea level rise is from 26 to 29cm in the whole Vietnam. By the end of 21st century, the highest sea level rise happens in the area from Ca Mau to Kien Giang, which is around 85-105cm; lowest rise happens from Mong Cai to Hon Dau, which is from 66 to 85cm. The average sea level rise in Vietnam is from 78 to 95cm.

3) Changes

The result of demonstrating risk regions flooded by sea level rise shows that: If the sea level rises 1m, about 39% of Mekong Delta area, over 10% of Red River Delta and Quang Ninh, over 2.5% of area of coastal central provinces are in the risk of being flooded. 20% of Ho Chi Minh City area is in the same risk as well.

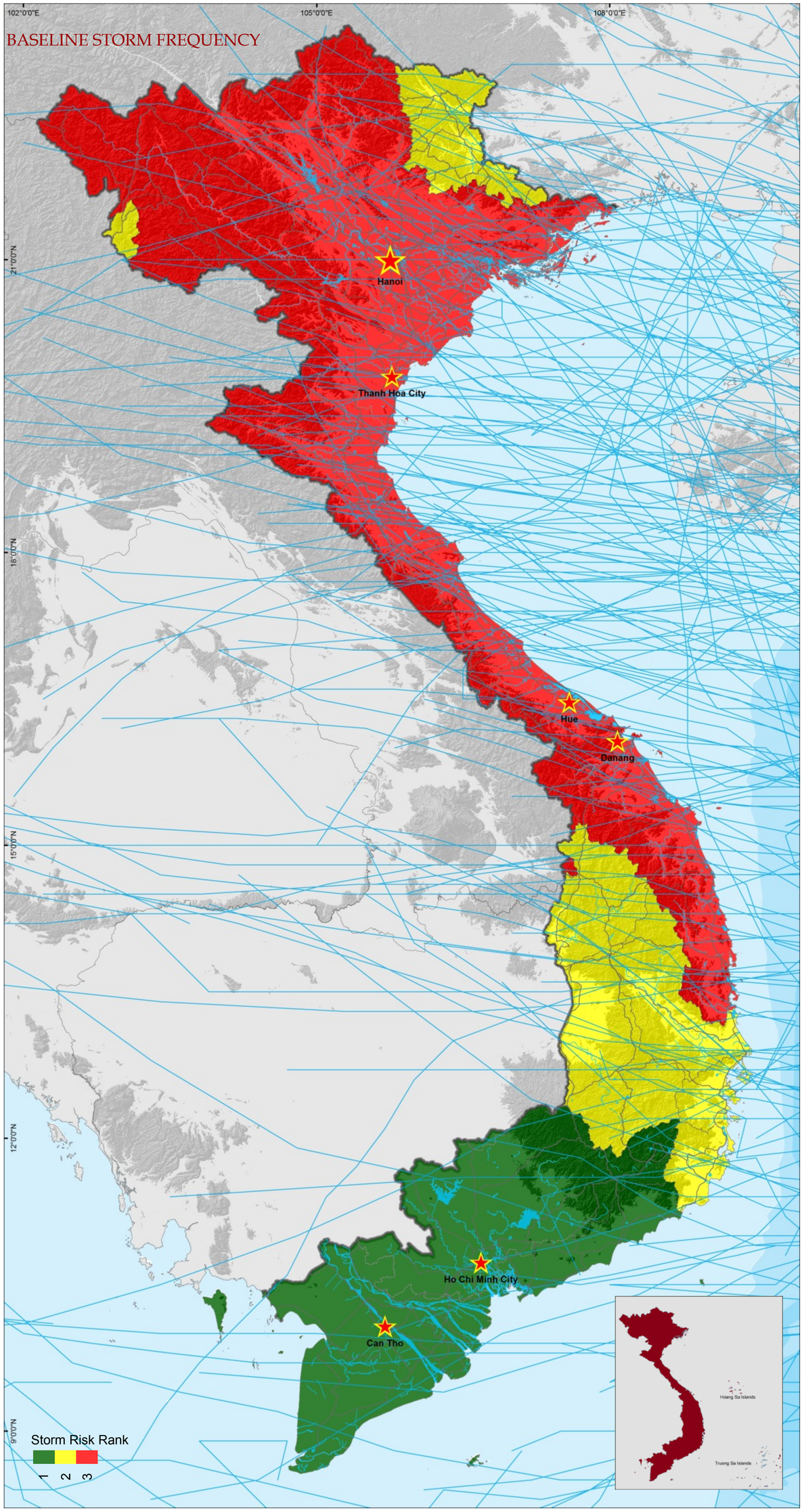
The calculated result based on database on transportation released by Map Published in 2005 indicates that if the sea level rise happens at 1m, 4% of railways, 9% of national highways and 12% of provincial roads will be affected around the country. In Mekong Delta area, the transportation system will be the most affected including 28% of national highways and 27% of provincial roads. In the coastal central, 4% of national highways, 5% of provincial roads and over 4% of railways will be influenced. In Red River Delta only, 5% of national highways, over 6% of provincial roads and nearly 4% of railways will be flooded.

According to population data from General Statistics Office in 2010, if the sea level rise is 1m, almost 35% of population in provinces of Mekong Delta, over 9% of population in Red River Delta and Quang Binh will be directly affected, 7% of Ho Chi Minh city only and 9% of population in coastal provinces in the Central will be influenced as well

Vietnam is located in the typhoon centre of the South China Sea (GTZ, 2003) and is therefore impacted four to six times a year by tropical storms. The storm season is typically between July and December, with a greater frequency during the rainy season of August to October.

The baseline storm frequency map was developed by analyzing nearly sixty years of UN OCHA (2012) storm tracking data, and relatively ranking the incidence of storms for each province. The map shows that storms mostly cross into the northern and central regions of the country, therefore increasing the potential climate threat. This includes many heavily populated coastal centers and the capital, Hanoi. The southern regions of Vietnam are relatively less impacted.

Best global estimates suggest that average cyclone strength will increase by an order of 10% due to climate change, and that the increase of the proportion of Category 4-5 cyclones will be even greater. Increasing cyclone intensities could compound projected increases in precipitation for Vietnam. This will increase the variability in rainfall throughout the high risk areas of the country, potentially leading to greater incidence and severity of flash floods, hill slope erosion rates and downstream flooding. Storms in Vietnam also bring potentially damaging high winds and storm surge, leading to significant coastal inundation.



STORMS

Vietnam is located in the typhoon center of the South China Sea (GTZ, 2003) and is therefore impacted four to six times a year by tropical storms. The storm season is typically between July and December, with a greater frequency during the rainy season of August to October.

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DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

MAP SCALE - 1: 3,000,000

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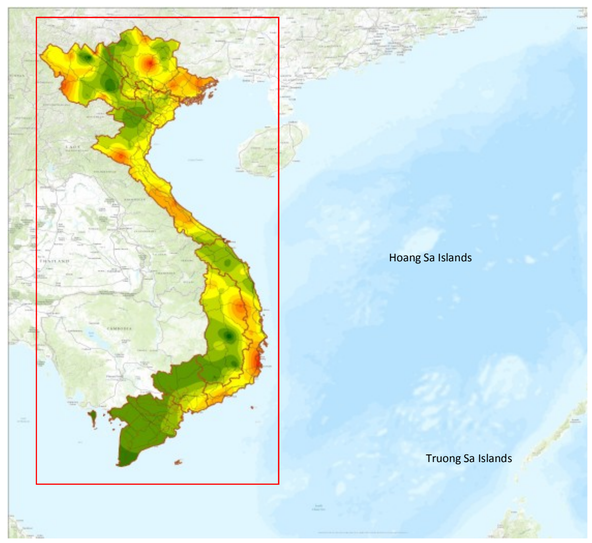
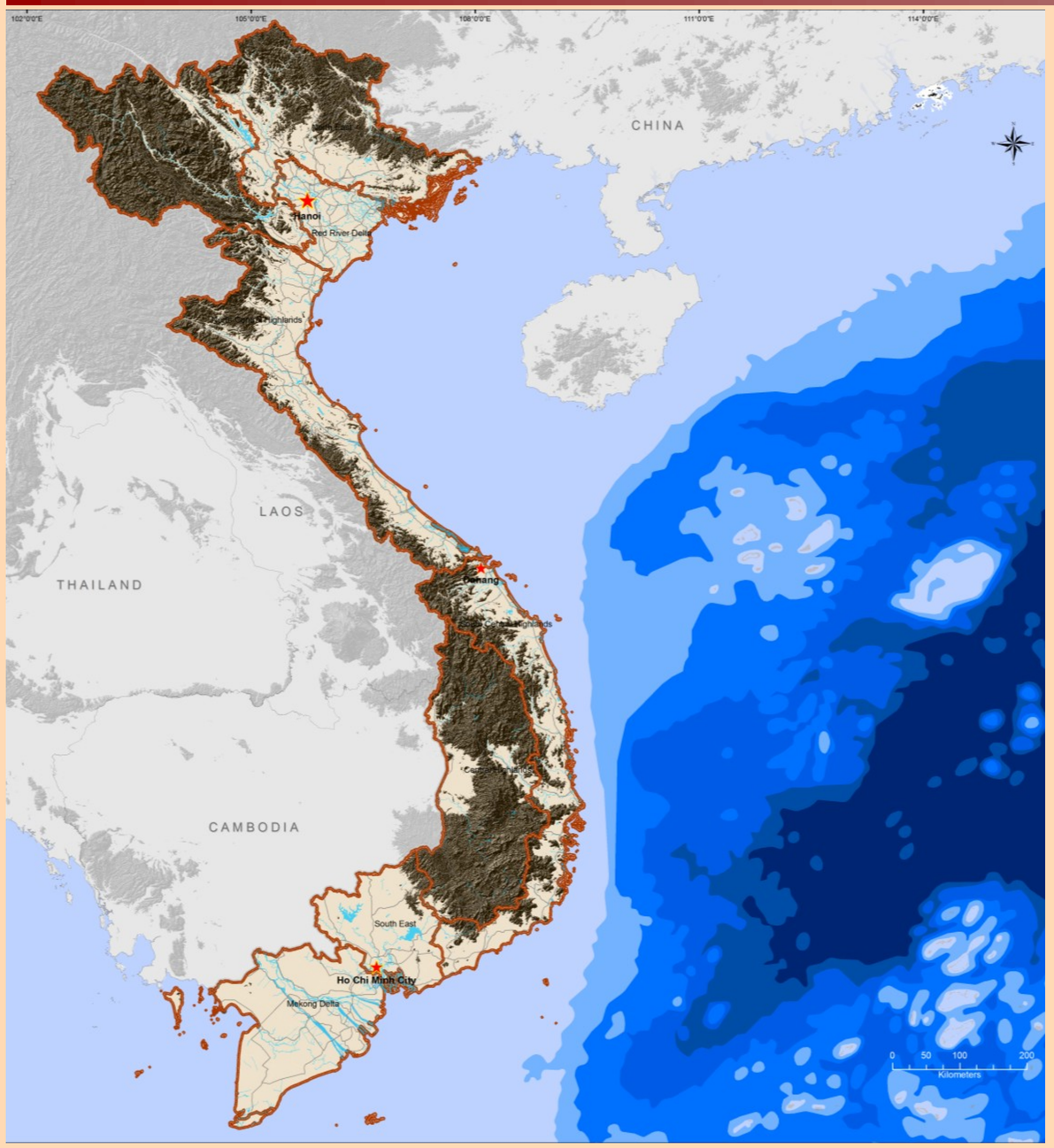


EPILOGUE



Authors	Arun Parameswaran, John Sawdon, Jorma Koponen, Nguyen Kim Dung, Mai Ky Vinh, Nguyen Phuong Hien, Dinh Thi Thanh Binh, Vu Phuong Nam
Government partners	MOIT ISEA – Industrial Safety & Environment Agency (EA), Dept. Environment MOT (IA), MONRE ICD (IA), Thanh Hoa DONRE (IA), Da Nang DOIT (IA), Ho Chi Minh City DONRE (IA)
Technical partners	Dept. of Environment (MOT), IMHEN - Institute of Metrology, Hydrology & Environment, TDSI – Transport Design & Strategy Institute, Dept. of Transport Thanh Hoa. Dept. of Transport Da Nang, Institute of Transport Planning and Management (University of Transport and Communication)
Produced by	*ADB TA-7779 VIE Support for the National Target Program with a focus on energy and transport*
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More information	www.niras.de | www.icem.com.au
Image	Cover image: Provincial Road 507, Thanh Hoa, Viet Nam. (photo credit: Mai Ky Vinh & Nguyen Kim Dung)
Project Team	Kim Harboe (Team Leader), David von Hippel, Arun Parameswaran, John Sawdon, Jorma Koponen, Kapil Chaudhery, Shahab Qureshi, Lawrie Wilson, Ha Dang Son (Deputy Team Leader), Dinh Thanh Binh, Nguye Duc Cuong, Nguyen Kim Dung, Mai Ky Vinh, Nguyen Quoc Khanh, Le Thi Huong, Nguyen Van Tuan, Vu Phuong Nam, Truong Quang Hoc, Ha Minh Khanh

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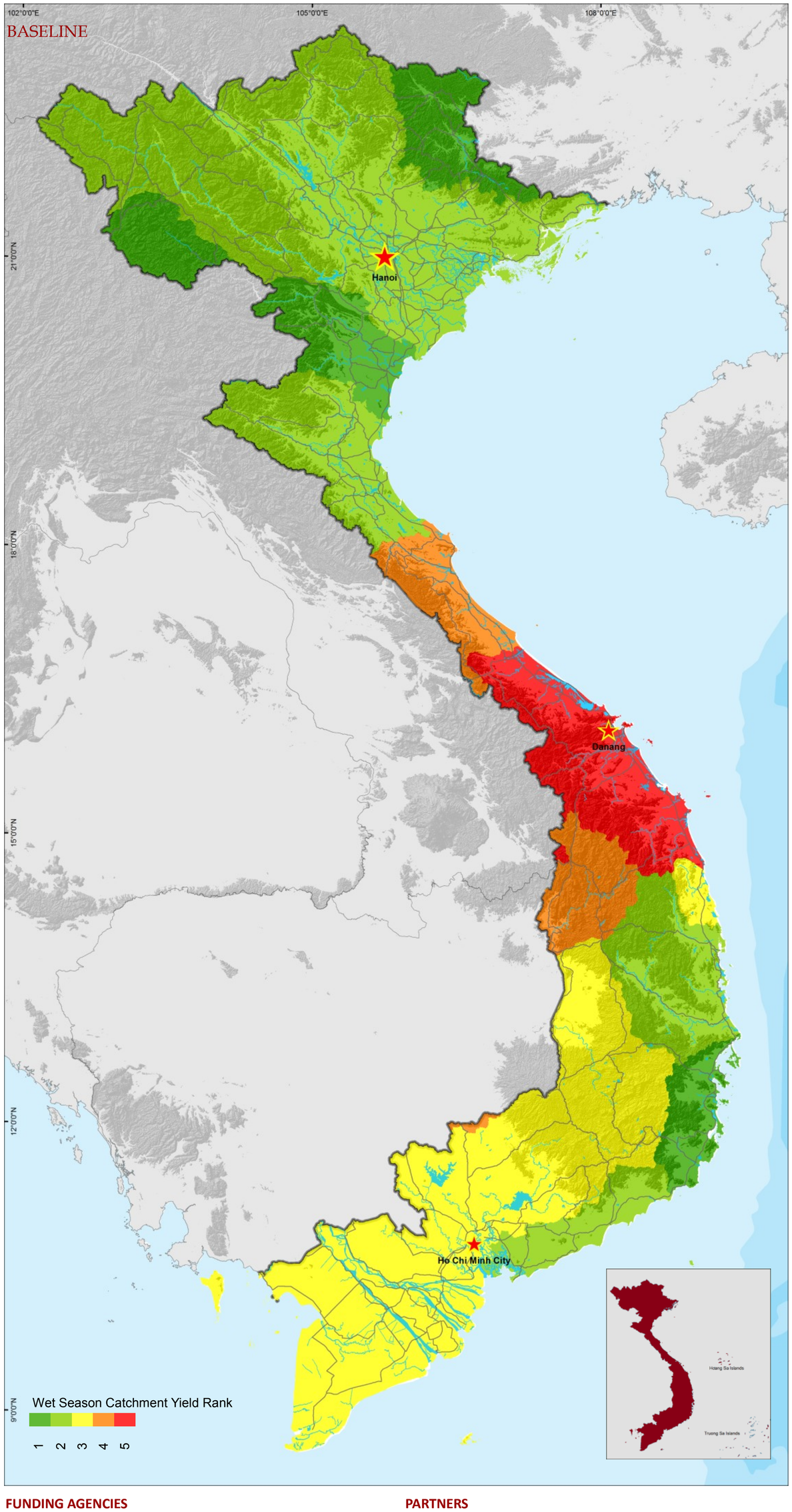
FUNDING AGENCIES

PARTNERS

COMPANIES

REGIONAL - ENERGY

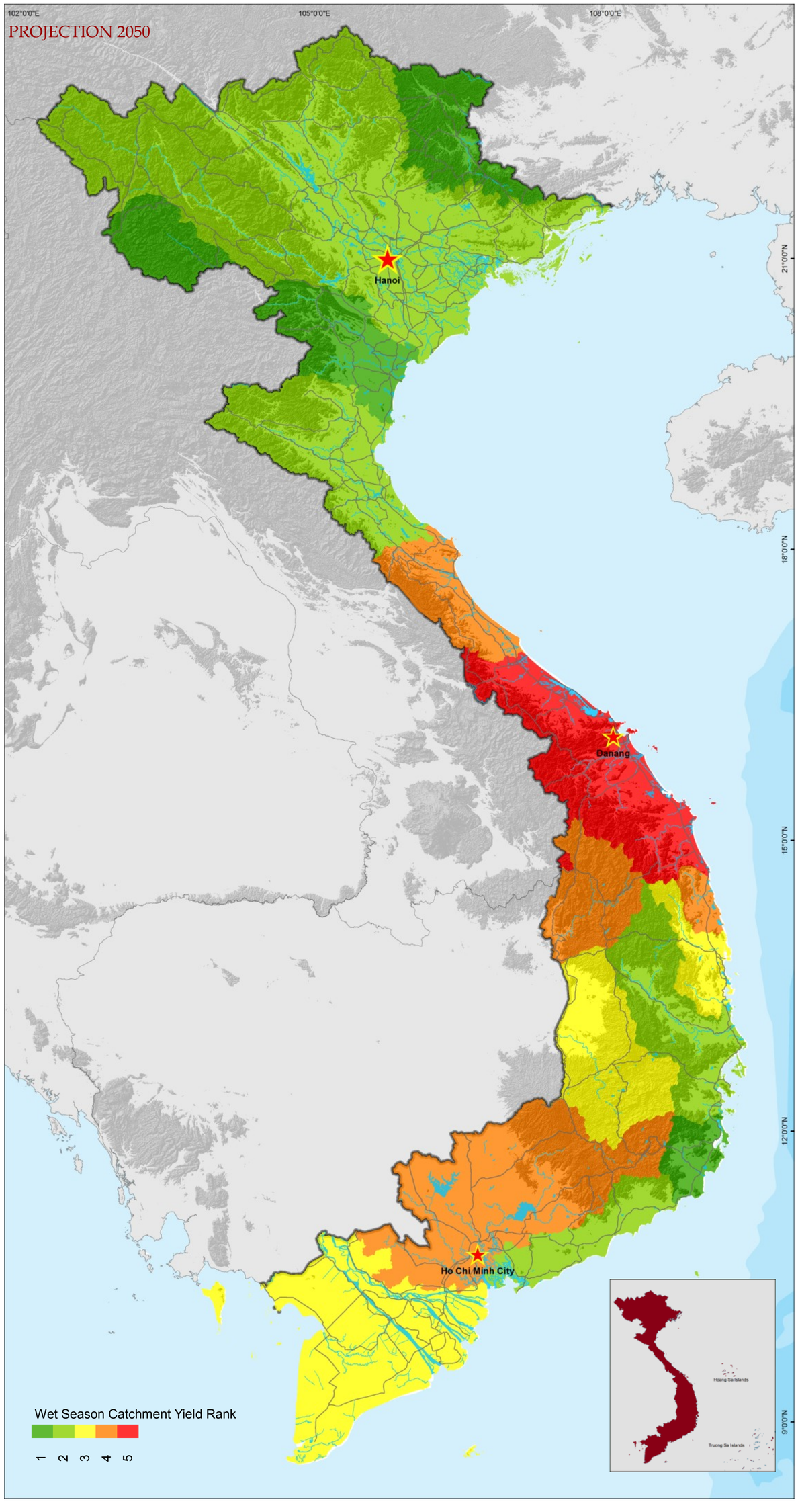
WET SEASON CATCHMENT YIELD



FUNDING AGENCIES

PARTNERS

COMPANIES



SUMMARY OF NATIONAL ASSESSMENT OF THREAT

Wet season catchment yield is used as a proxy indicator to estimate the risk of slow onset riverine flooding by river basin. This indicator is intended to link the climate parameter of rainfall, for which national level projections were available, to the risk of flooding at a national scale. To determine the wet season basin yield, Viet Nam was split into 25 major river basins, using official boundaries from the National Atlas of Viet Nam. The basin area influences the time that it takes for water to drain through the upper to the lower reaches of the basin. Therefore, it gives a good indication of ranking of priorities at this level of geographical scope.

As wet season basin yield uses a basin approach, it gives a relative indication of risk of flooding for basins across the country, but doesn't give relative risk within a basin. This provides enough information to set priorities at the national level, which can then be further investigated at the provincial level where more is known about individual river basins and the assets concerned.

Climate projections for 2050 indicate a significant increase in flooding risk in southern provinces within the Dong Nai River Basin due to climate change (see Section 4.1.3.2). Other provinces located in central coastal Viet Nam in the Vu Gia Thu Bon and the Sre Pok river basins, including Quang Nam and Dak Lak, are affected in both the baseline and 2050 scenario, indicating that flooding is already a threat to affected assets.

Hydropower plants are most vulnerable to flooding, with about 40-50% of plants, both existing and planned, forecast to be in the High and Very High range of impacts. While there is little observed difference between flood threat in the baseline and 2050 scenarios, it is worth pointing out that 17 planned hydro plants are to be built in areas that are already experiencing a Very High flooding risk. As noted above, the national screening assessment uses wet season catchment yield as a proxy indicator and, due to the complexity of river basin dynamics, some caution is required in interpreting the results before a more detailed analysis at the asset level.

The risk to hydropower plants is that flood discharge in these rivers may be greater than can be managed by the plants spillway capacity, which poses a risk to dam failure and catastrophic risks downstream. Some hydropower plants with large reservoirs can have a flood control benefit by storing flood discharge and releasing it more slowly, however, the benefits very much depend on good operational management and communication within plant cascades and downstream assets where large releases become necessary.

Substations and transmission lines could be severely affected by flooding (about 30-50% of listed assets are found to be High or Very High). The planned 500kV transmission backbone is particularly affected with climate change forecast to significantly increase the impact of flooding from around 6% to 39% of all planned lines (a 5 fold increase).

Flooding can cause interrupt the services provided by transmission assets through erosion compromising foundations and, in the most severe cases, inundation of equipment preventing operation and causing metal fatigue for hot components such as transformers. However, actual preventive measures such as raising the elevation of foundations, for instance, would significantly reduce the impact of flooding on those assets.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

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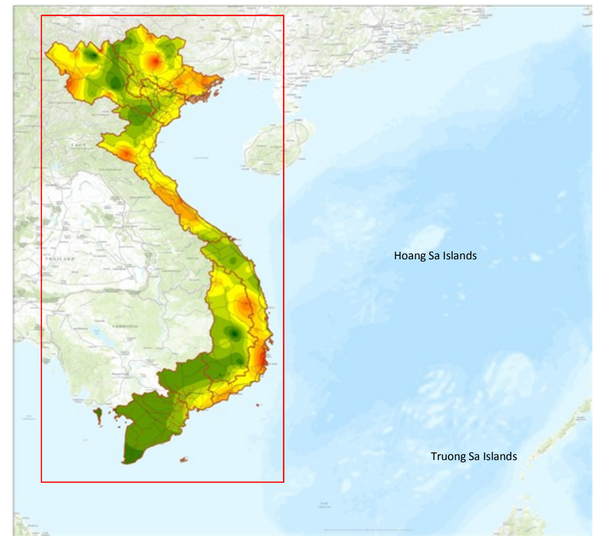
MAP SCALE - 1: 3,000,000

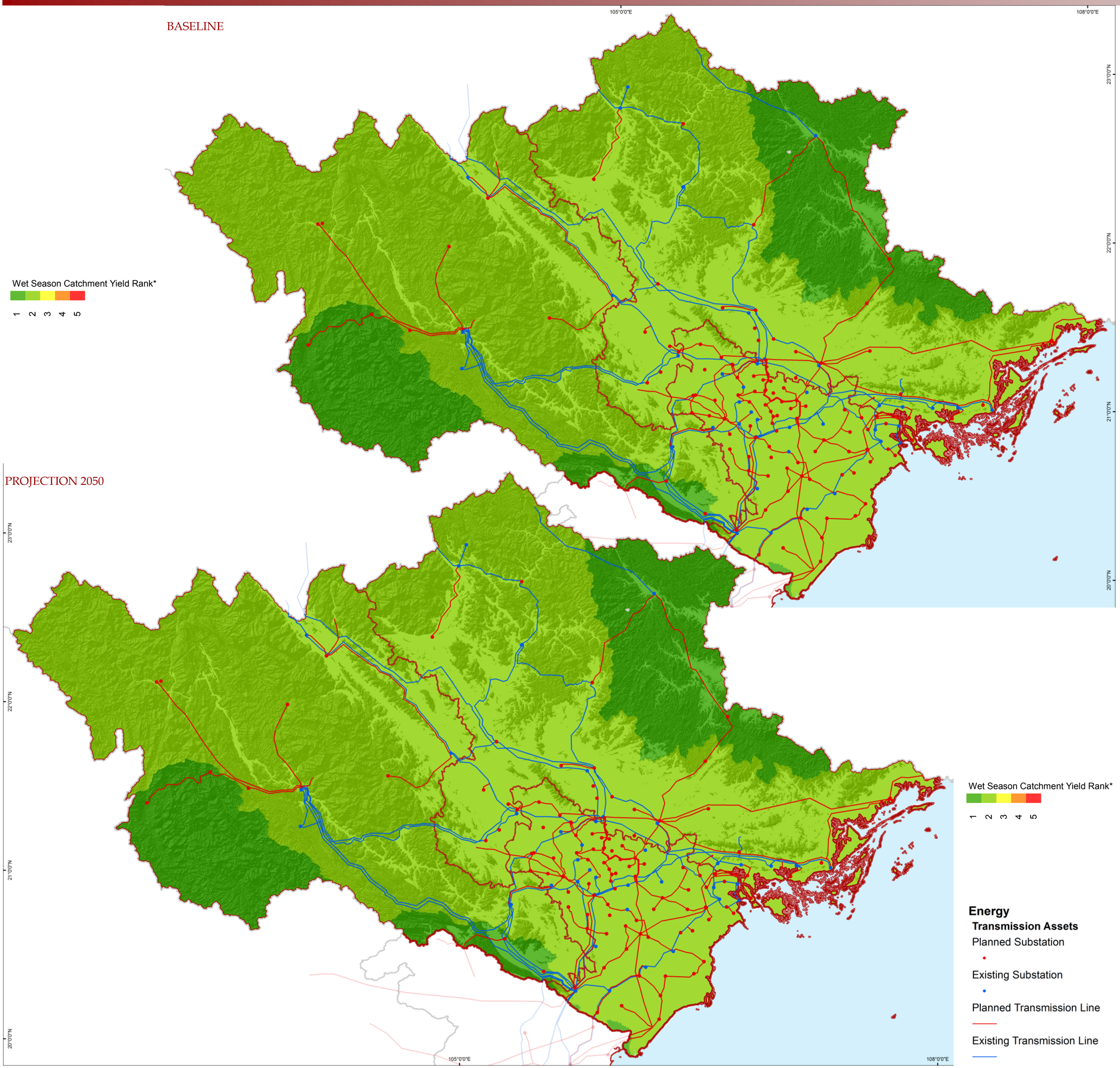
INDEX MAP



REGION 1 - TRANSMISSION LINE AND SUBSTATION (WET SEASON CATCHMENT YIELD)

BASELINE

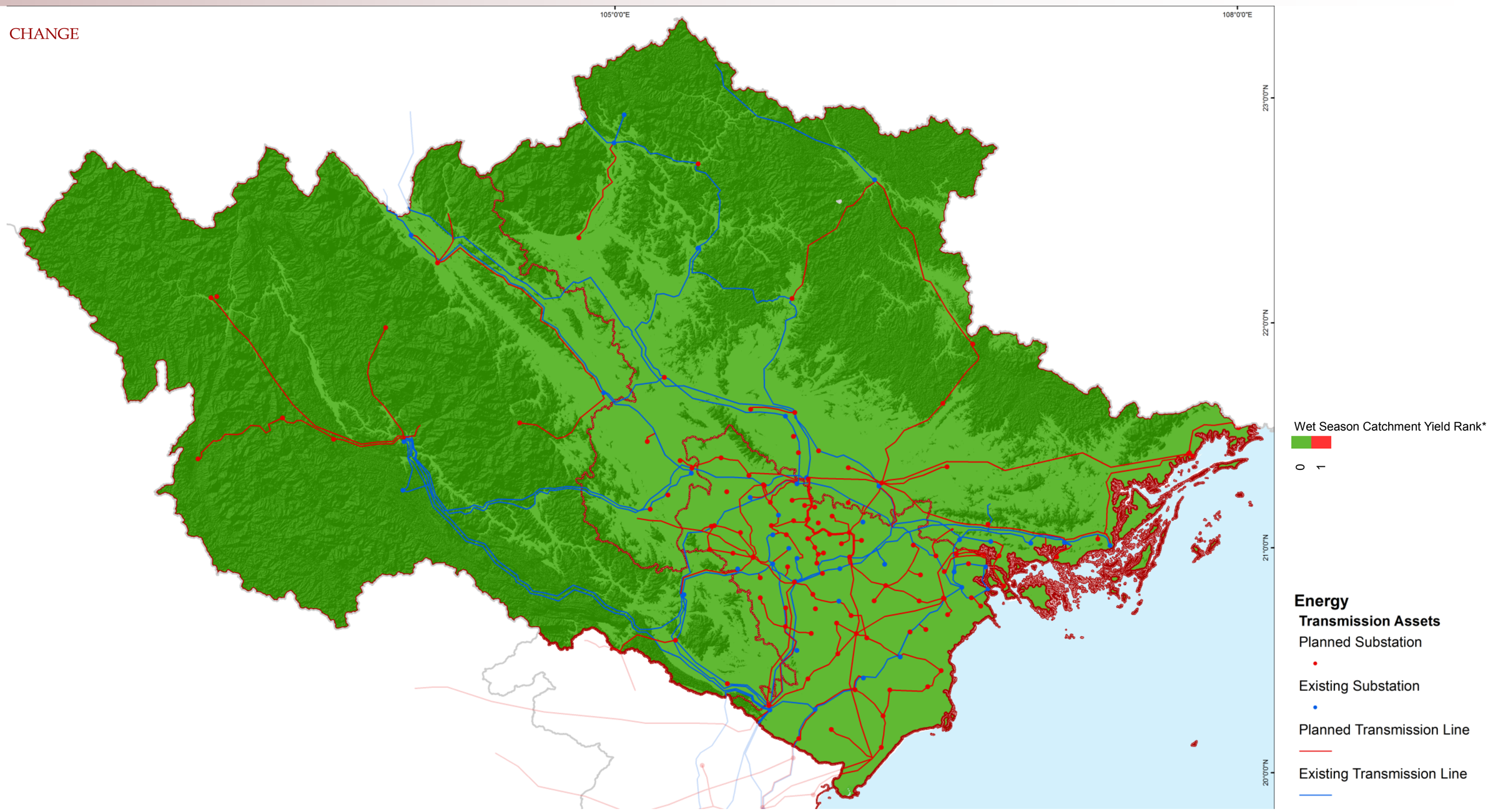
PROJECTION 2050

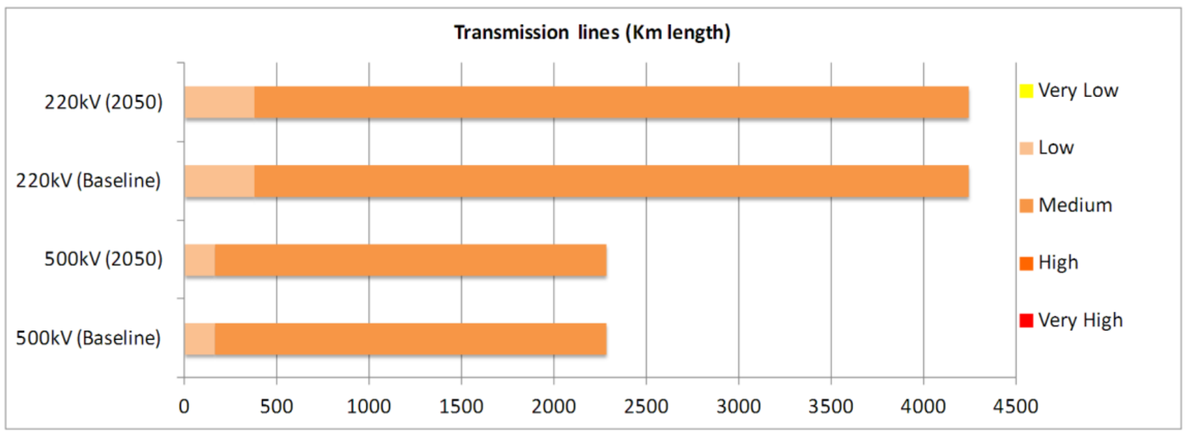


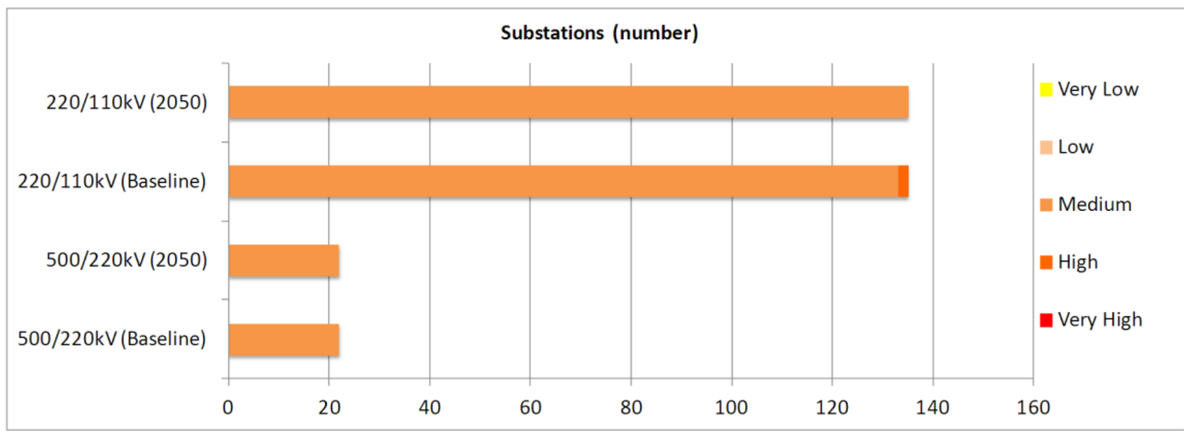
FUNDING AGENCIES

PARTNERS

COMPANIES







Region 1 includes the following provinces: Bắc Cạn, Bắc Giang, Bắc Ninh, Cao Bằng, Điện Biên, Hà Giang, Hà Nam, Hà Nội, Hải Dương, Hải Phòng, Hoà Bình, Hưng Yên, Lai Châu, Lạng Sơn, Lào Cai, Nam Định, Ninh Bình, Phú Thọ, Quảng Ninh, Sơn La, Thái Bình, Thái Nguyên, Tuyên Quang, Vĩnh Phúc, Yên Bái.

DATA SOURCES

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IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

MAP SCALE - 1: 1,200,000

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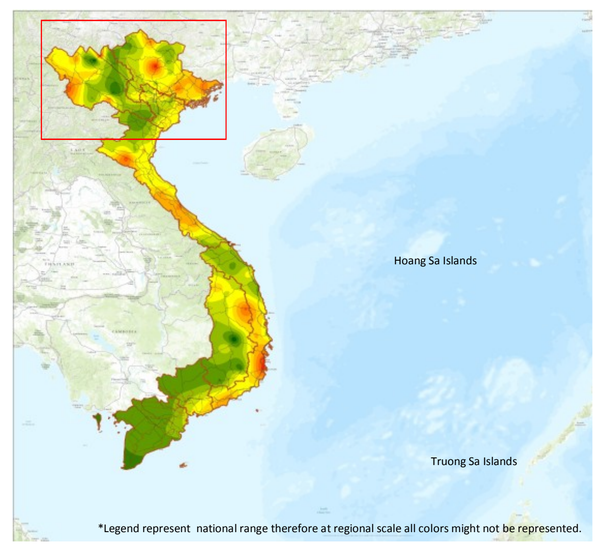
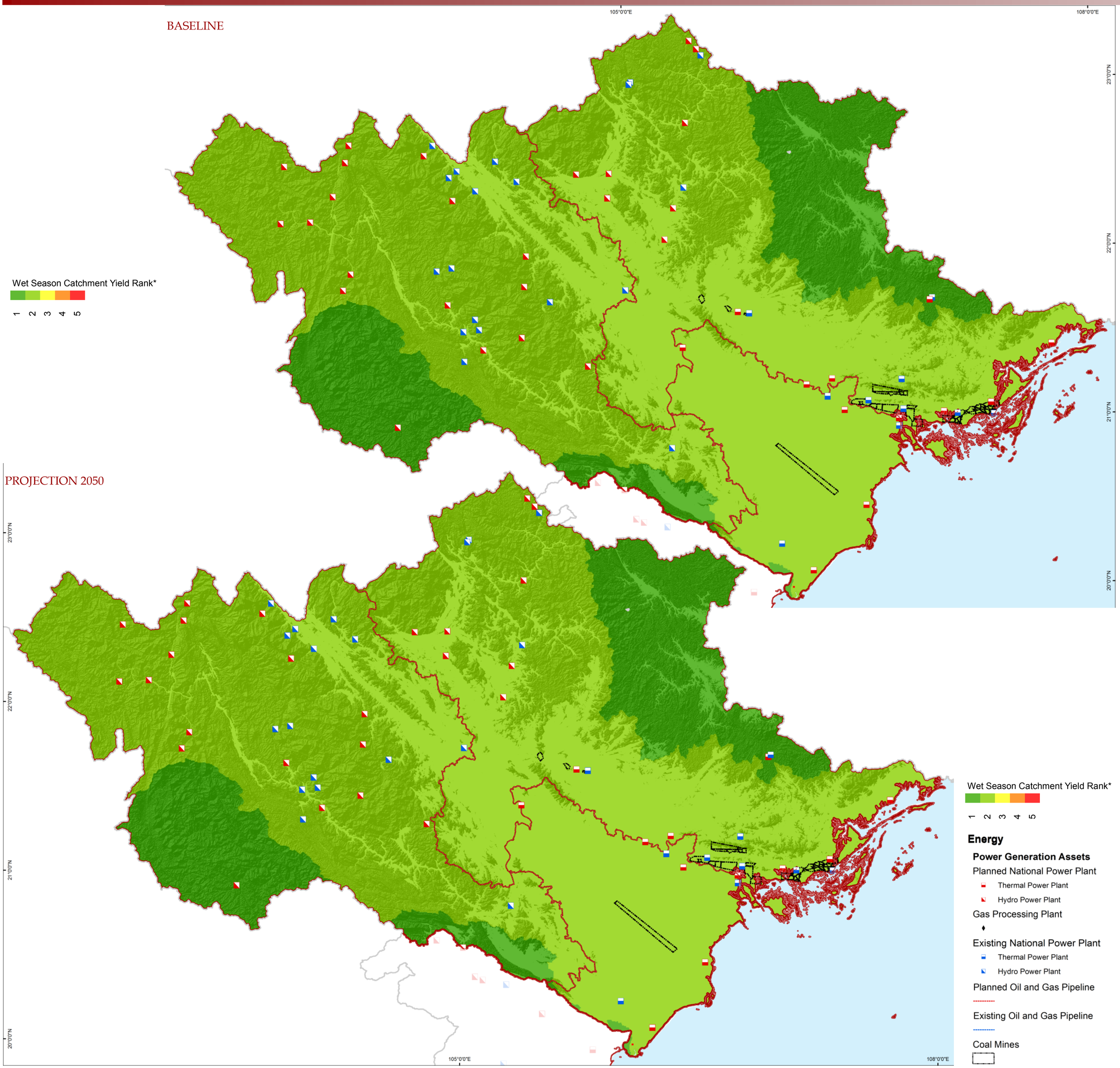


REGION 1 - POWER PLANTS (WET SEASON CATCHMENT YIELD)

BASELINE

PROJECTION 2050



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PARTNERS

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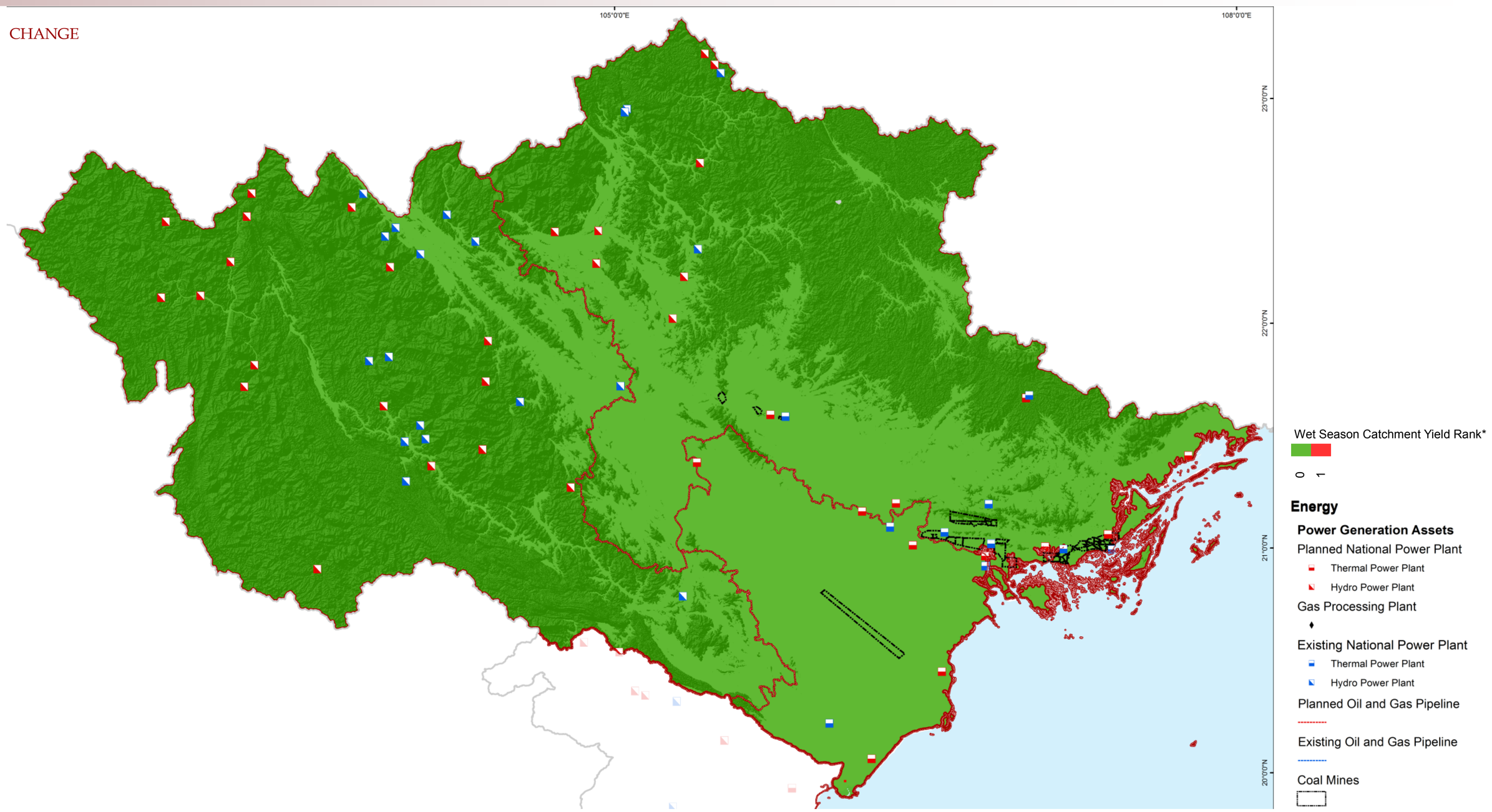

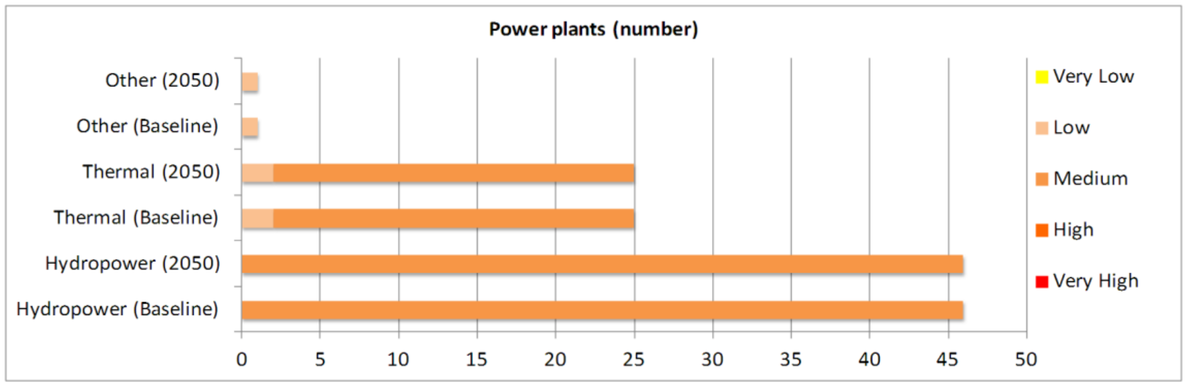

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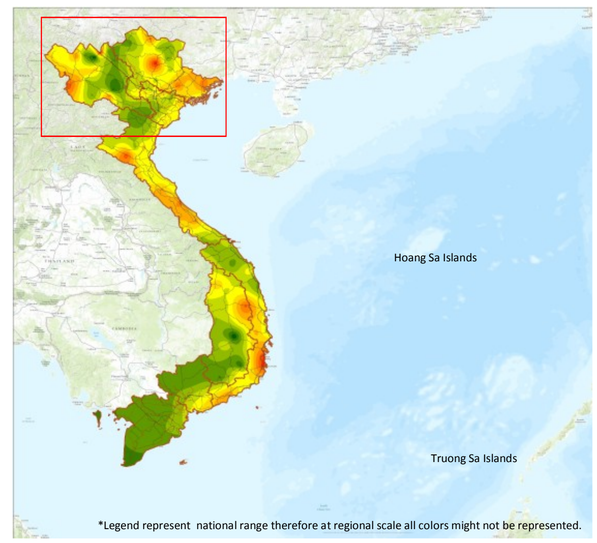
MAP SCALE - 1: 1,200,000

INDEX MAP



REGION 2 - TRANSMISSION LINE AND SUBSTATION (WET SEASON CATCHMENT YIELD)

BASELINE

PROJECTION 2050

Wet Season Catchment Yield Rank*

1 2 3 4 5

Energy

Transmission Assets

Planned Substation

Existing Substation

Planned Transmission Line

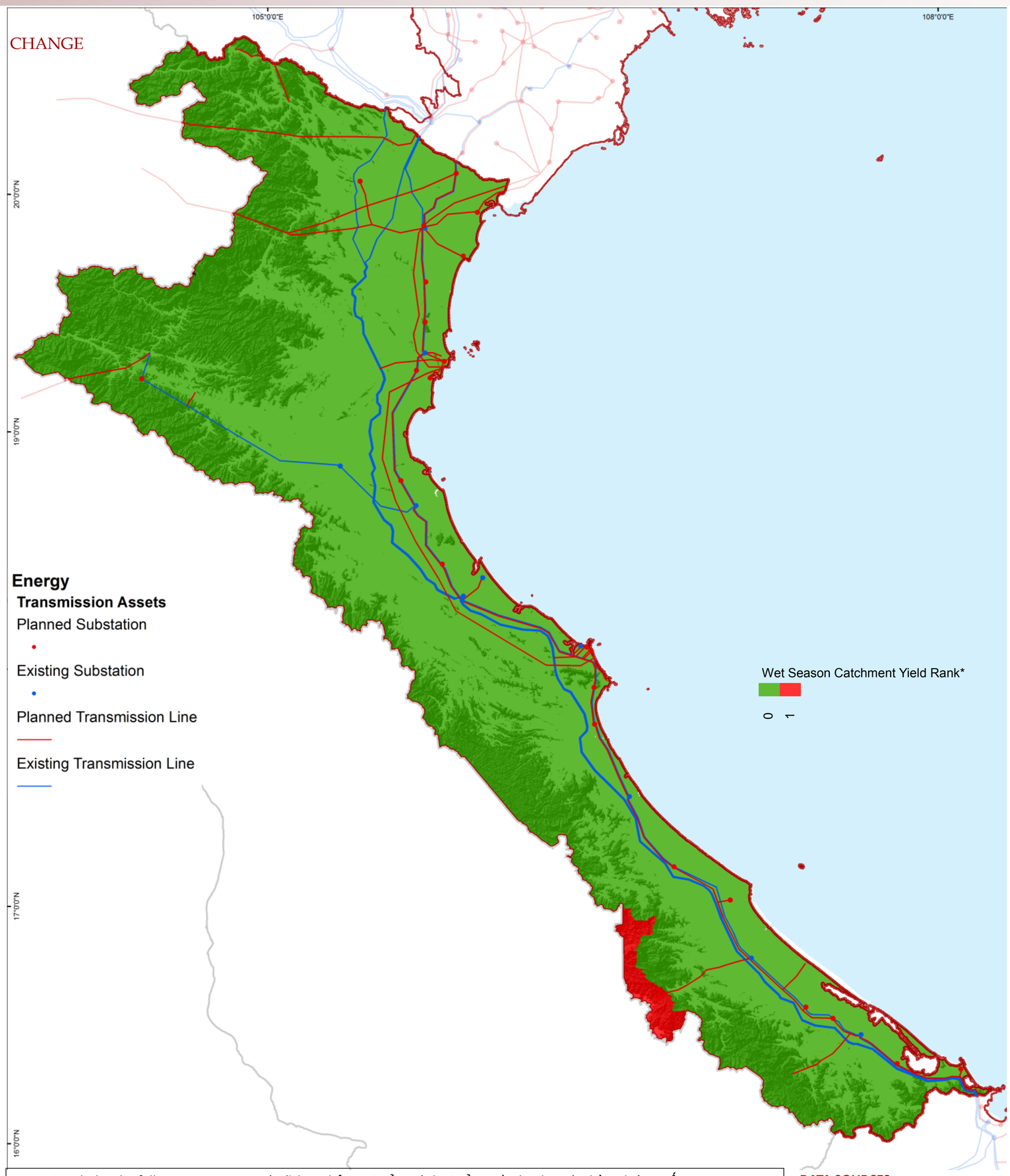
Existing Transmission Line

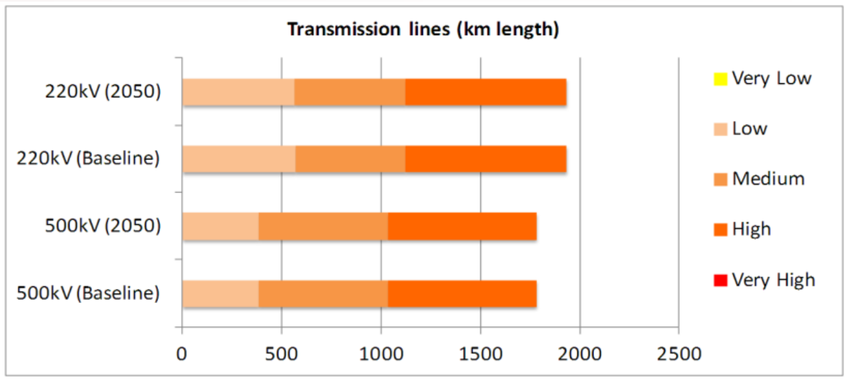
FUNDING AGENCIES

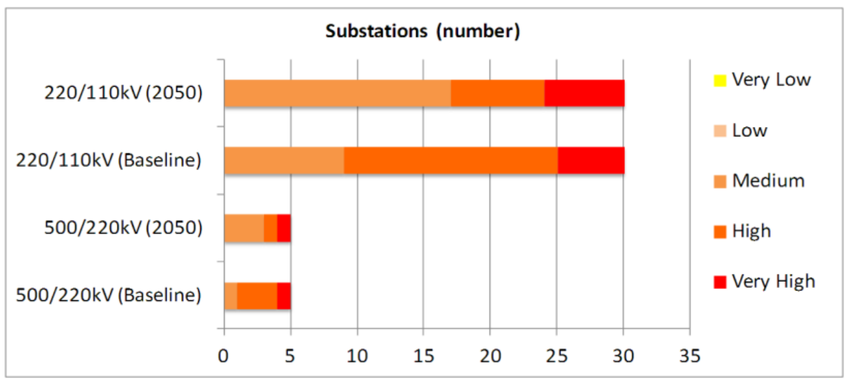
PARTNERS

COMPANIES

CHANGE







Region 2 includes the following provinces: Hà Tĩnh, Nghệ An, Quảng Bình, Quảng Trị, Thanh Hoá, Thừa Thiên Huế.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

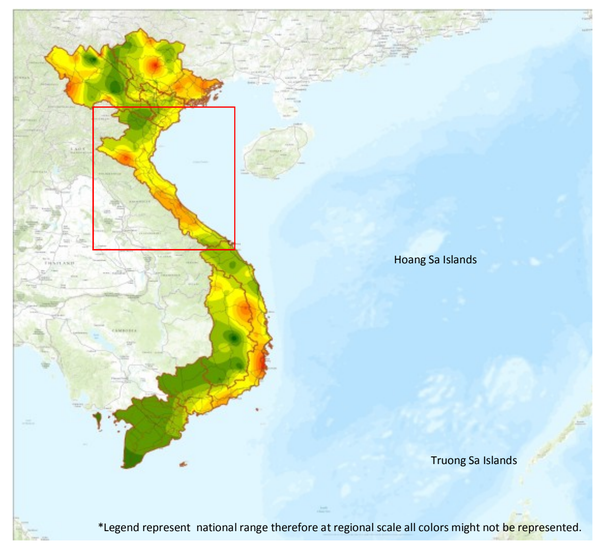
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

MAP SCALE - 1: 1,200,000

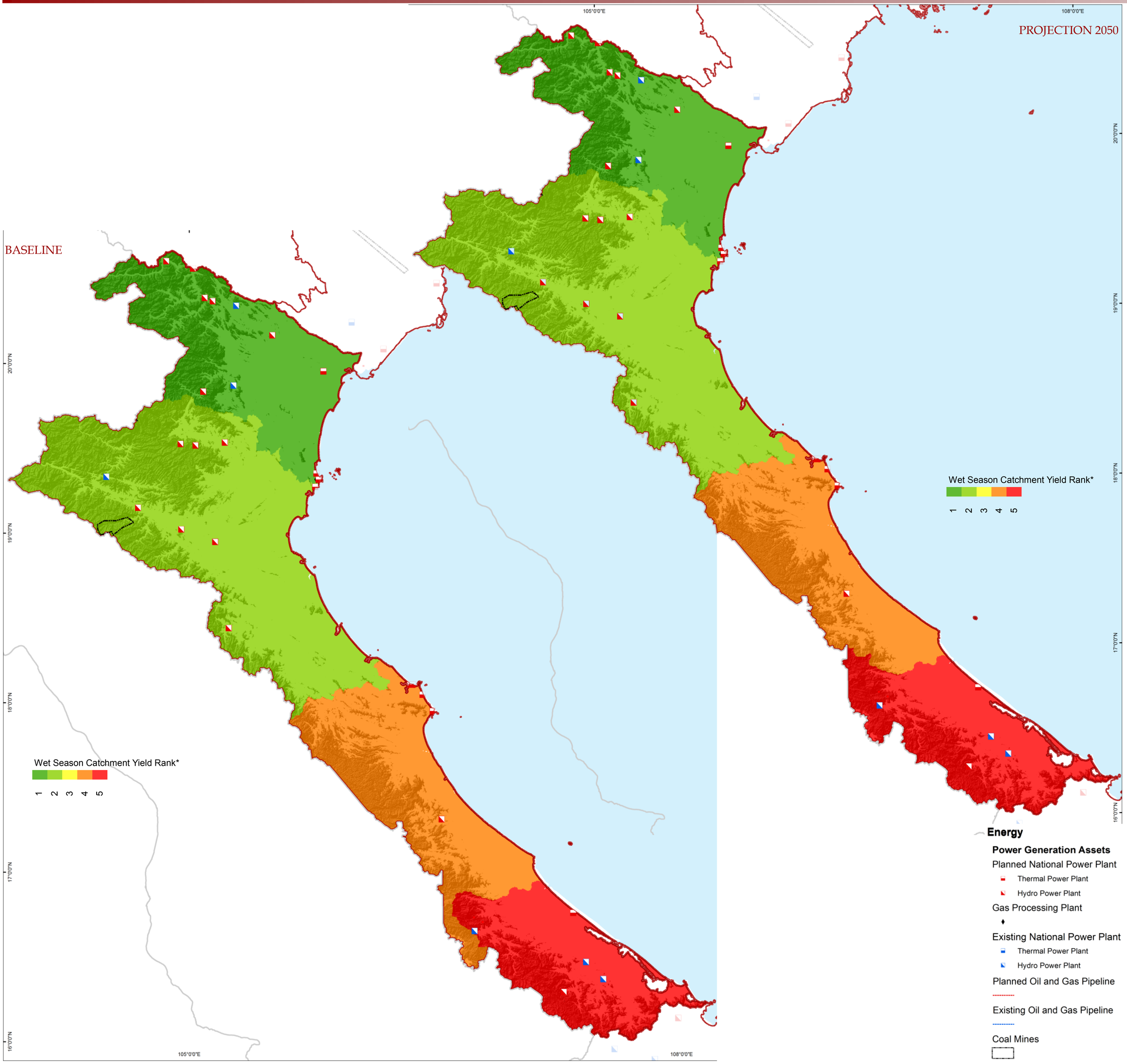
INDEX MAP



REGION 2 - POWER PLANTS (WET SEASON CATCHMENT YIELD)

BASELINE

PROJECTION 2050

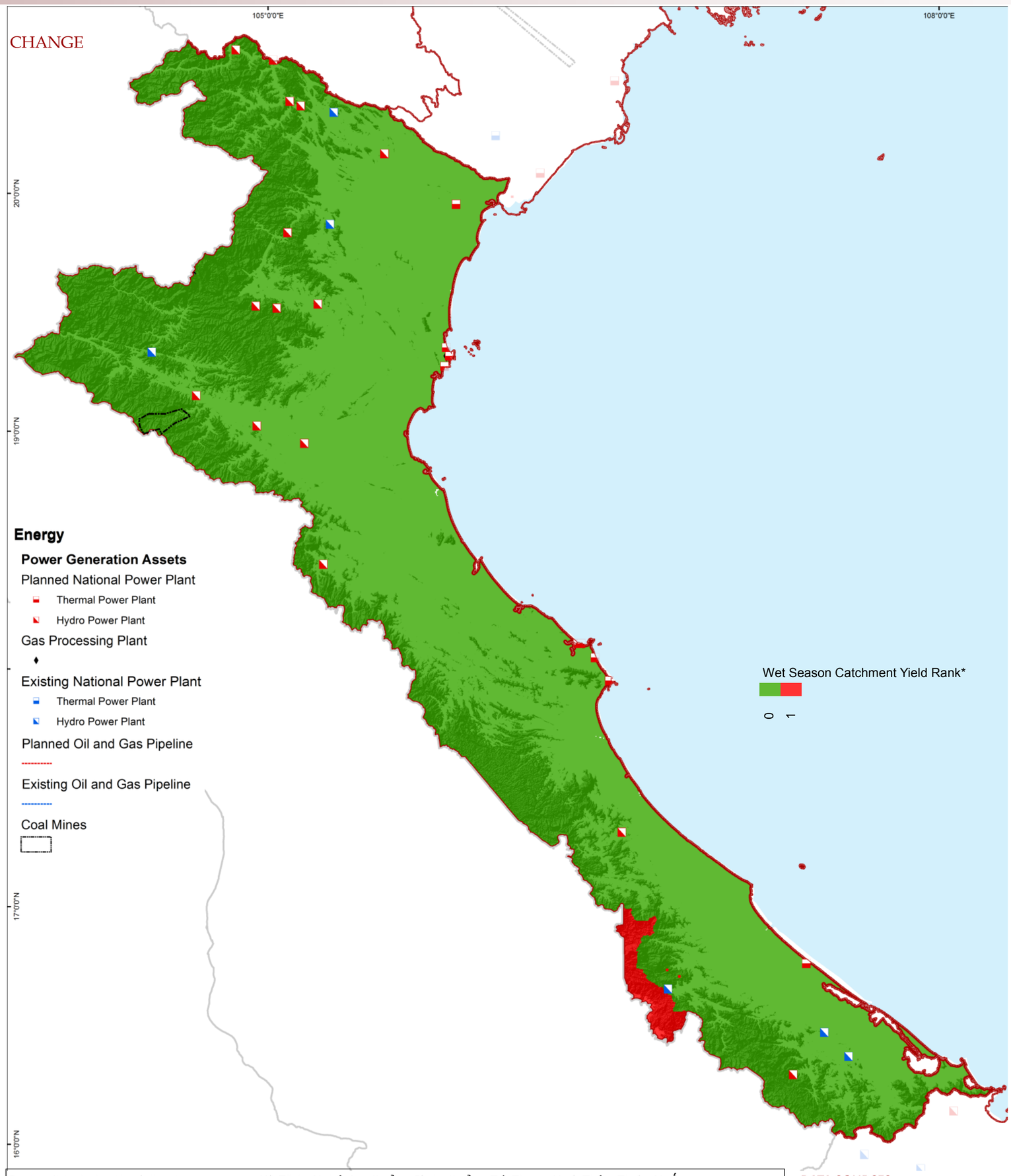


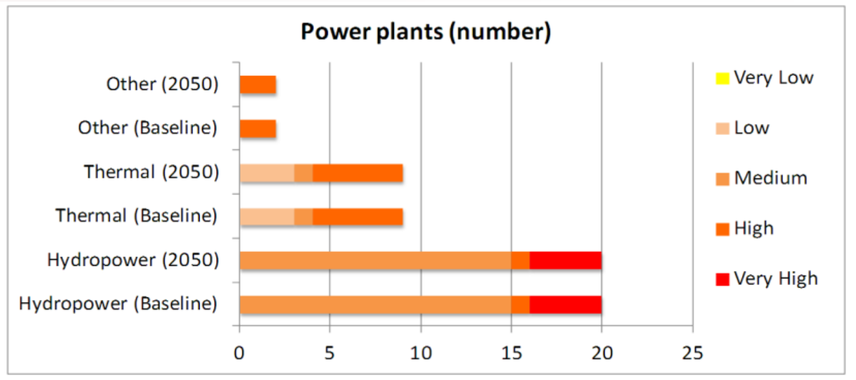
FUNDING AGENCIES

PARTNERS

COMPANIES

CHANGE





Region 2 includes the following provinces: Hà Tĩnh, Nghệ An, Quảng Bình, Quảng Trị, Thanh Hoá, Thừa Thiên Huế.

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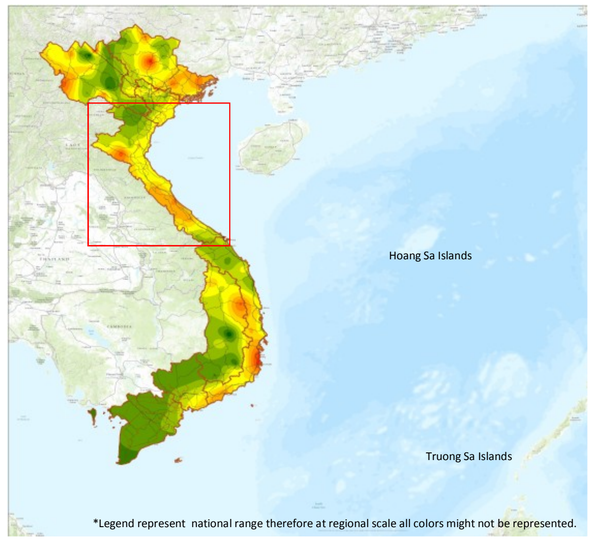
GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

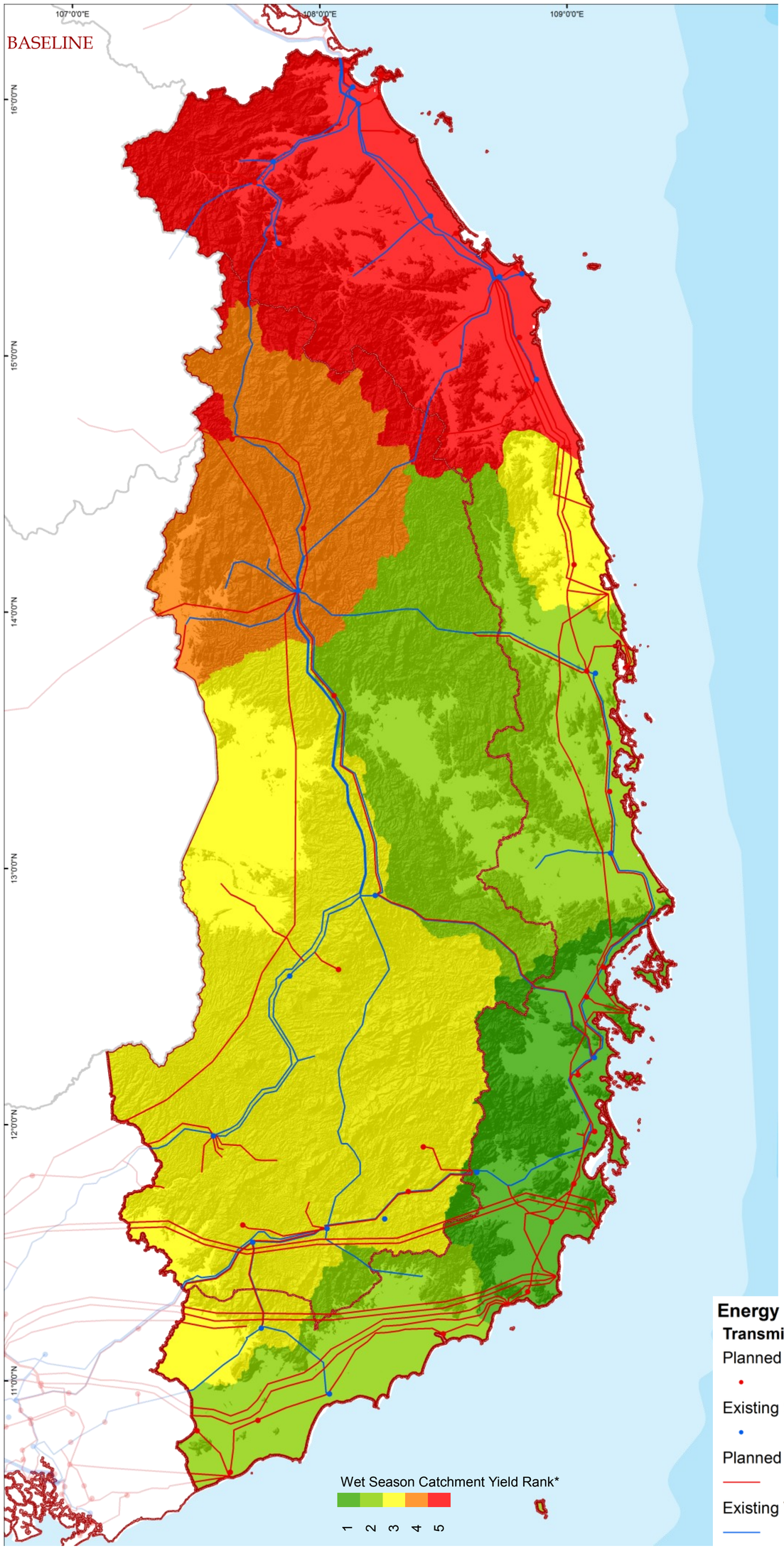
MAP SCALE - 1: 1,200,000

INDEX MAP

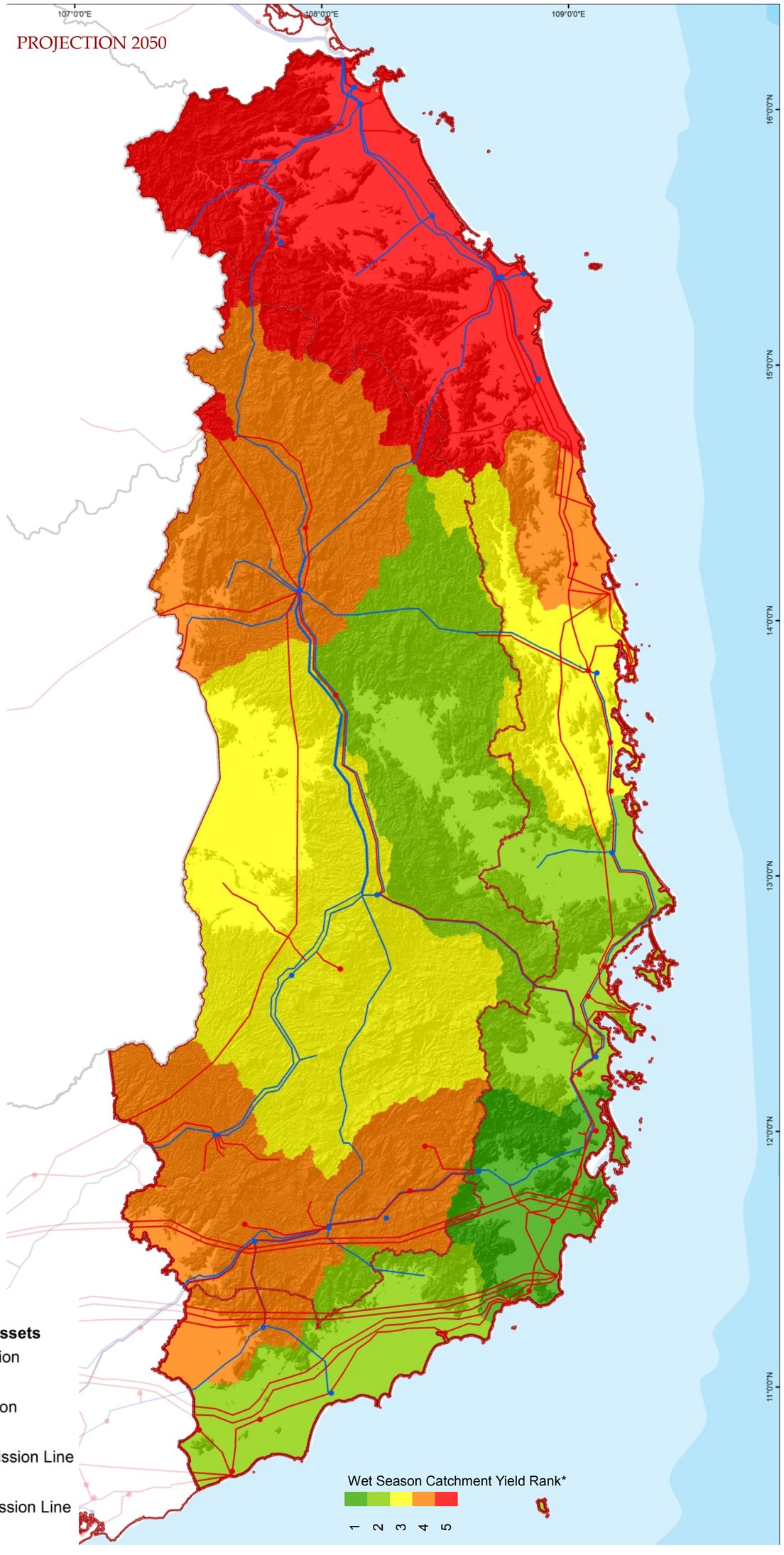


REGION 3 - TRANSMISSION LINE AND SUBSTATION (WET SEASON CATCHMENT YIELD)

BASELINE



PROJECTION 2050



Energy

Transmission Assets

Planned Substation

Existing Substation

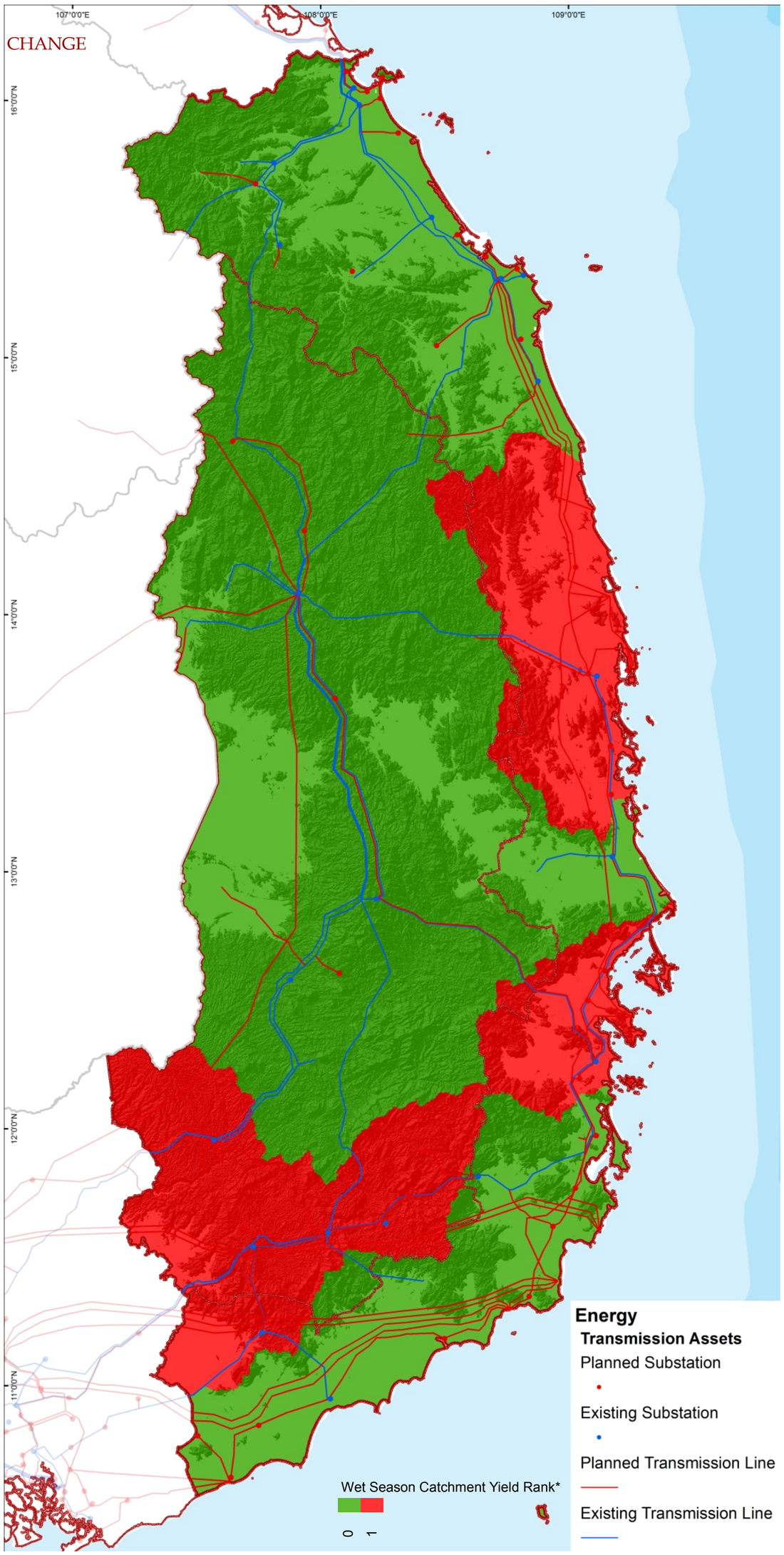
Planned Transmission Line

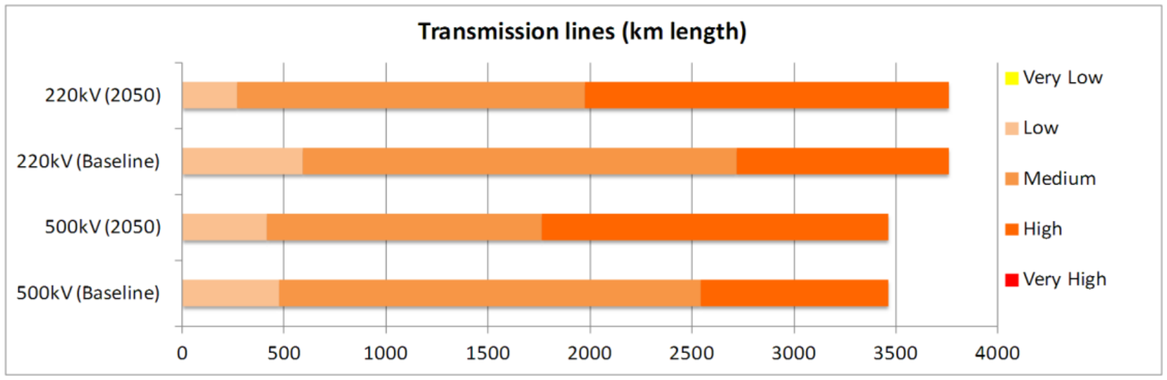
Existing Transmission Line

FUNDING AGENCIES

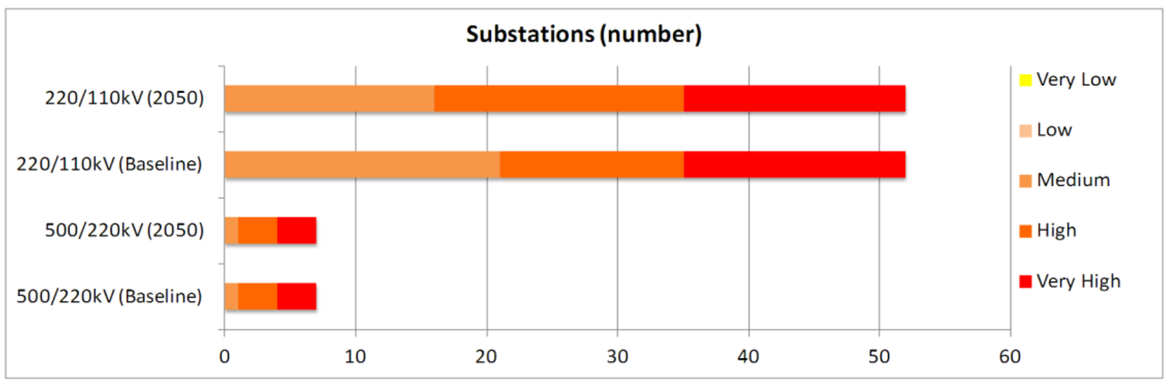
PARTNERS

COMPANIES





Region 3 includes the following provinces: Bình Định, Bình Thuận, Đà Nẵng, Đăk Lăk, Đăk Nông, Gia Lai, Khánh Hoà, Kon Tum, Lâm Đồng, Ninh Thuận, Phú Yên, Quảng Nam, Quảng Ngãi.



DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

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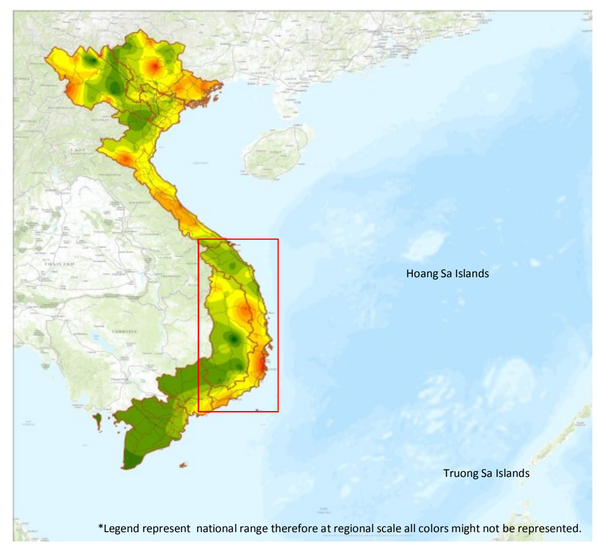
GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

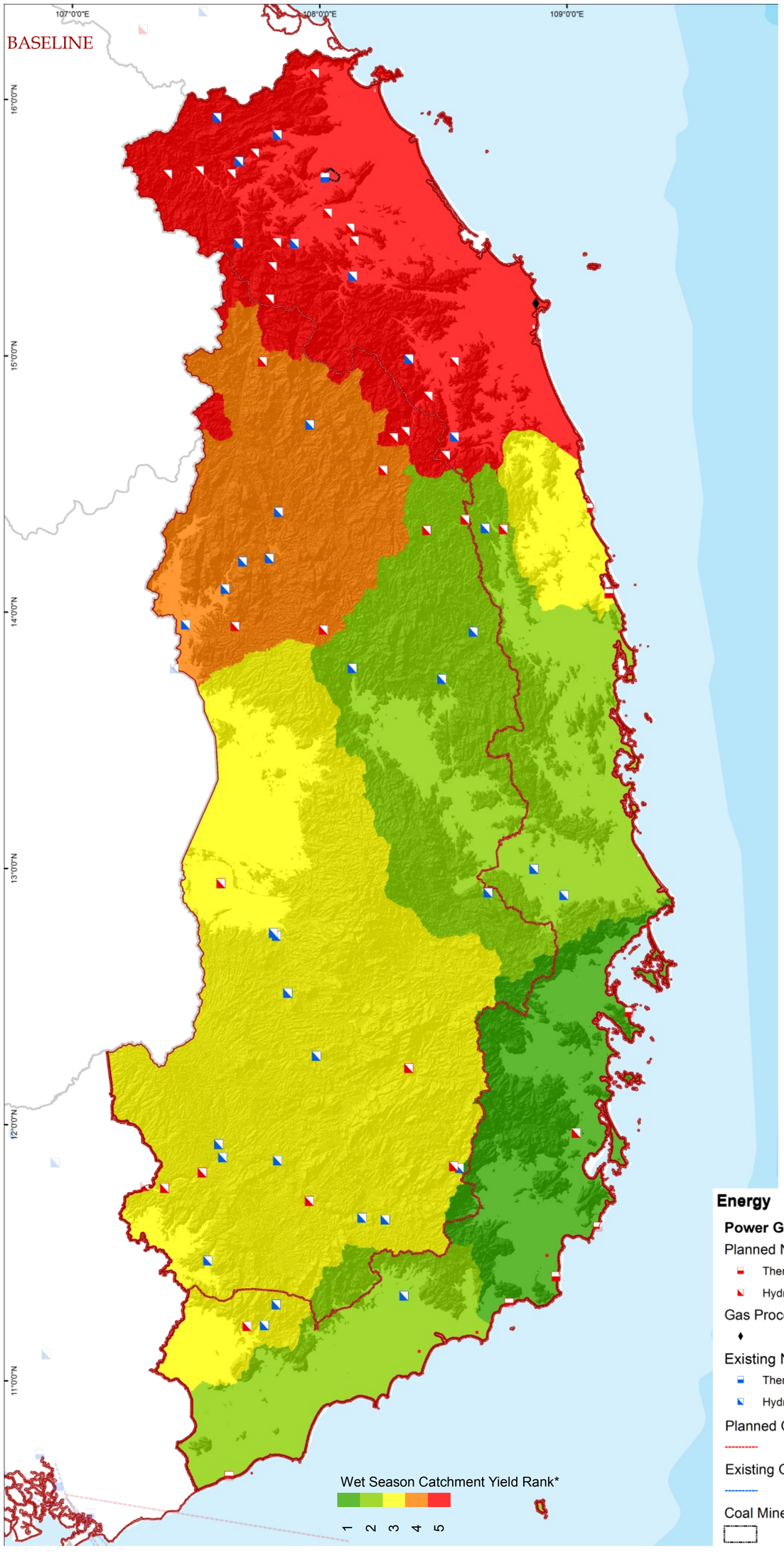
MAP SCALE - 1: 1,200,000

INDEX MAP

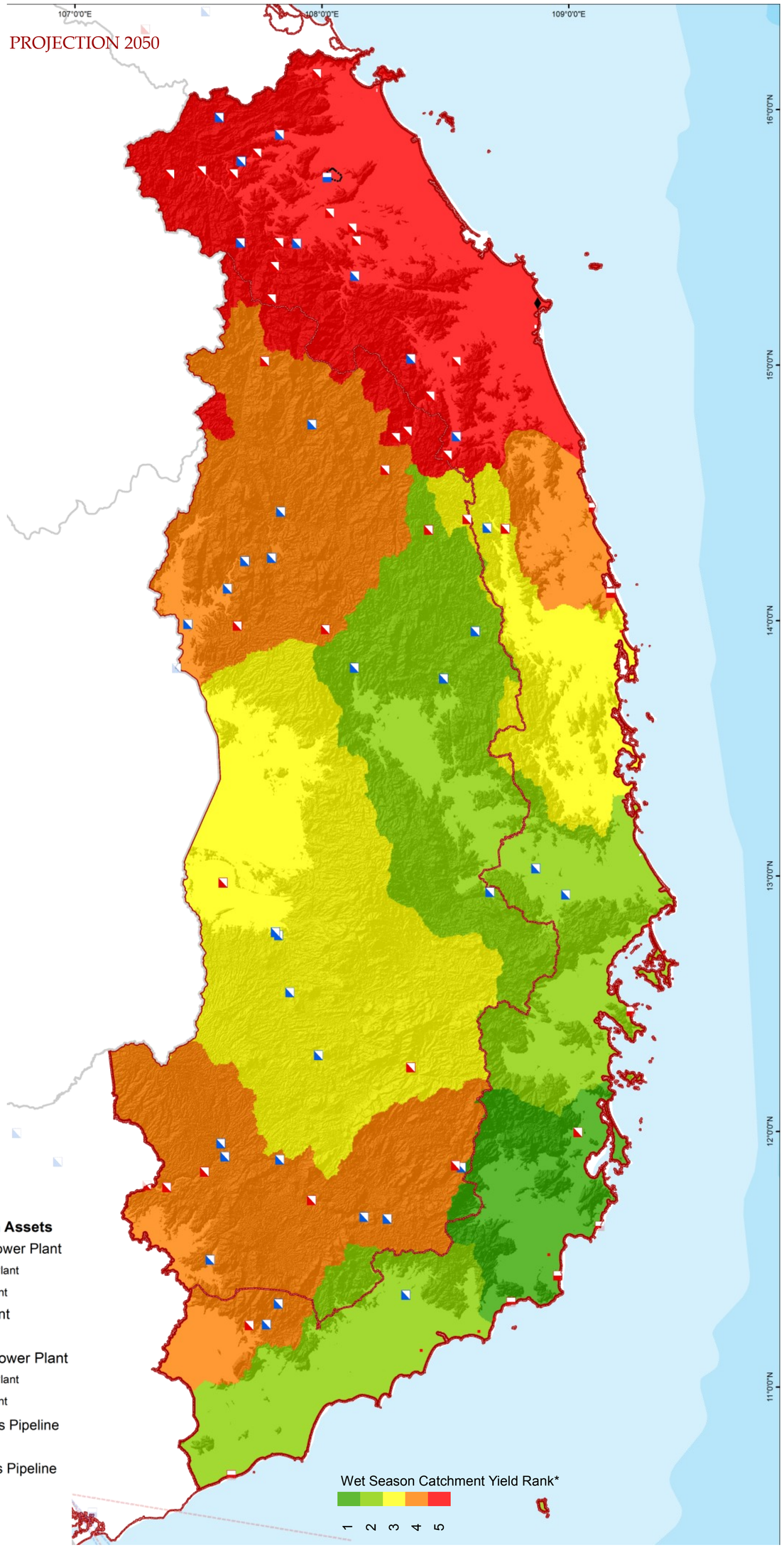


REGION 3 - POWER PLANTS (WET SEASON CATCHMENT YIELD)

BASELINE



PROJECTION 2050



Energy

Power Generation Assets

Planned National Power Plant
- Thermal Power Plant
- Hydro Power Plant

Gas Processing Plant

Existing National Power Plant
- Thermal Power Plant
- Hydro Power Plant

Planned Oil and Gas Pipeline

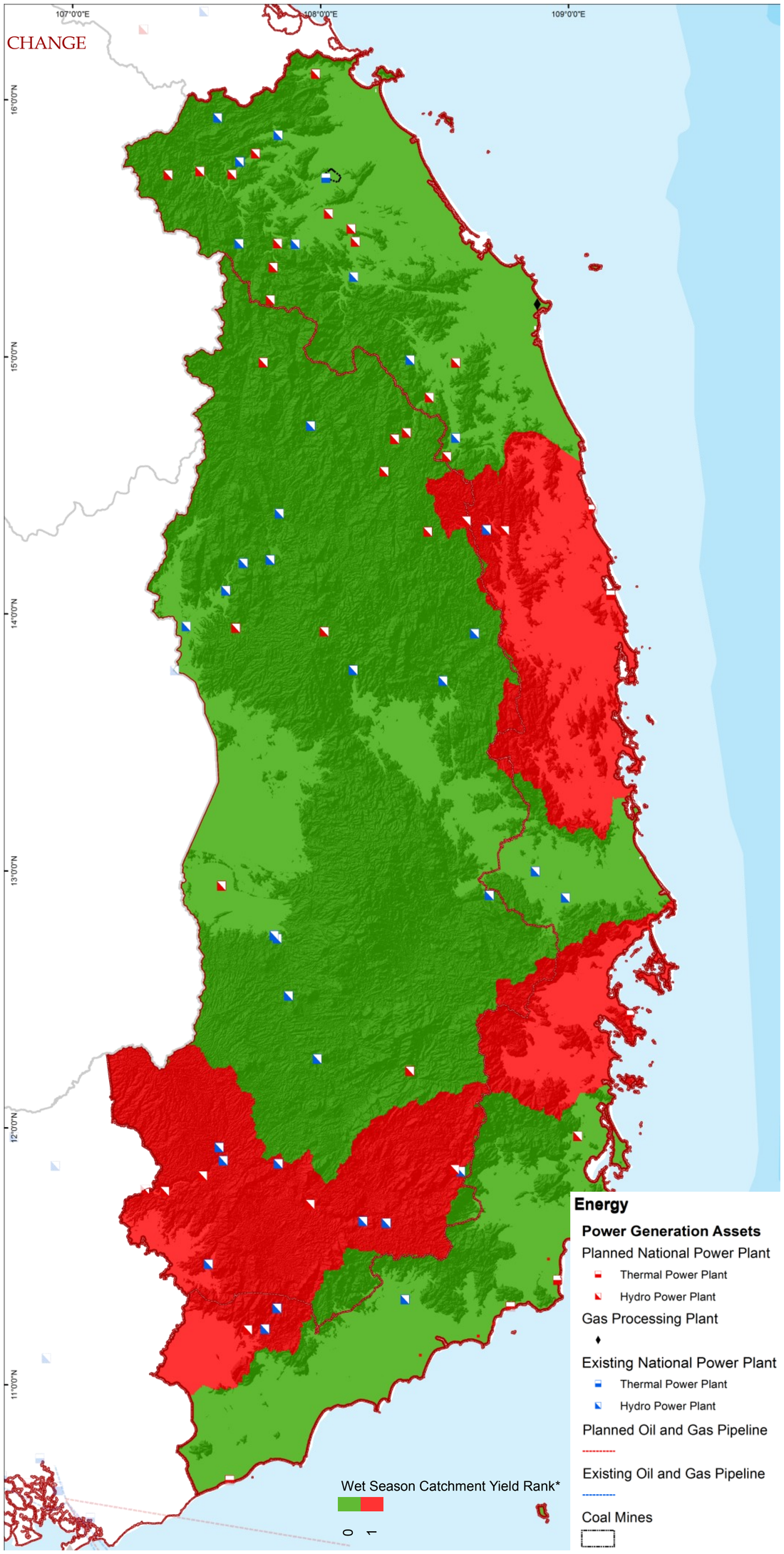
Existing Oil and Gas Pipeline

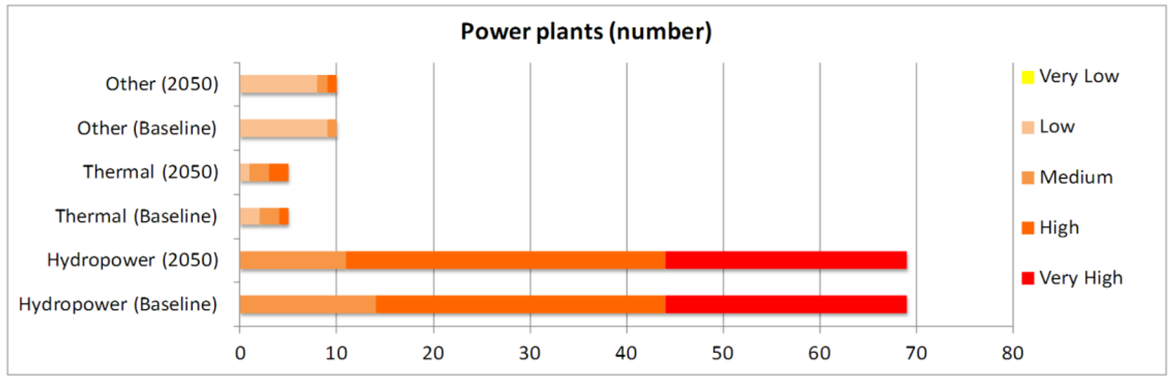
Coal Mines

FUNDING AGENCIES

PARTNERS

COMPANIES





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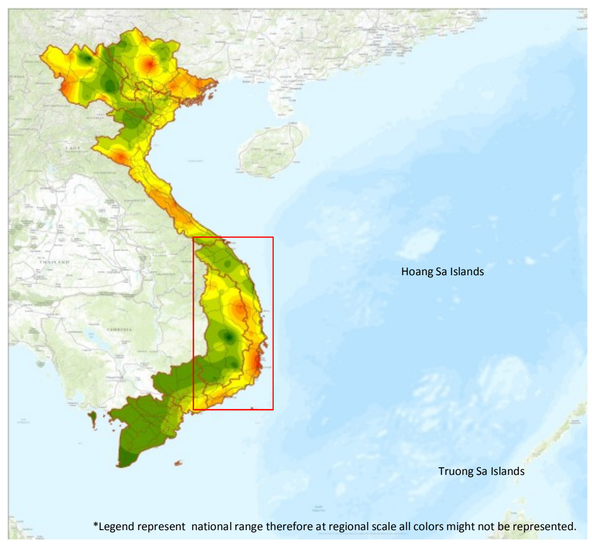
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

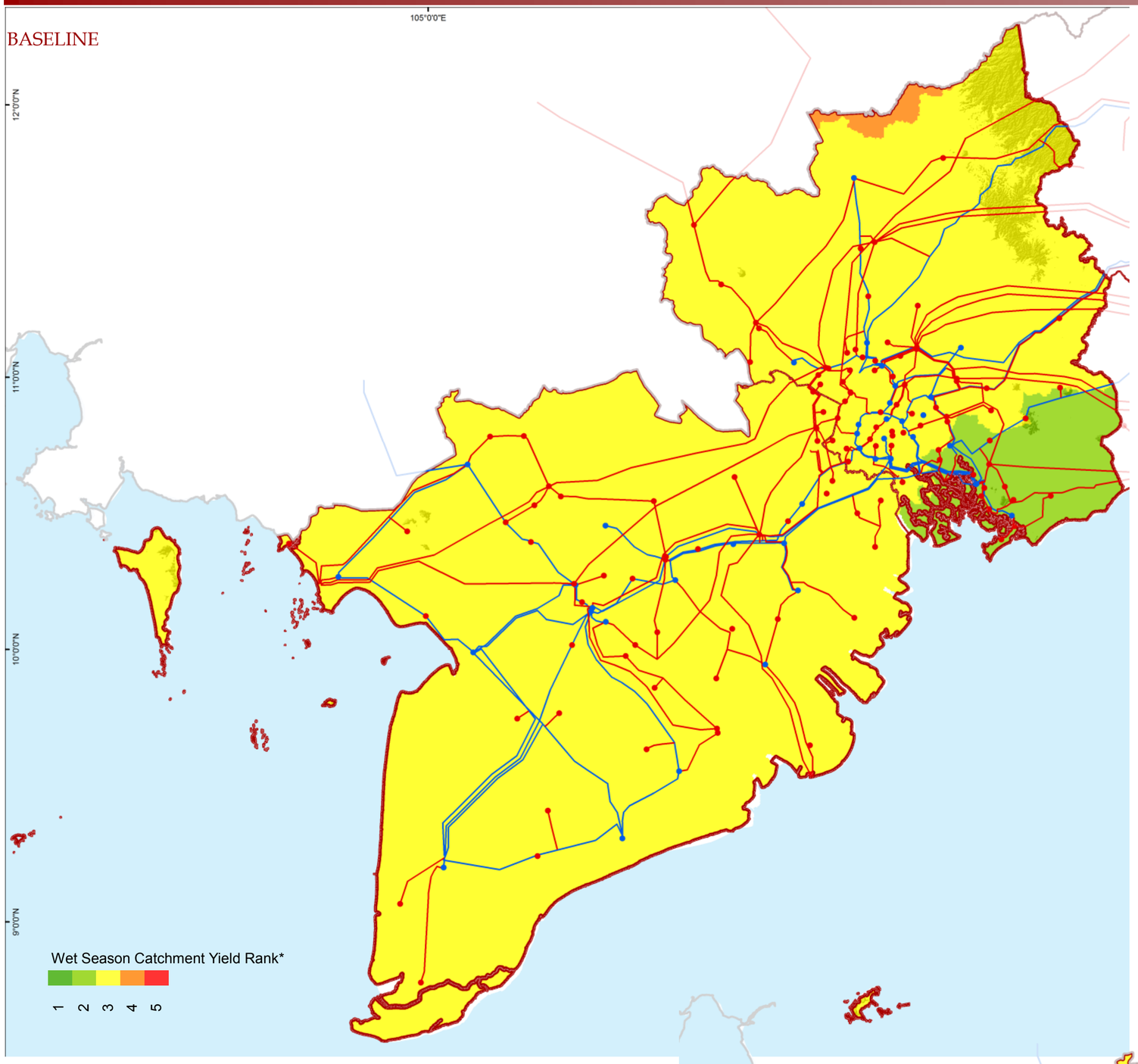
MAP SCALE - 1: 1,200,000

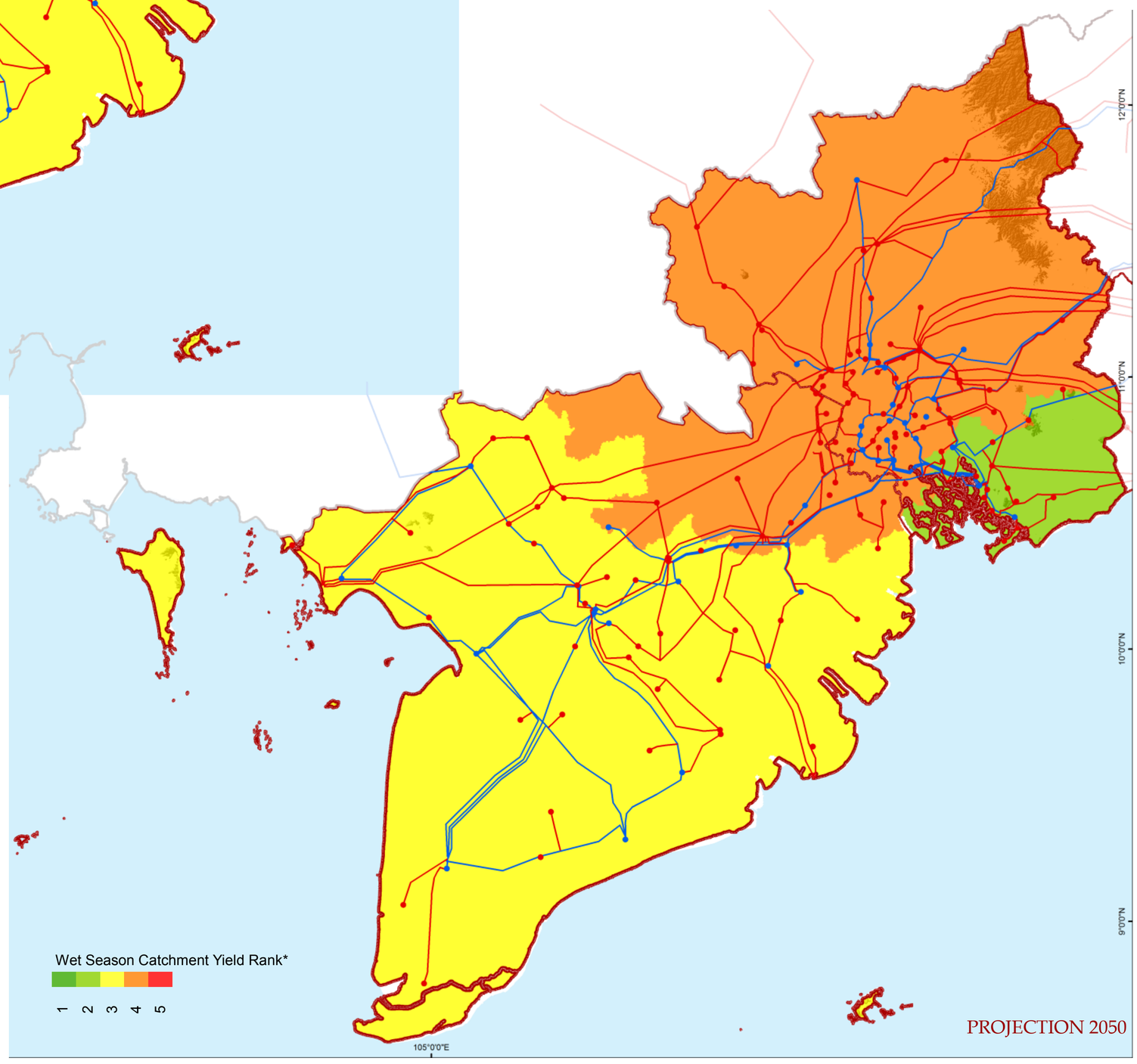
INDEX MAP



REGION 4 - TRANSMISSION LINE AND SUBSTATION (WET SEASON CATCHMENT YIELD)

BASELINE





Energy

Transmission Assets

Planned Substation

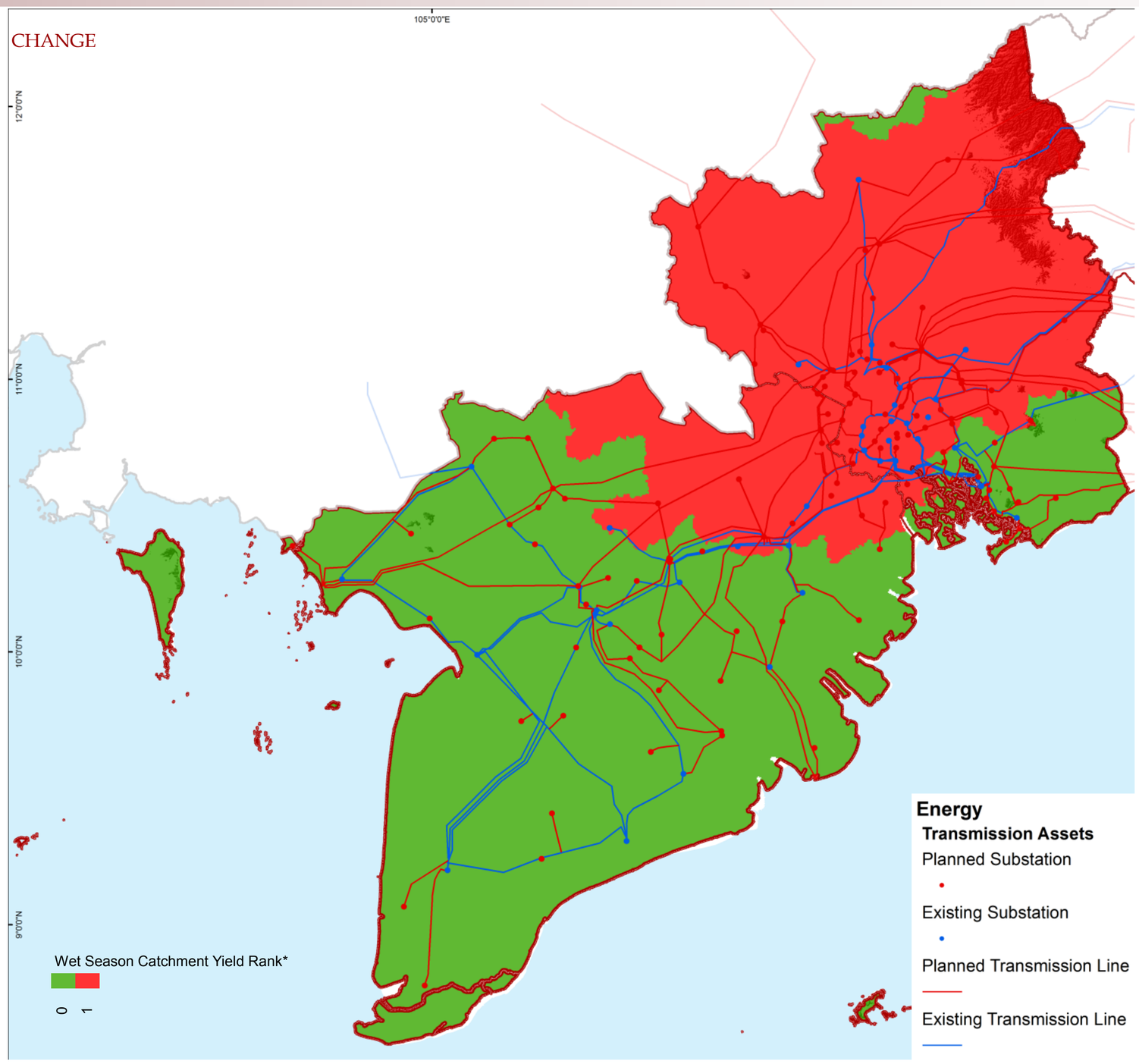
Existing Substation

Planned Transmission Line

Existing Transmission Line

PROJECTION 2050

CHANGE



Energy

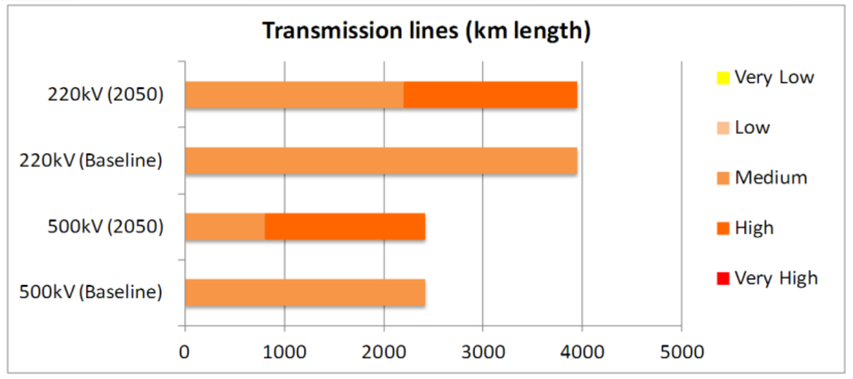
Transmission Assets

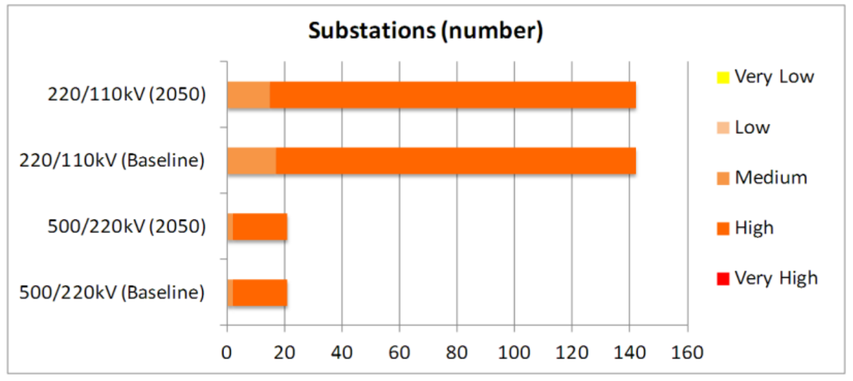
Planned Substation

Existing Substation

Planned Transmission Line

Existing Transmission Line





Region 4 includes the following provinces: An Giang, Bà Rịa Vũng Tàu, Bạc Liêu, Bến Tre, Bình Dương, Bình Phước, Cà Mau, Đồng Nai, Đồng Tháp, Hậu Giang, Kiên Giang, Long An, Sóc Trăng, Tây Ninh, Tiền Giang, TP Cần Thơ, TP Hồ Chí Minh, Trà Vinh, Vinh Long.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

IE - ENERGY INFRASTRUCTURE

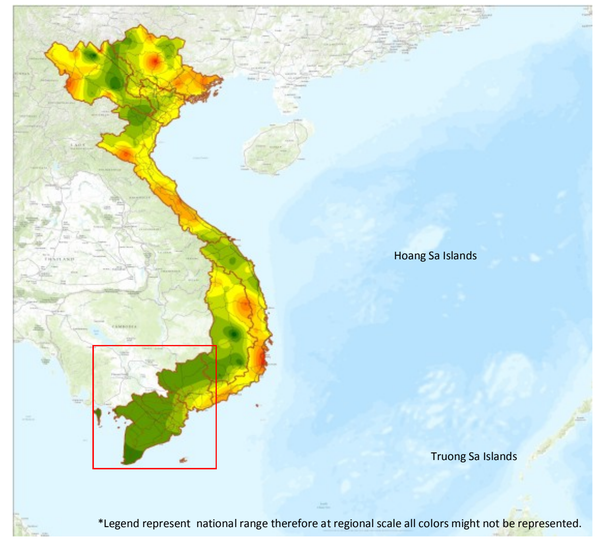
GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

N
W
E
S

MAP SCALE - 1: 1,200,000

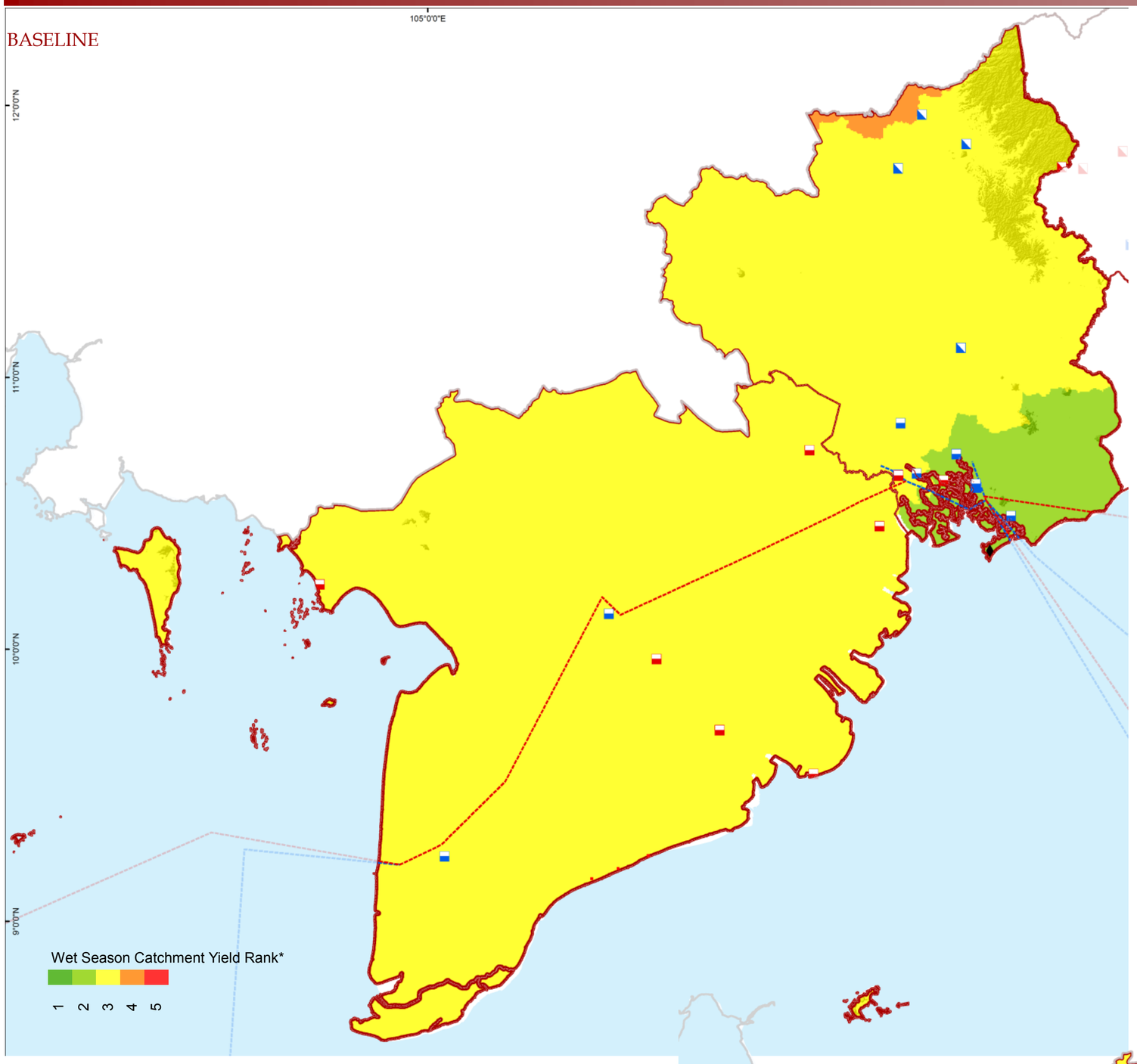
INDEX MAP

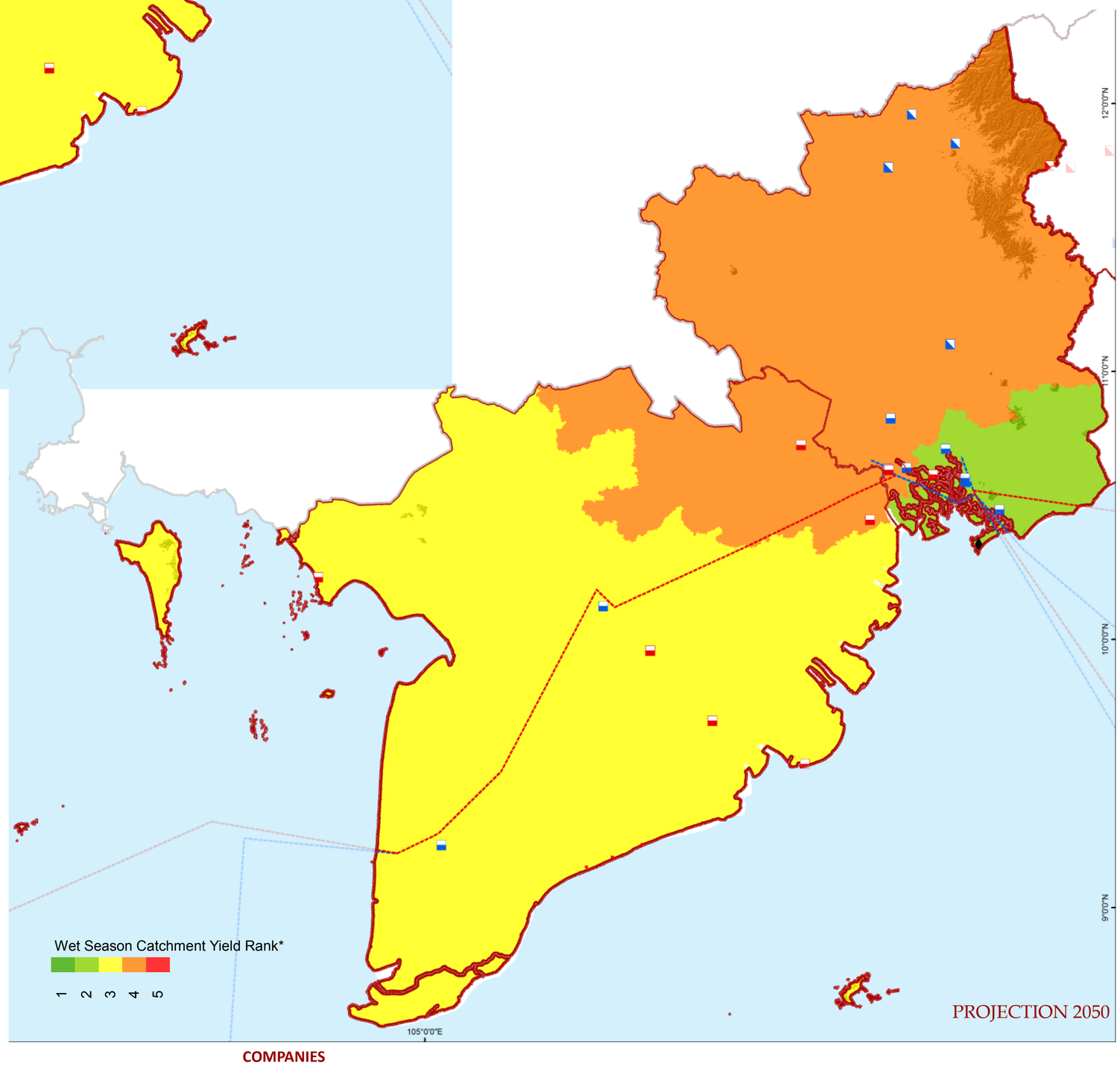


*Legend represent national range therefore at regional scale all colors might not be represented.

REGION 4 - POWER PLANTS (WET SEASON CATCHMENT YIELD)

BASELINE





Energy

Power Generation Assets

Planned National Power Plant

- Thermal Power Plant
- Hydro Power Plant

Gas Processing Plant

Existing National Power Plant

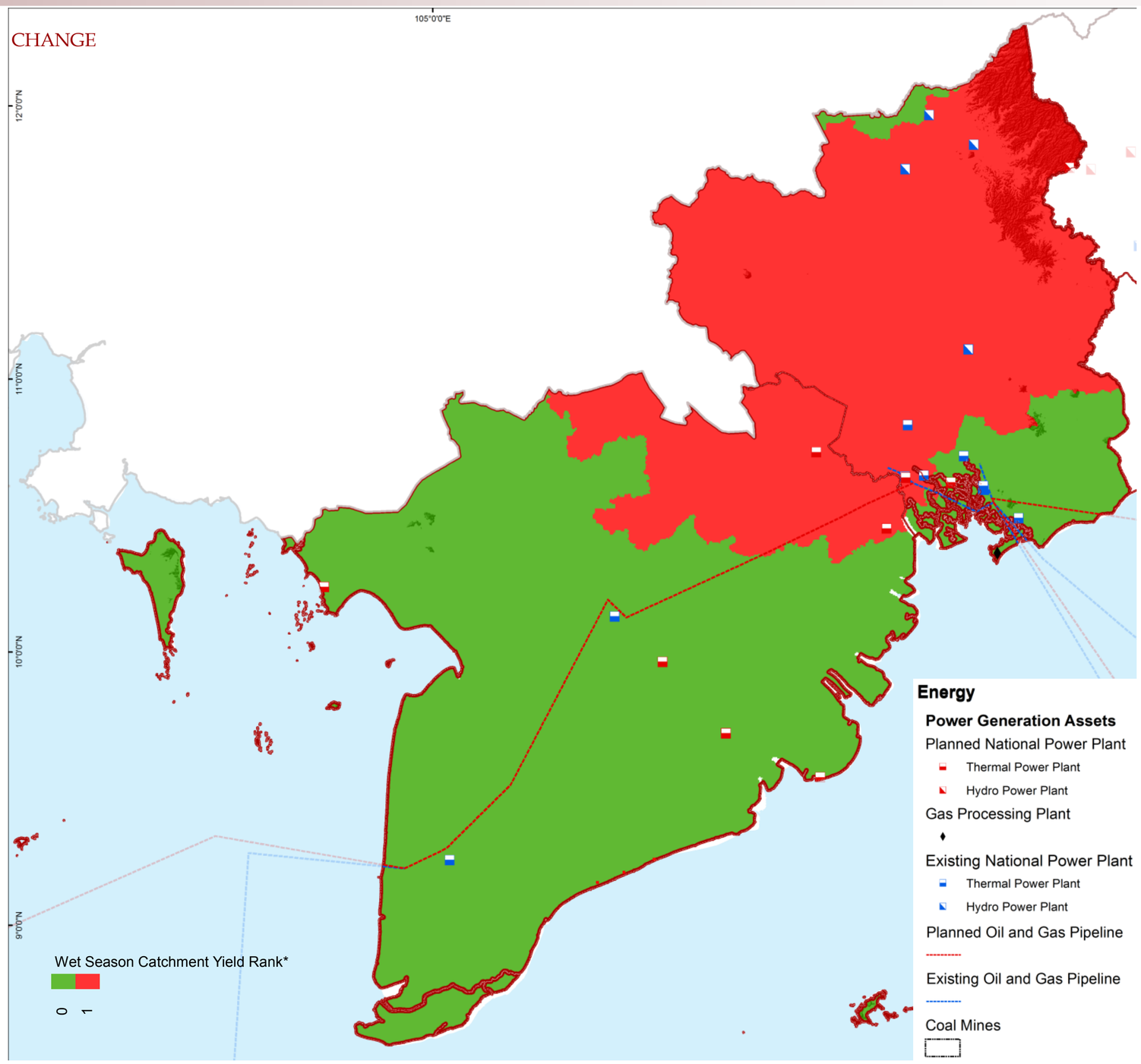
- Thermal Power Plant
- Hydro Power Plant

Planned Oil and Gas Pipeline

Existing Oil and Gas Pipeline

Coal Mines

CHANGE



Energy

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Gas Processing Plant

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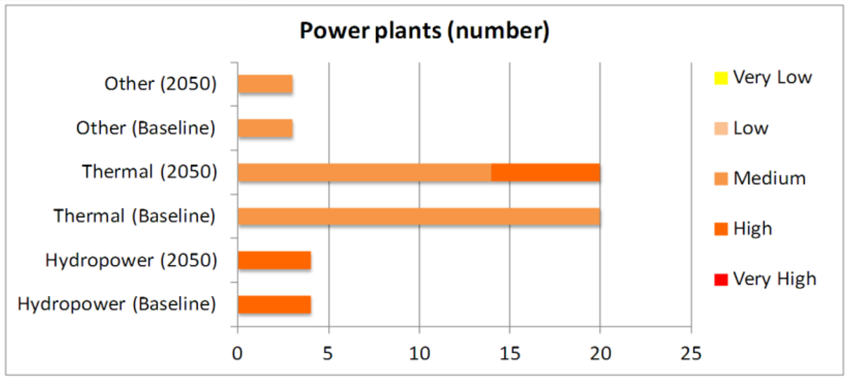
Coal Mines



Region 4 includes the following provinces: An Giang, Bà Rịa Vũng Tàu, Bạc Liêu, Bến Tre, Bình Dương, Bình Phước, Cà Mau, Đồng Nai, Đồng Tháp, Hậu Giang, Kiên Giang, Long An, Sóc Trăng, Tây Ninh, Tiền Giang, TP Cần Thơ, TP Hồ Chí Minh, Trà Vinh, Vinh Long.

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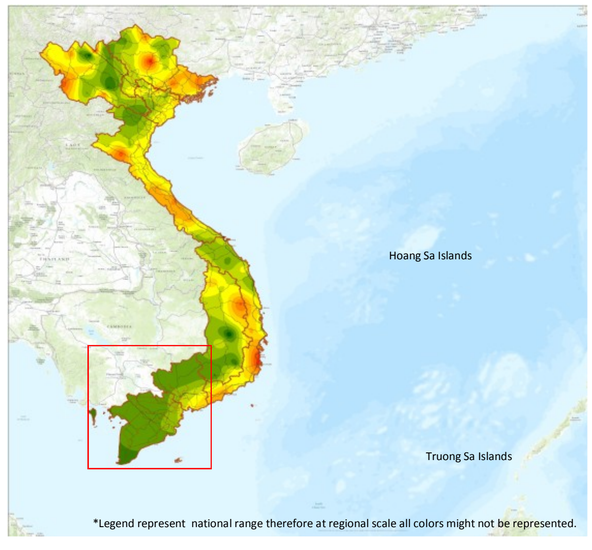
GEOGRAPHIC REFERENCE INFORMATION

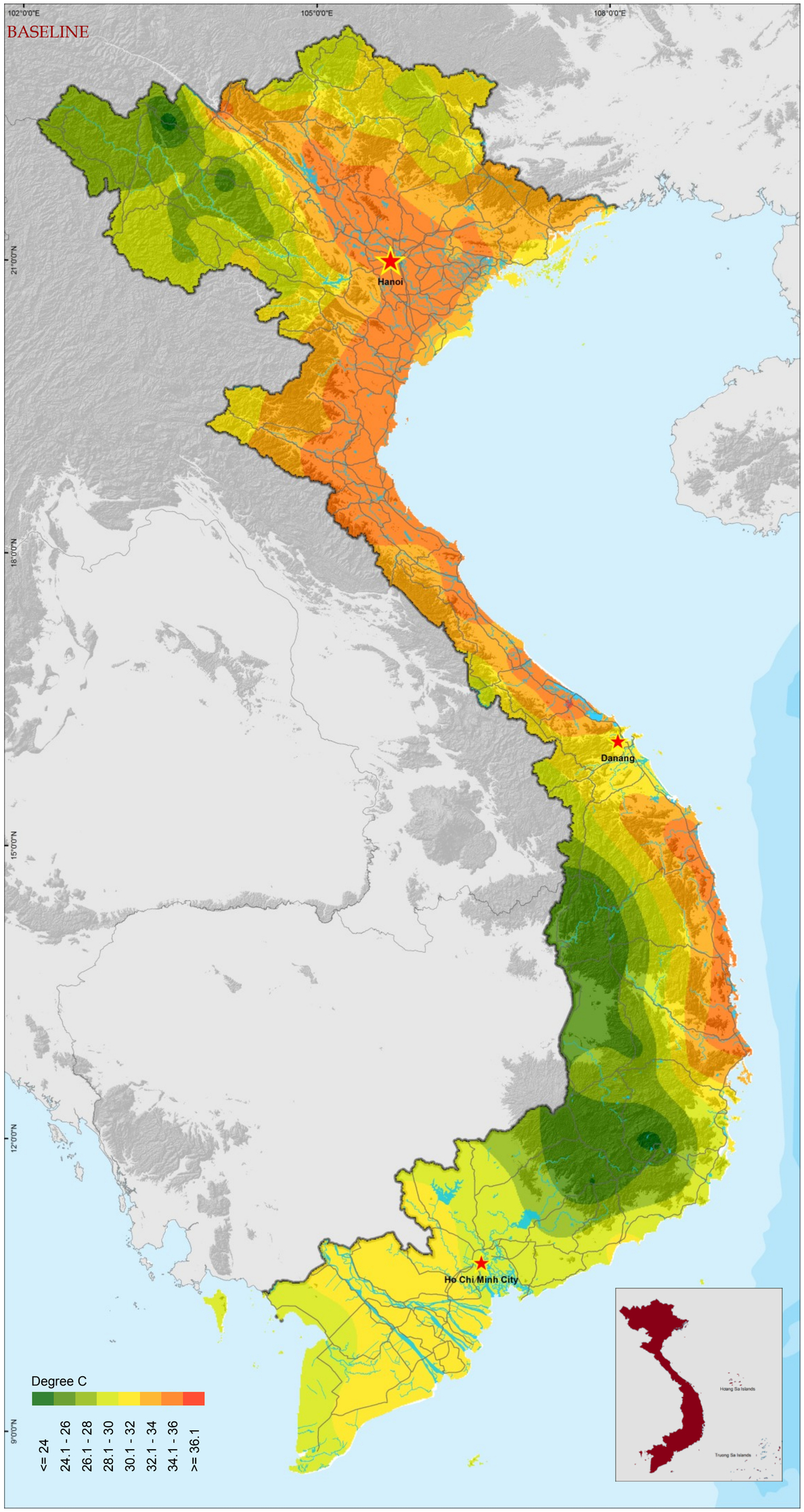
GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

MAP SCALE - 1: 1,200,000

INDEX MAP



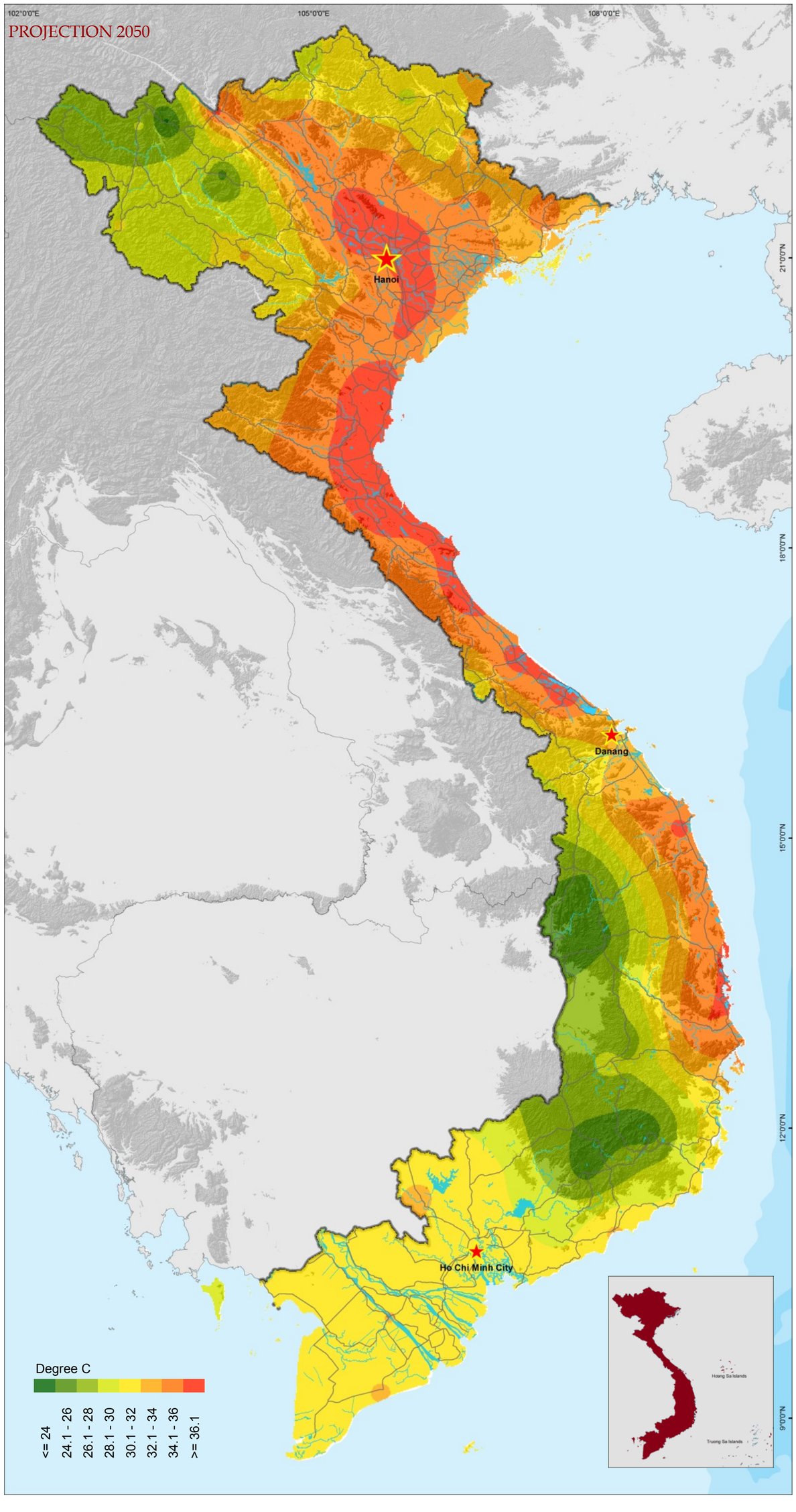
AVERAGE MAXIMUM TEMPERATURE (JUNE - AUGUST)



FUNDING AGENCIES

PARTNERS

COMPANIES



SUMMARY OF NATIONAL ASSESSMENT OF THREAT

Generally, the temperatures and incidence of hot days vary depending on elevation, with high altitude areas being cooler and having fewer hot days than lower altitudes. There are however exceptions, such as the Northwest, Central and South-East region which are hotter because they are affected by overland winds, blowing from Lao PDR to the West of Vietnam. By contrast, the Southern region is affected by the monsoon blowing from the East Sea, which reduces overall temperatures and the incidence of heat waves.

The indicator chosen for sustained heat is mean daily maximum temperature for the hottest months, June to August in the baseline and 2050. Climate projections for 2050 indicate an increase in average maximum temperature during the hottest months, June to August, between 1.2 to 2.2oC compared to the baseline. The highest relative temperature increases tend to be in the higher altitude areas, which have lower baseline temperatures. The exception to this is in the area between Da Nang and Thanh Hoa, which will experience a 6 to 8% temperature increase. There are slightly lower temperature increases of 1.2oC to 1.6oC in the lower parts of the Delta, south of the Central Highlands and a few coastal areas near Ha Noi, Da Nang and Nha Trang.

From the analysis of sustained heat threat against energy assets in the national assessment, it has been determined that 93% of existing and 88% of planned thermal power plants (i.e. coal-fired, CCGT) are in the High and Very High categories, indicating that they are significantly affected by the forecast increase in average maximum temperature. All three planned nuclear plants (categorized as “other generation”) are also in the High and Very High range, indicating that they are planned to be built in areas with significant temperature risk that may affect their performance. Hydropower plants are less affected by this threat.

Thermal plants, including coal, gas and nuclear plants are negatively affected by higher cooling water temperatures and, unless this is taken into account during plant design, plant economics and operational lifetimes of equipment may suffer.

Around 20% of the high voltage substations (by number) are in the High or Very High range, while around 56% of existing and 63% of planned transmission lines (by length) would be affected. Of the planned transmission lines, 500kV transmission lines or the backbone of the North-South national grid system are particularly highly impacted with 70% of the length of planned lines at High or Very High risk.

Operational lifetimes can be reduced and grid system losses can increase as a result of the sustained heat, which can result in overheating of transformers in substations and transmission line sagging and reduced conductivity.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

IE - ENERGY INFRASTRUCTURE

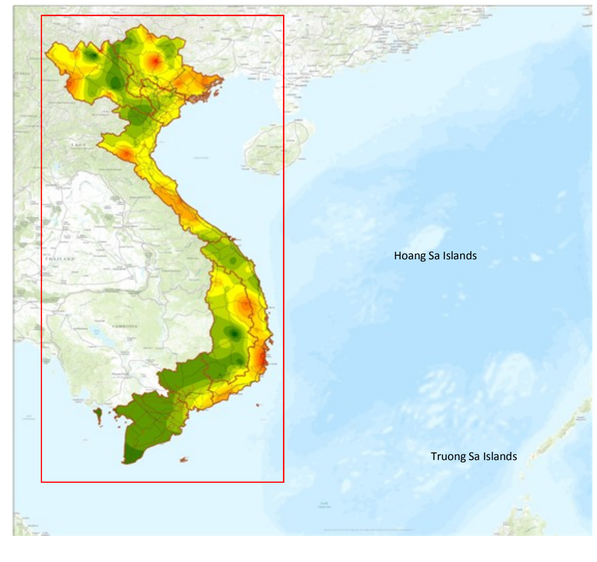
GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

N
W
E
S

MAP SCALE - 1: 3,000,000

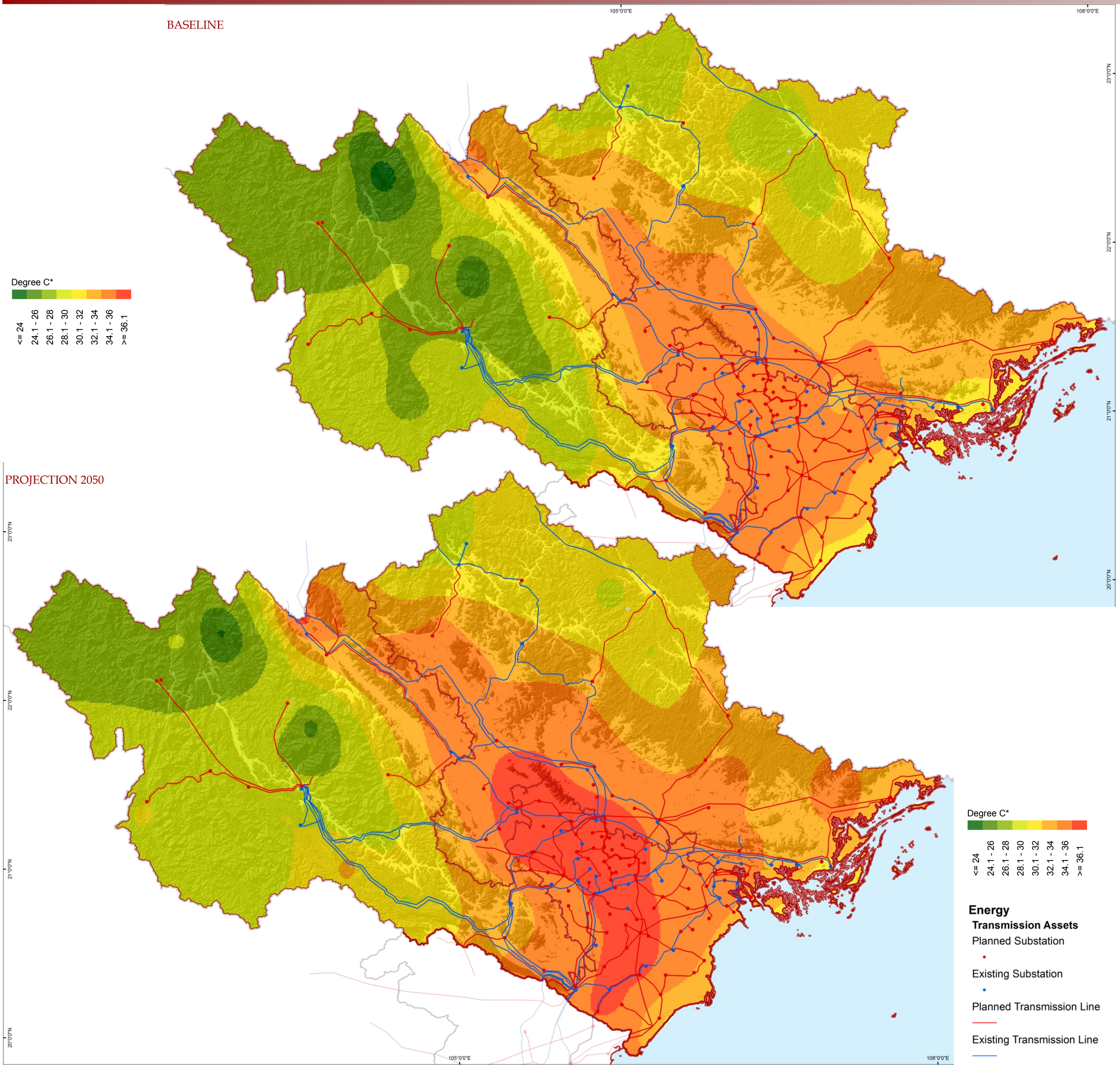
INDEX MAP



REGION 1 - TRANSMISSION LINE AND SUBSTATION (AVERAGE MAXIMUM TEMPERATURE JUNE - AUGUST)

BASELINE

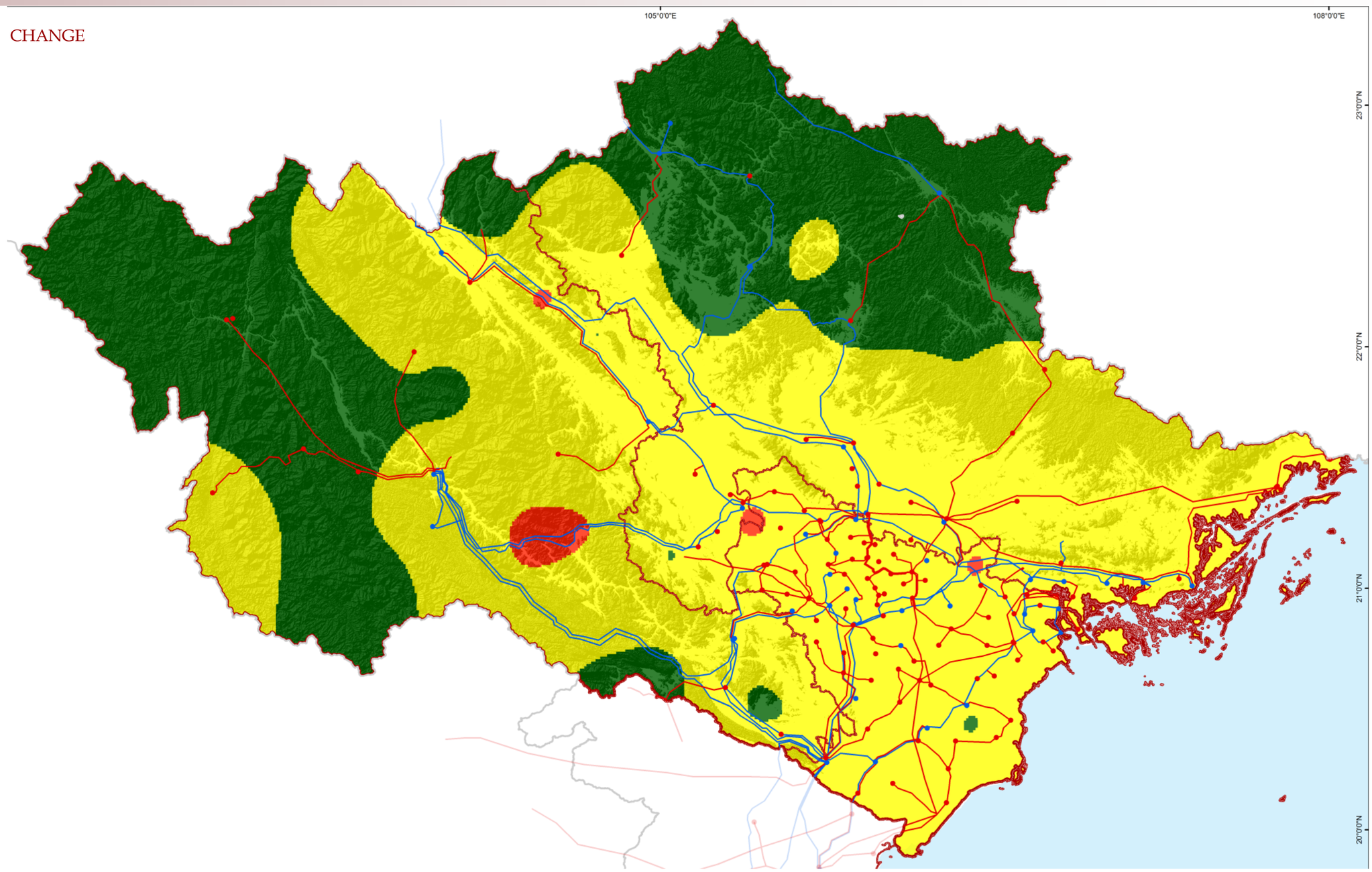
PROJECTION 2050

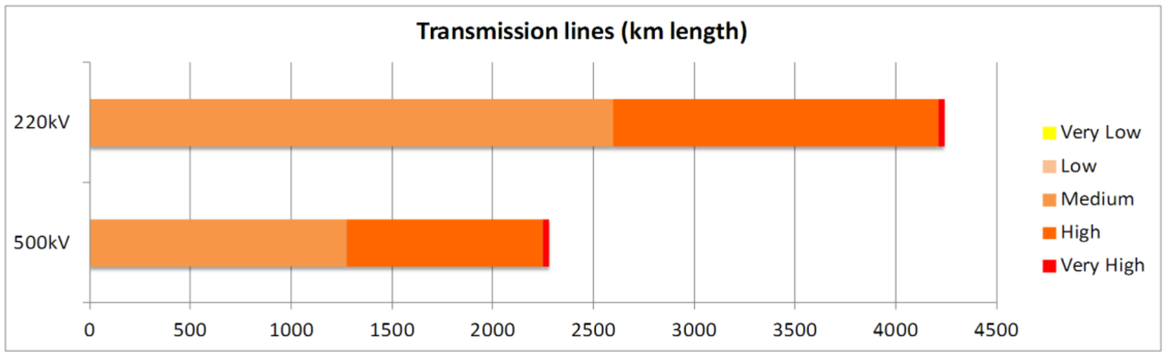


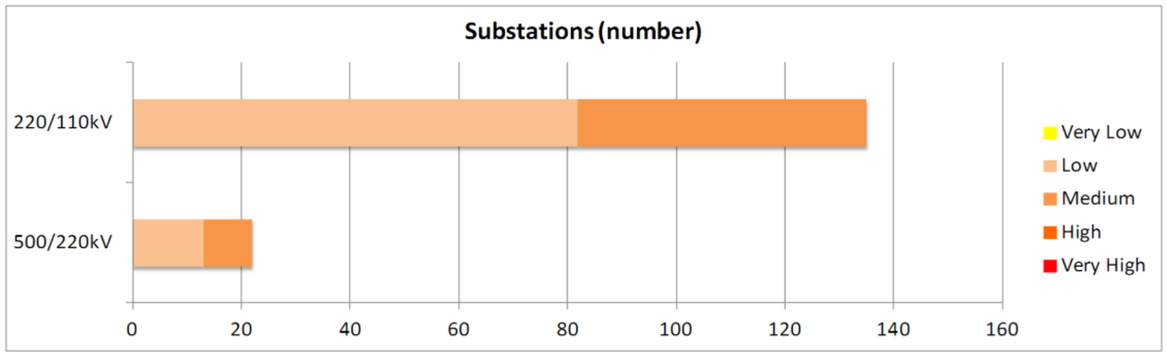
FUNDING AGENCIES

PARTNERS

COMPANIES







Region 1 includes the following provinces: Bắc Cạn, Bắc Giang, Bắc Ninh, Cao Bằng, Điện Biên, Hà Giang, Hà Nam, Hà Nội, Hải Dương, Hải Phòng, Hoà Bình, Hưng Yên, Lai Châu, Lạng Sơn, Lào Cai, Nam Định, Ninh Bình, Phú Thọ, Quảng Ninh, Sơn La, Thái Bình, Thái Nguyên, Tuyên Quang, Vĩnh Phúc, Yên Bái.

DATA SOURCES

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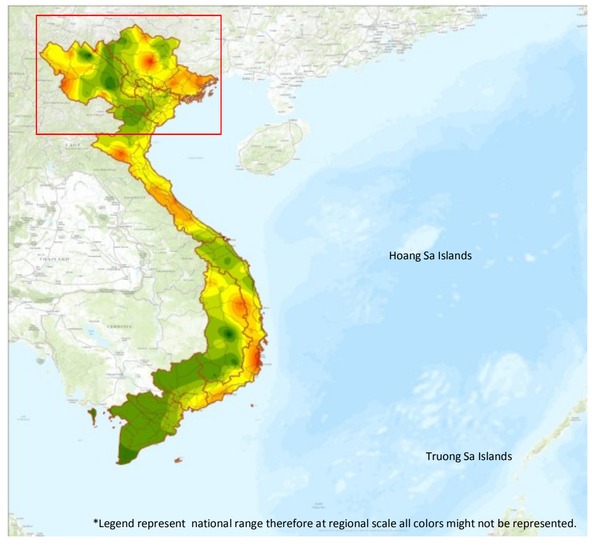
GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

MAP SCALE - 1: 1,200,000

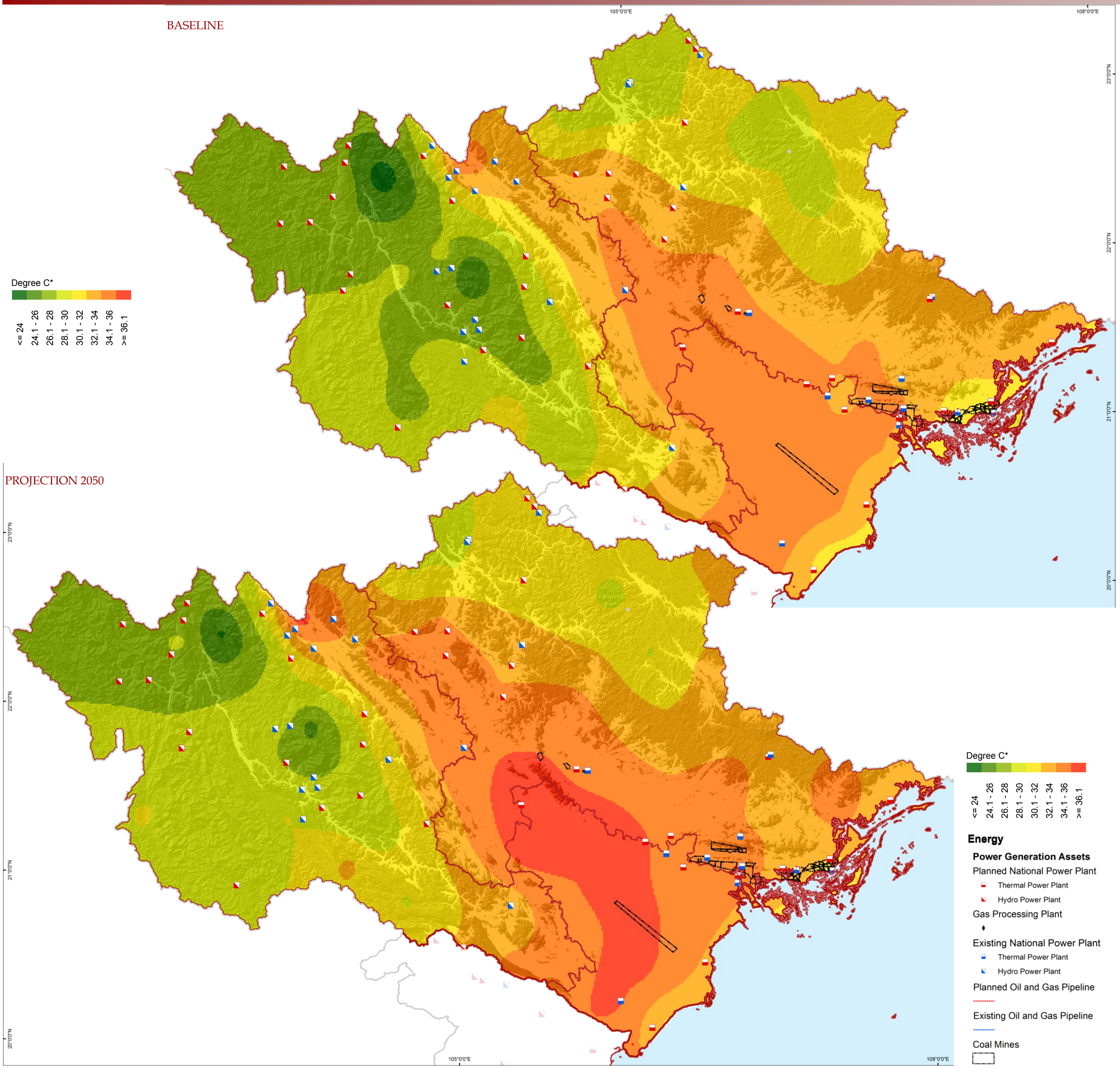
INDEX MAP



REGION 1 - POWER PLANTS (AVERAGE MAXIMUM TEMPERATURE JUNE - AUGUST)

BASELINE

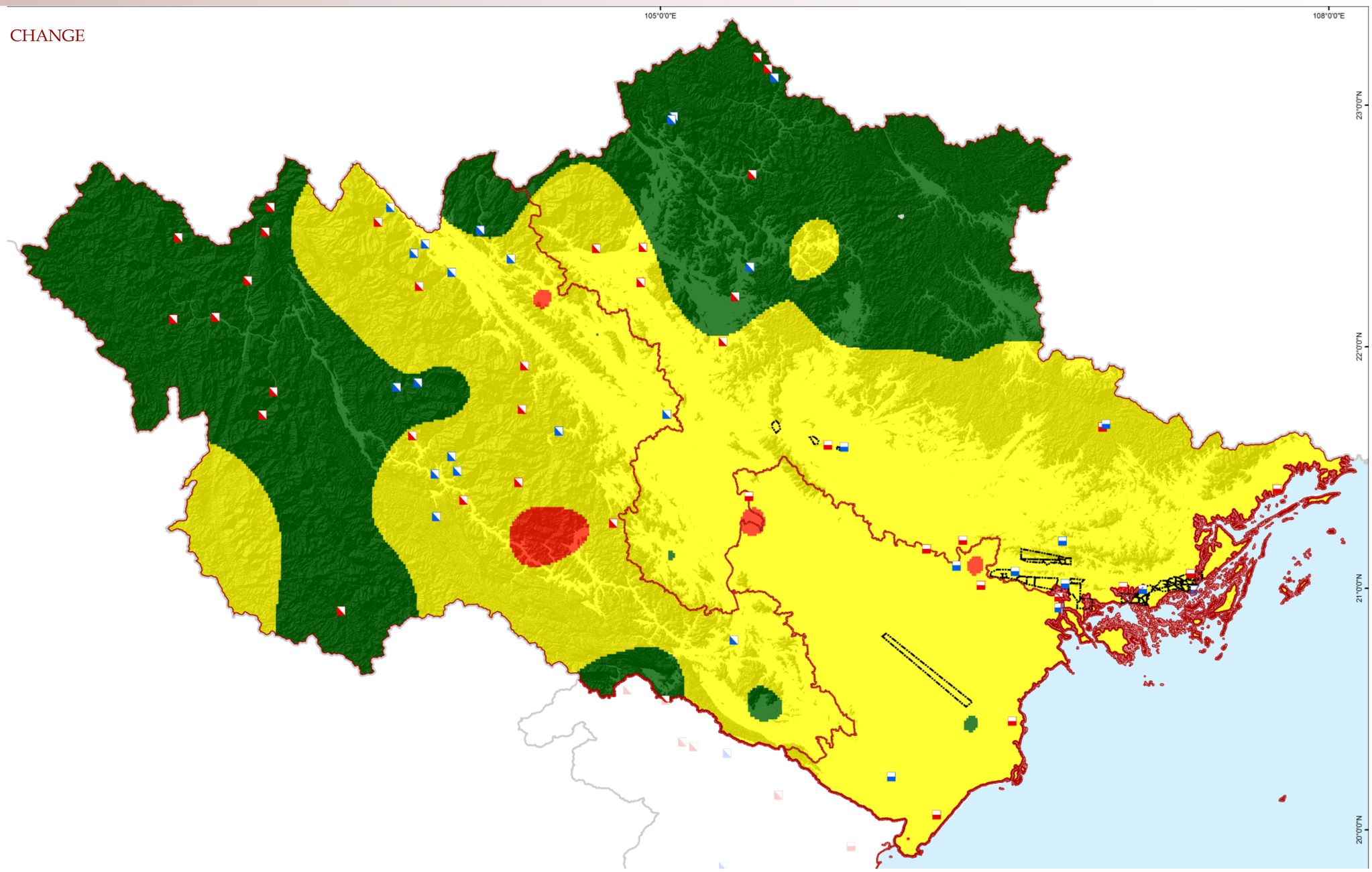
PROJECTION 2050

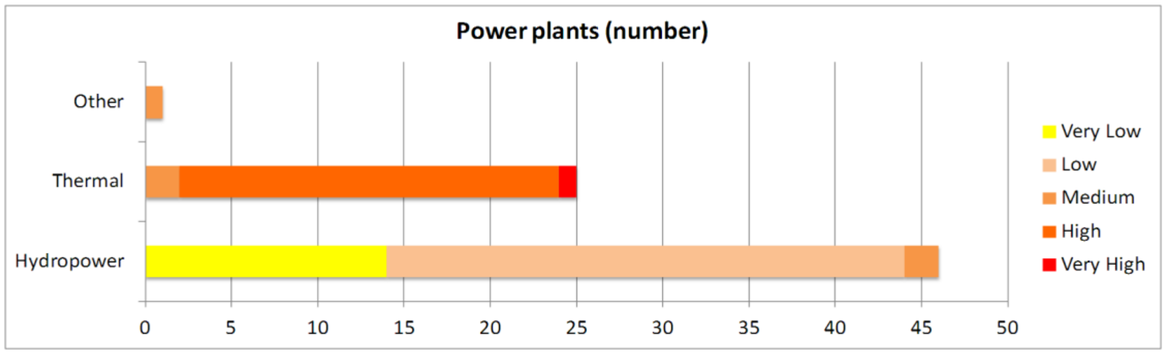


FUNDING AGENCIES

PARTNERS

COMPANIES





Region 1 includes the following provinces: Bắc Cạn, Bắc Giang, Bắc Ninh, Cao Bằng, Điện Biên, Hà Giang, Hà Nam, Hà Nội, Hải Dương, Hải Phòng, Hoà Bình, Hưng Yên, Lai Châu, Lạng Sơn, Lào Cai, Nam Định, Ninh Bình, Phú Thọ, Quảng Ninh, Sơn La, Thái Bình, Thái Nguyên, Tuyên Quang, Vĩnh Phúc, Yên Bái.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

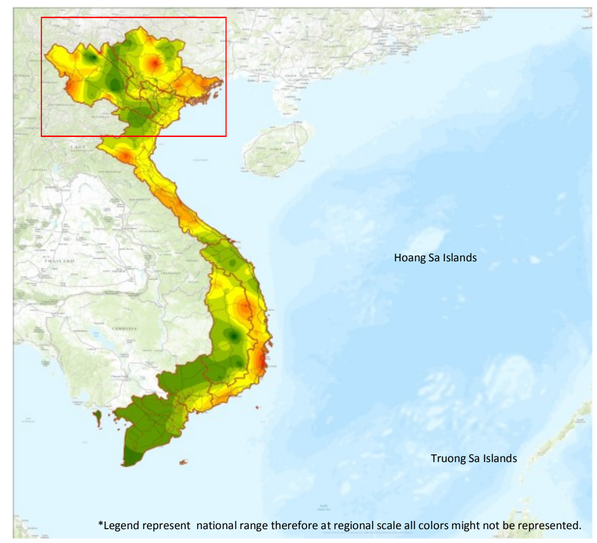
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

MAP SCALE - 1: 1,200,000

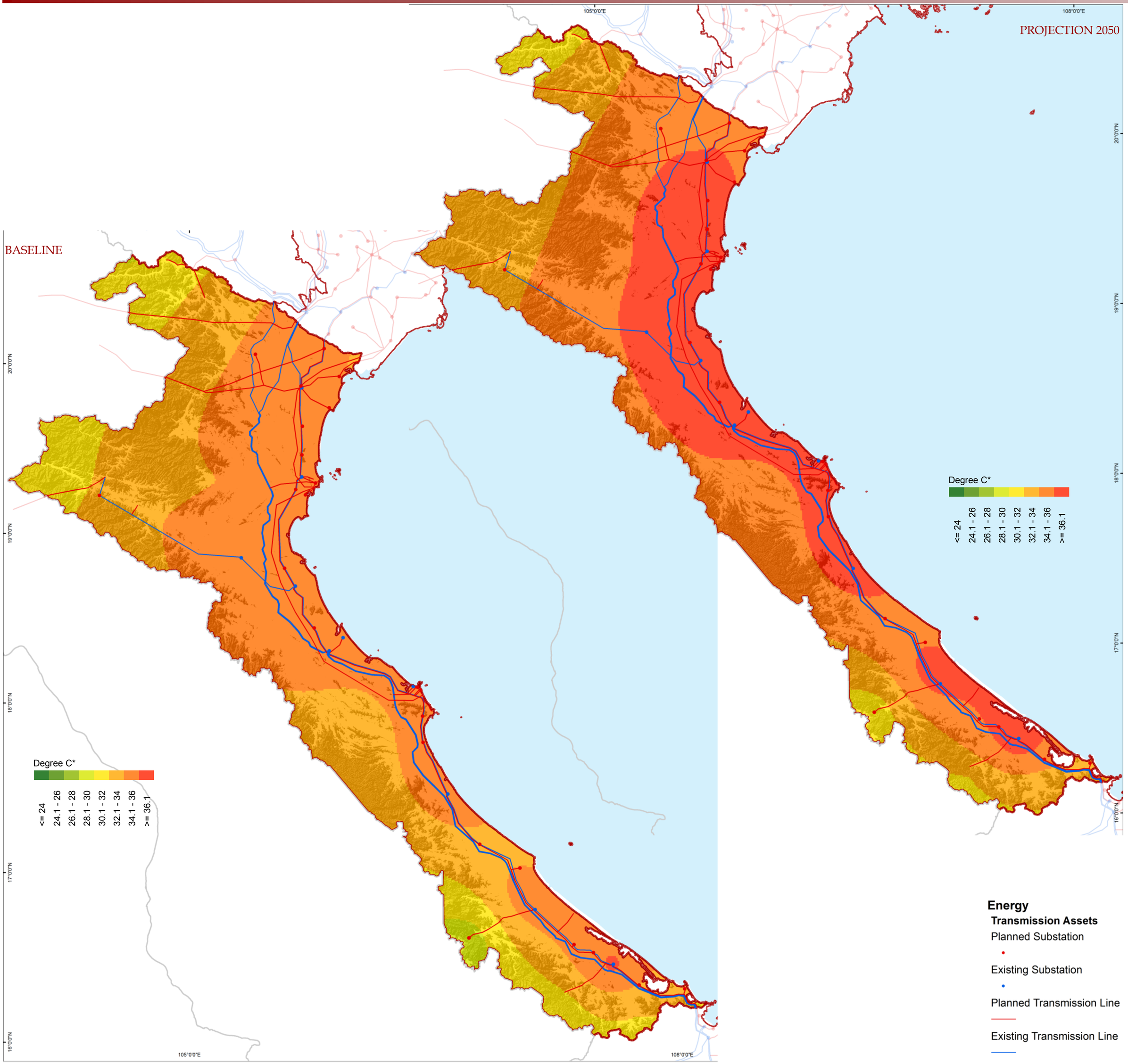
INDEX MAP



REGION 2 - TRANSMISSION LINE AND SUBSTATION (AVERAGE MAXIMUM TEMPERATURE JUNE - AUGUST)

BASELINE

PROJECTION 2050



Energy

Transmission Assets

Planned Substation

Existing Substation

Planned Transmission Line

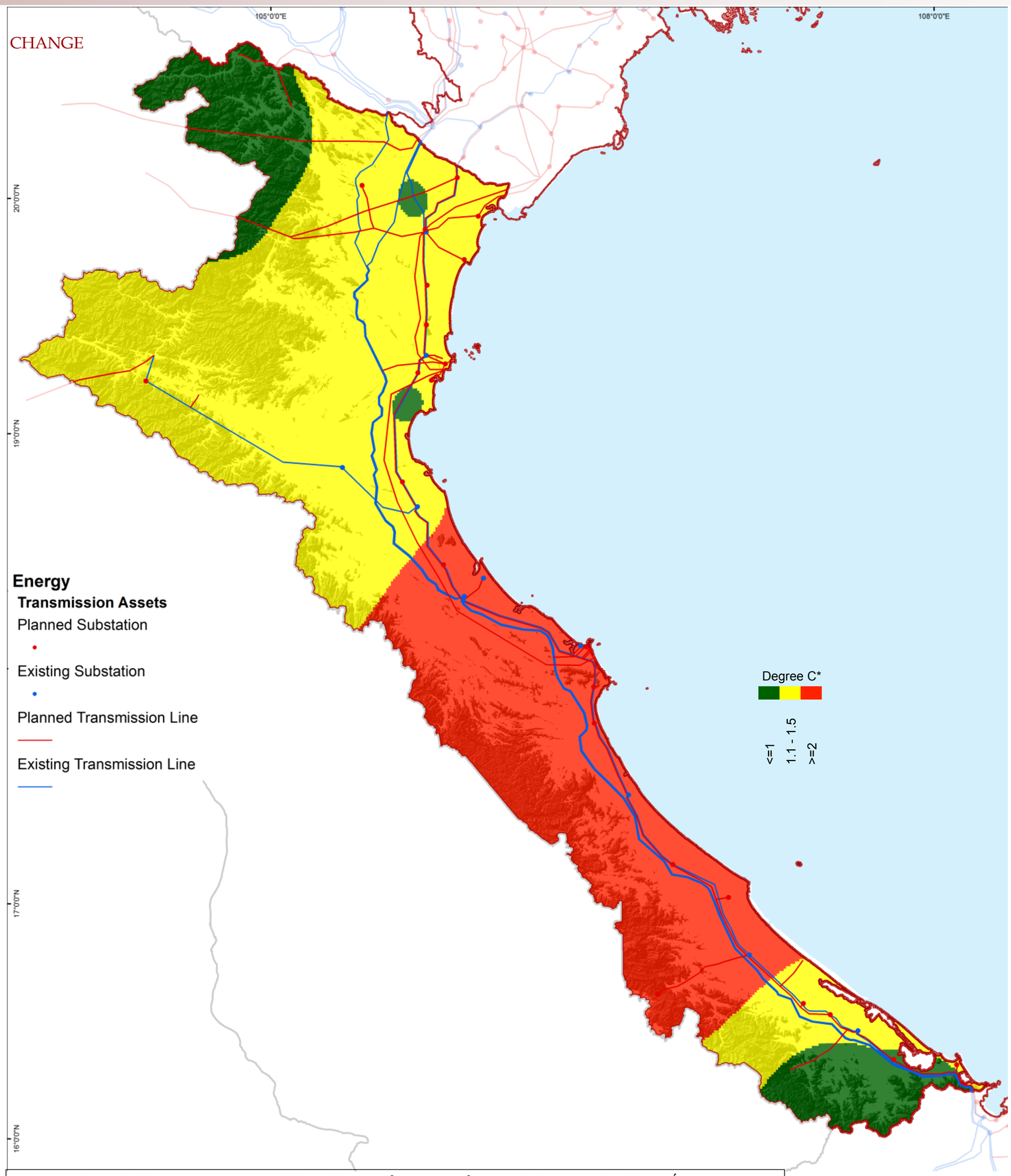
Existing Transmission Line

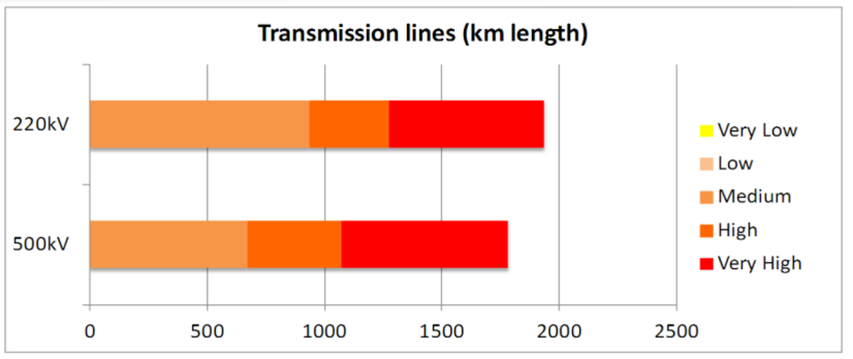
FUNDING AGENCIES

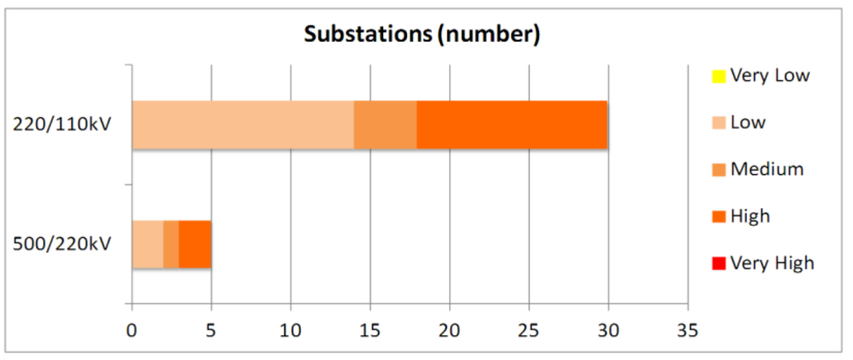
PARTNERS

COMPANIES

CHANGE







Region 2 includes the following provinces: Hà Tĩnh, Nghệ An, Quảng Bình, Quảng Trị, Thanh Hoá, Thừa Thiên Huế.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

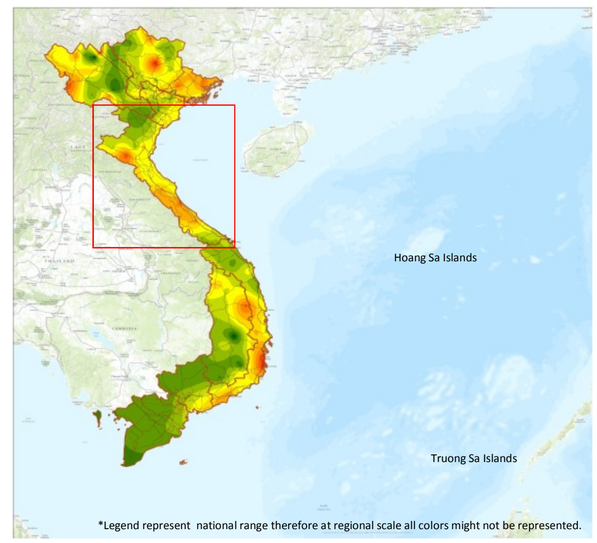
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

MAP SCALE - 1: 1,200,000

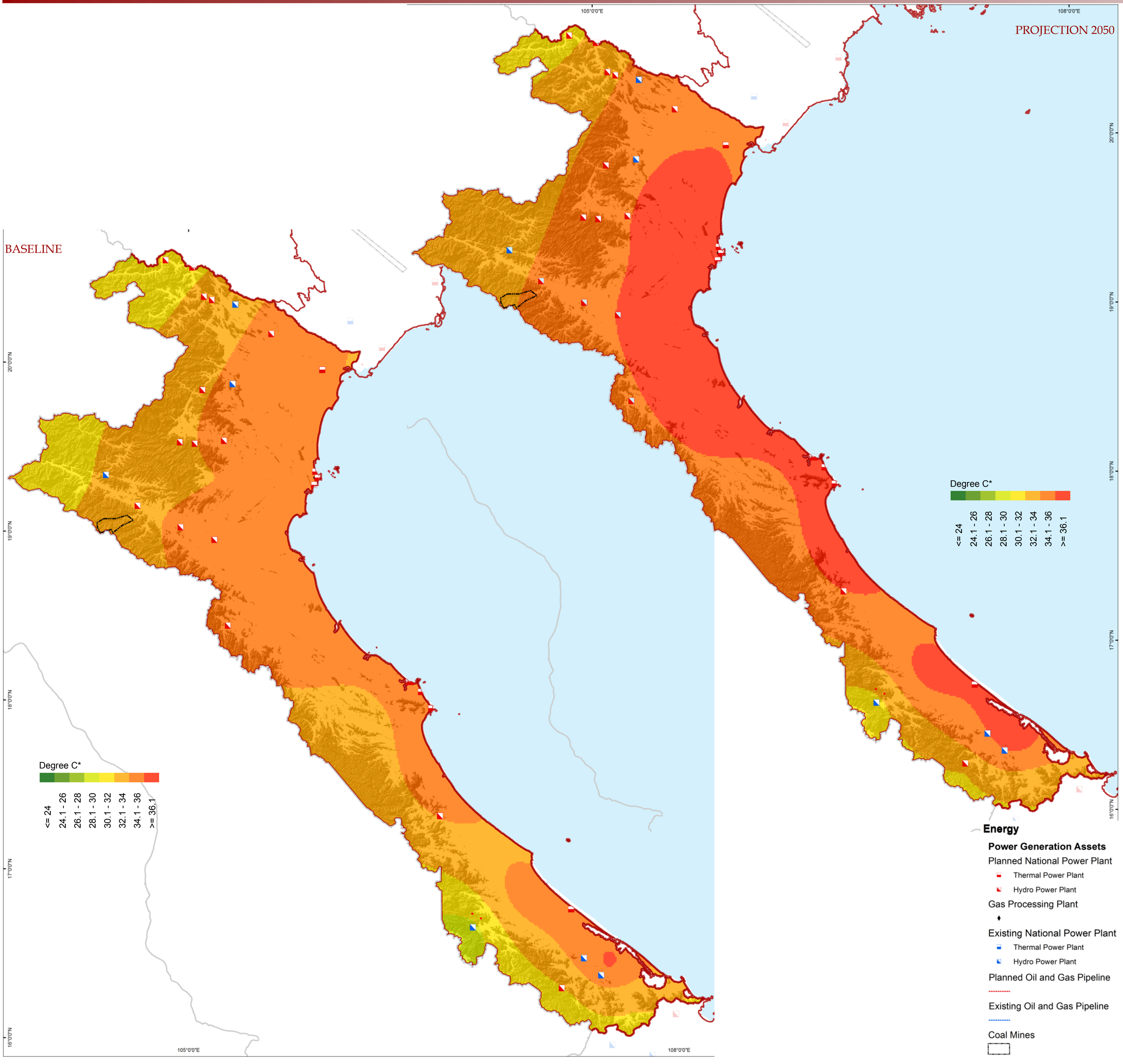
INDEX MAP



REGION 2 - POWER PLANTS (AVERAGE MAXIMUM TEMPERATURE JUNE - AUGUST)

BASELINE

PROJECTION 2050

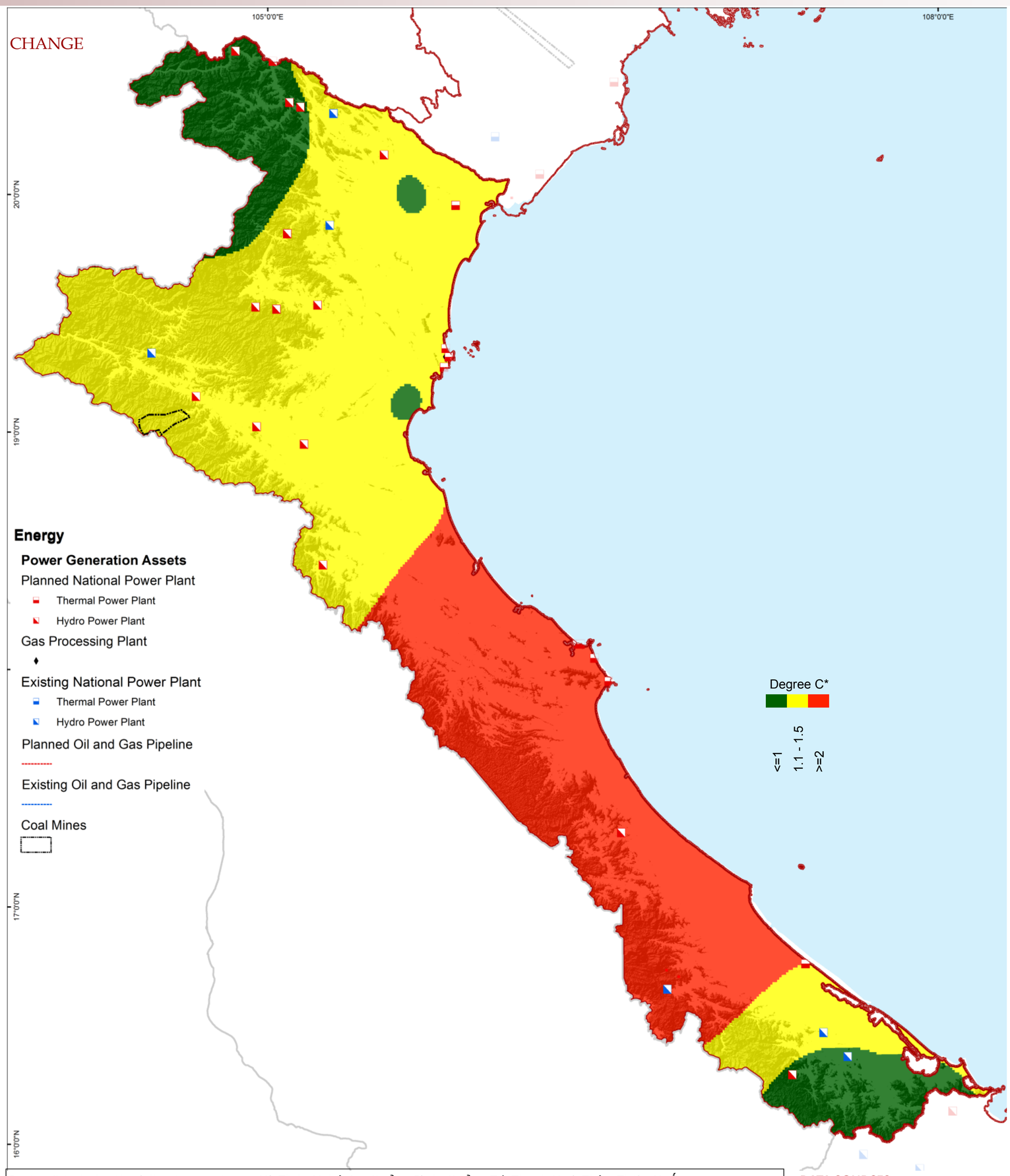


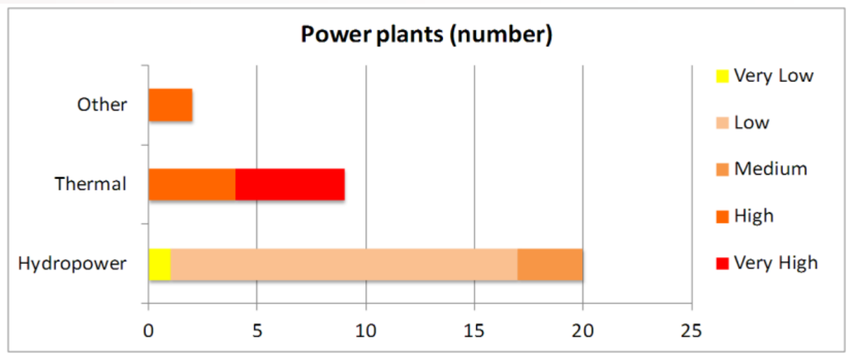
FUNDING AGENCIES

PARTNERS

COMPANIES

CHANGE





Region 2 includes the following provinces: Hà Tĩnh, Nghệ An, Quảng Bình, Quảng Trị, Thanh Hoá, Thừa Thiên Huế.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

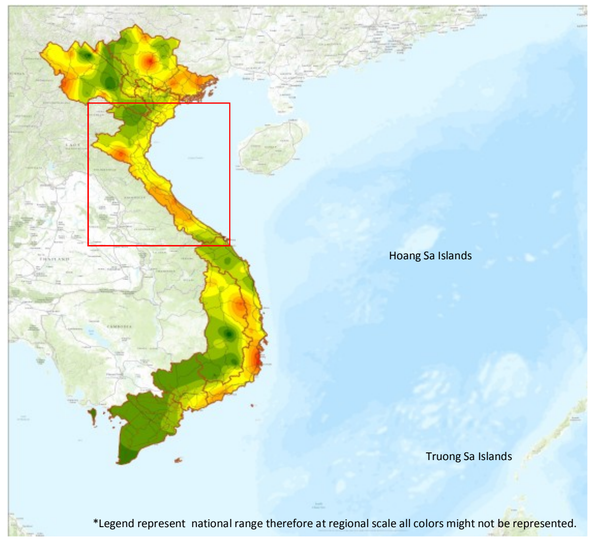
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

MAP SCALE - 1: 1,200,000

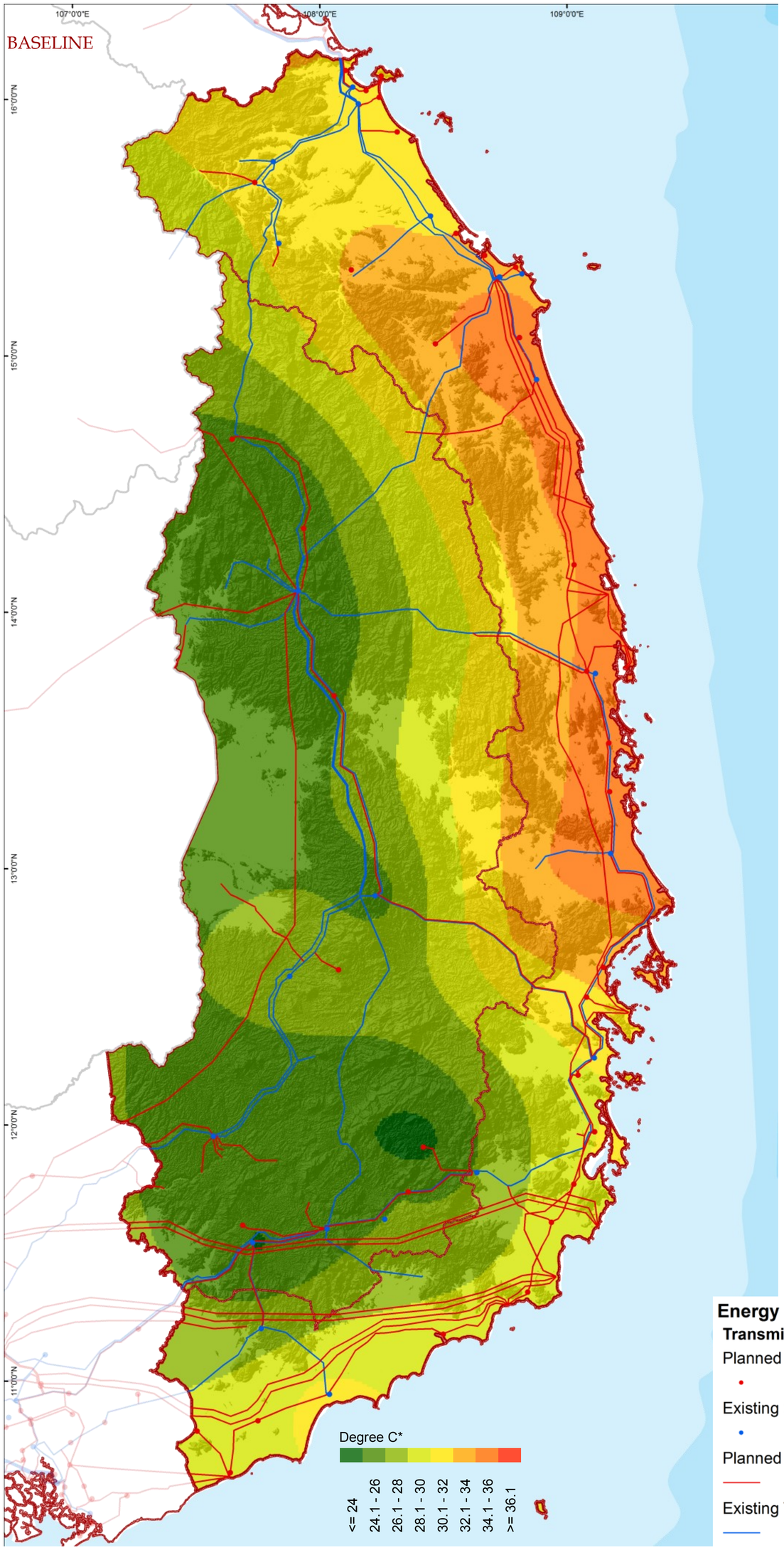
INDEX MAP



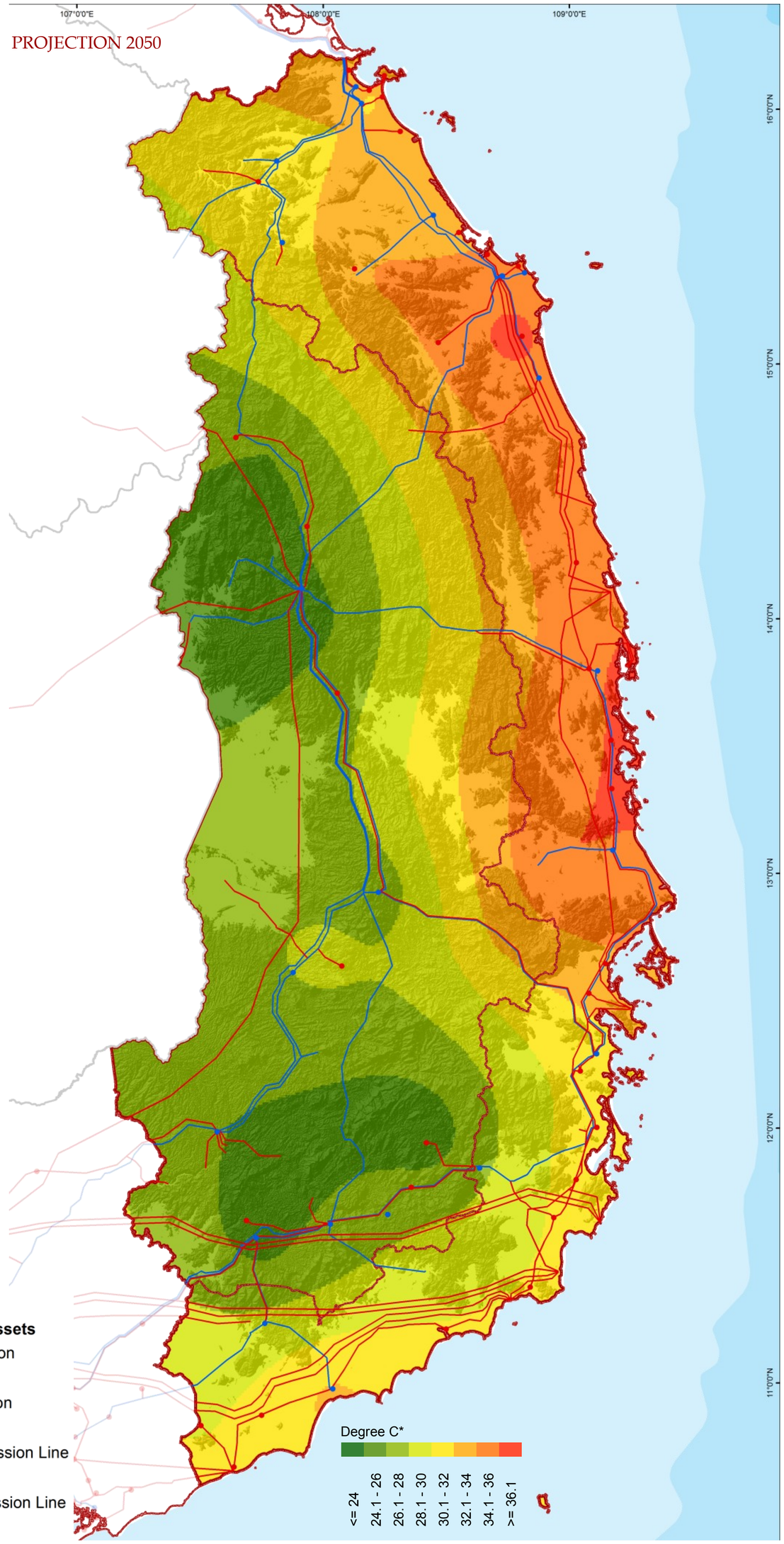
*Legend represent national range therefore at regional scale all colors might not be represented.

REGION 3 - TRANSMISSION LINE AND SUBSTATION (AVERAGE MAXIMUM TEMPERATURE JUNE - AUGUST)

BASELINE



PROJECTION 2050



Energy

Transmission Assets

Planned Substation

Existing Substation

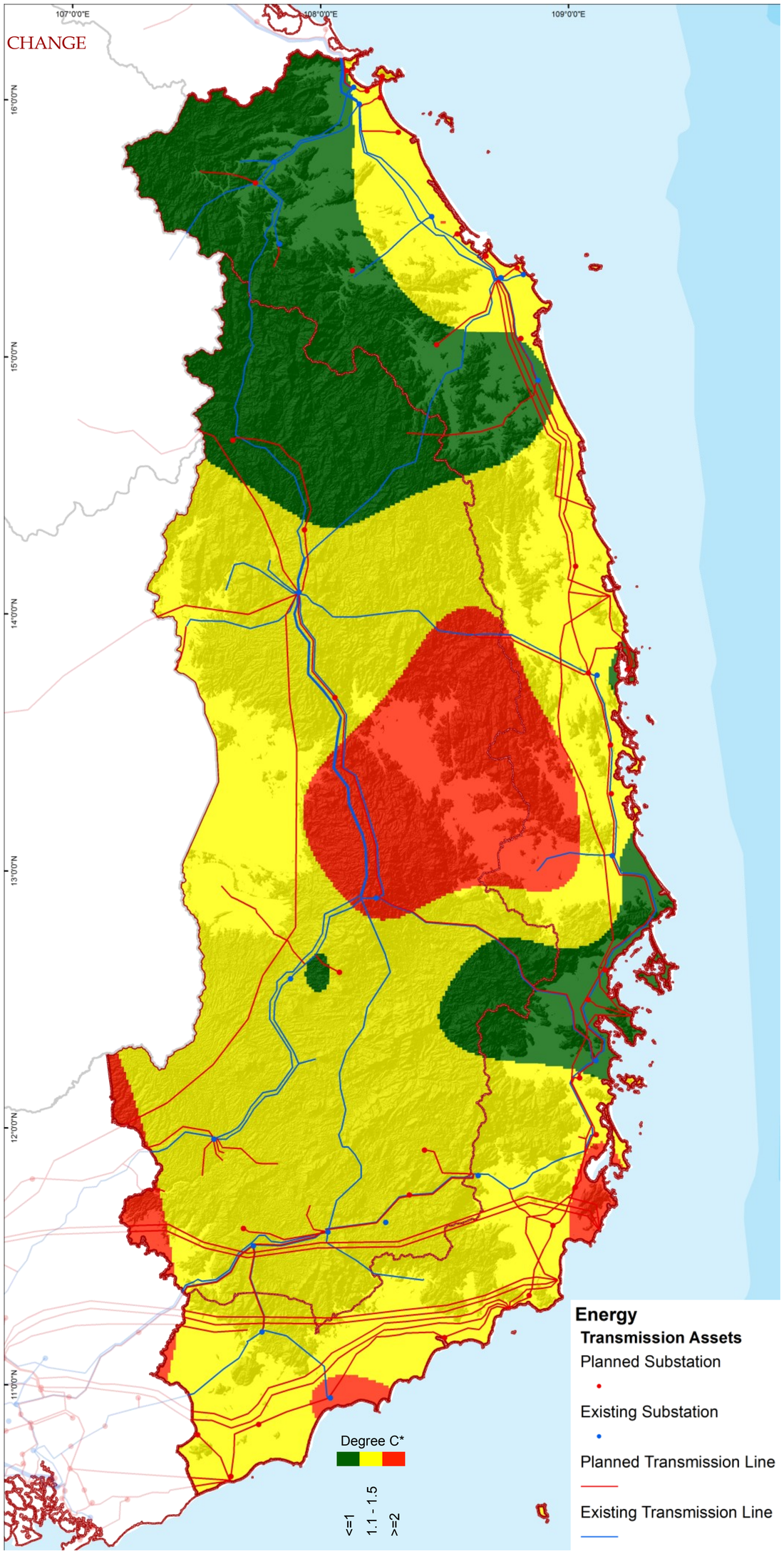
Planned Transmission Line

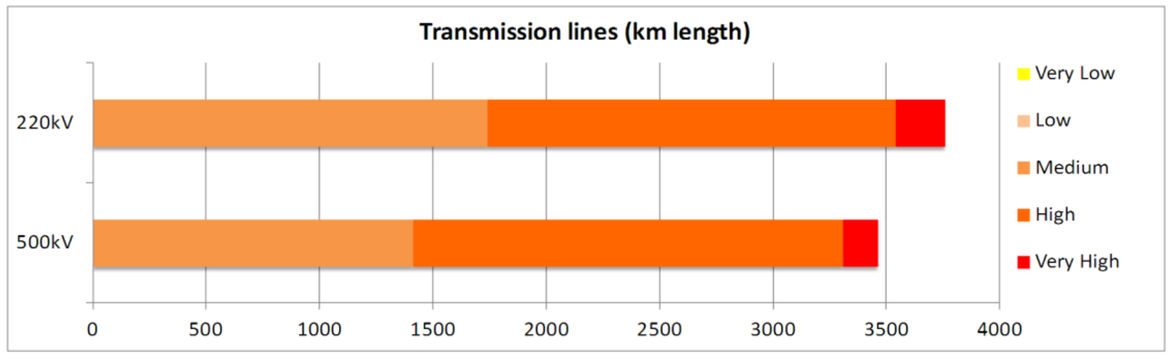
Existing Transmission Line

FUNDING AGENCIES

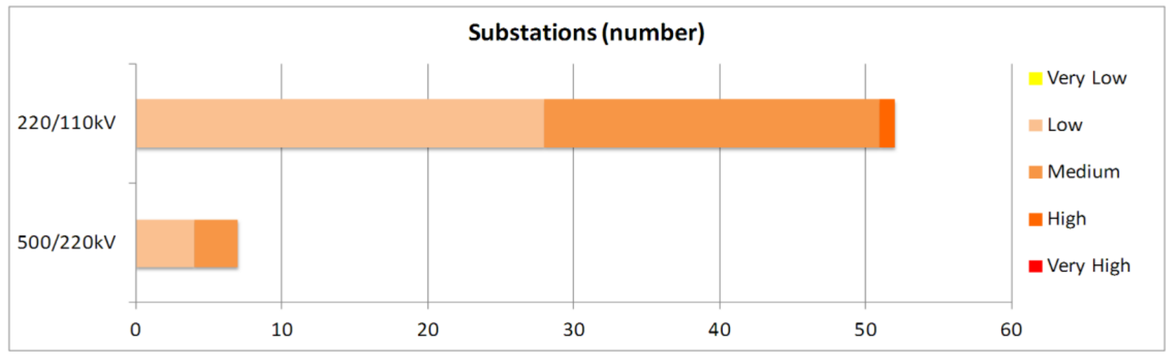
PARTNERS

COMPANIES





Region 3 includes the following provinces: Bình Định, Bình Thuận, Đà Nẵng, Đăk Lăk, Đăk Nông, Gia Lai, Khánh Hoà, Kon Tum, Lâm Đồng, Ninh Thuận, Phú Yên, Quảng Nam, Quảng Ngãi.



DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

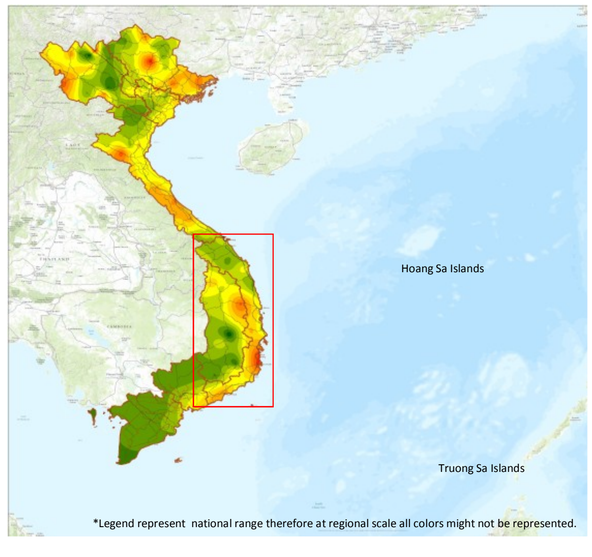
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

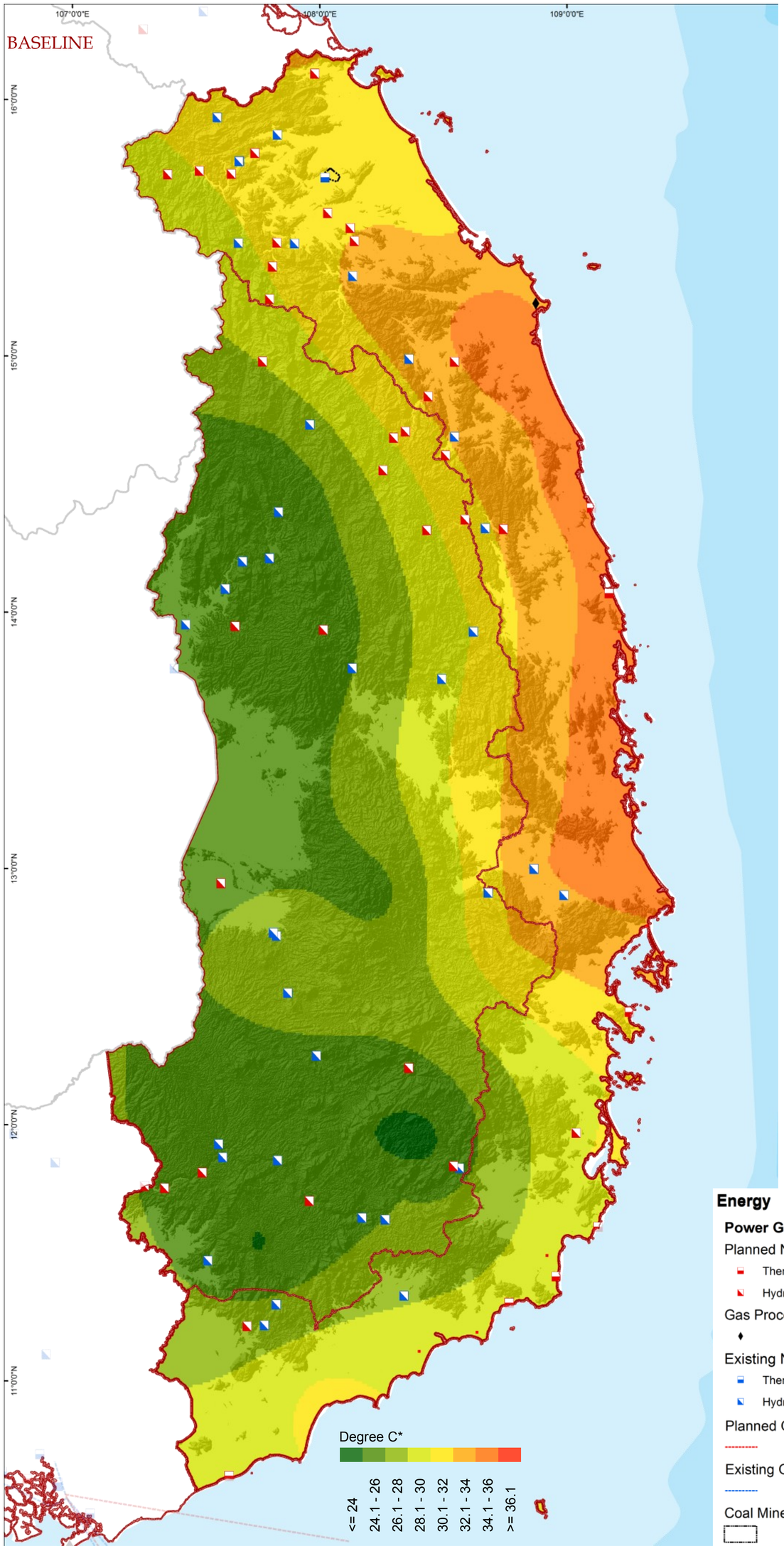
MAP SCALE - 1: 1,200,000

INDEX MAP

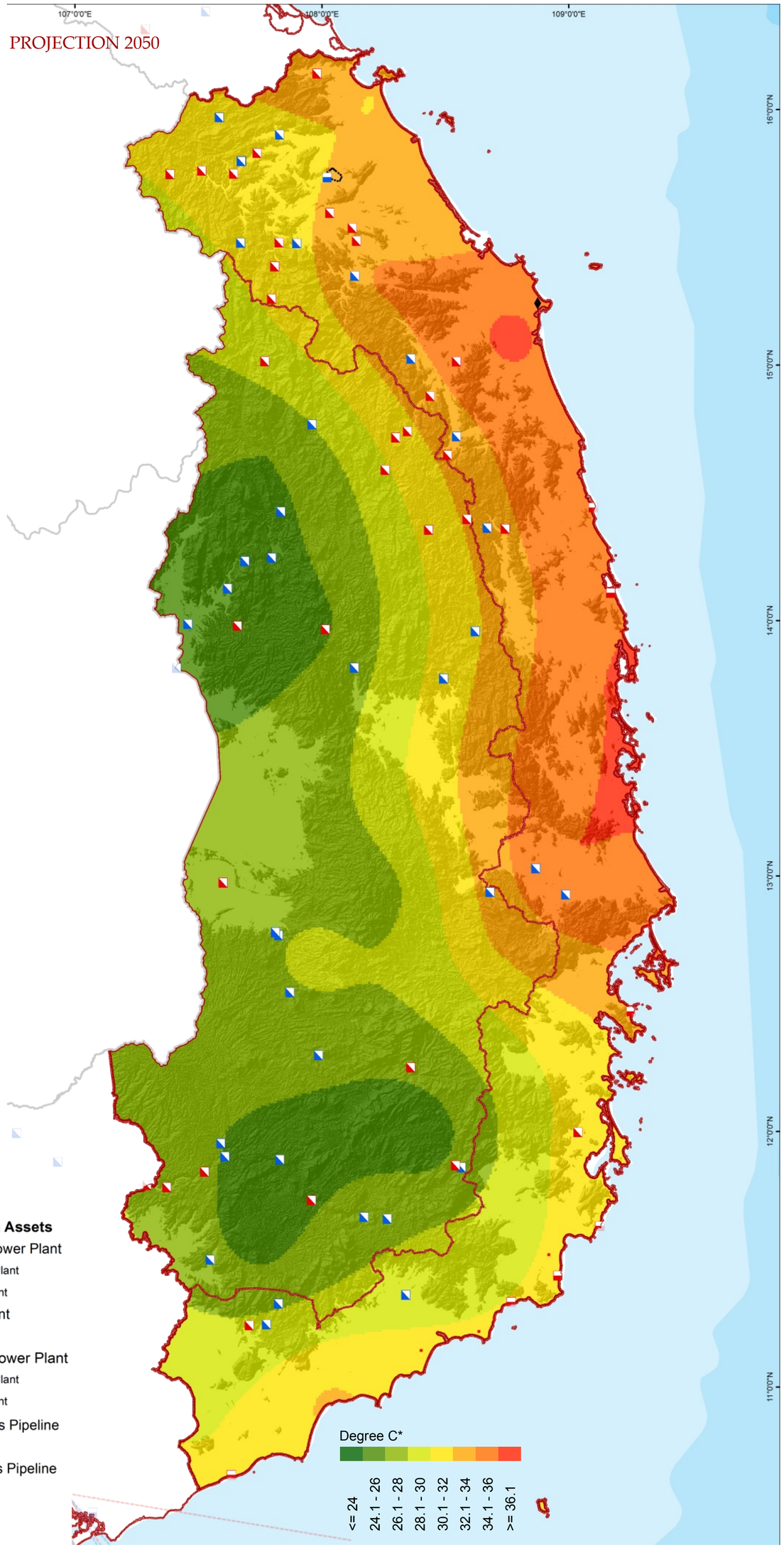


REGION 3 - POWER PLANTS (AVERAGE MAXIMUM TEMPERATURE JUNE - AUGUST)

BASELINE



PROJECTION 2050



Energy

Power Generation Assets

Planned National Power Plant

- Thermal Power Plant
- Hydro Power Plant

Gas Processing Plant

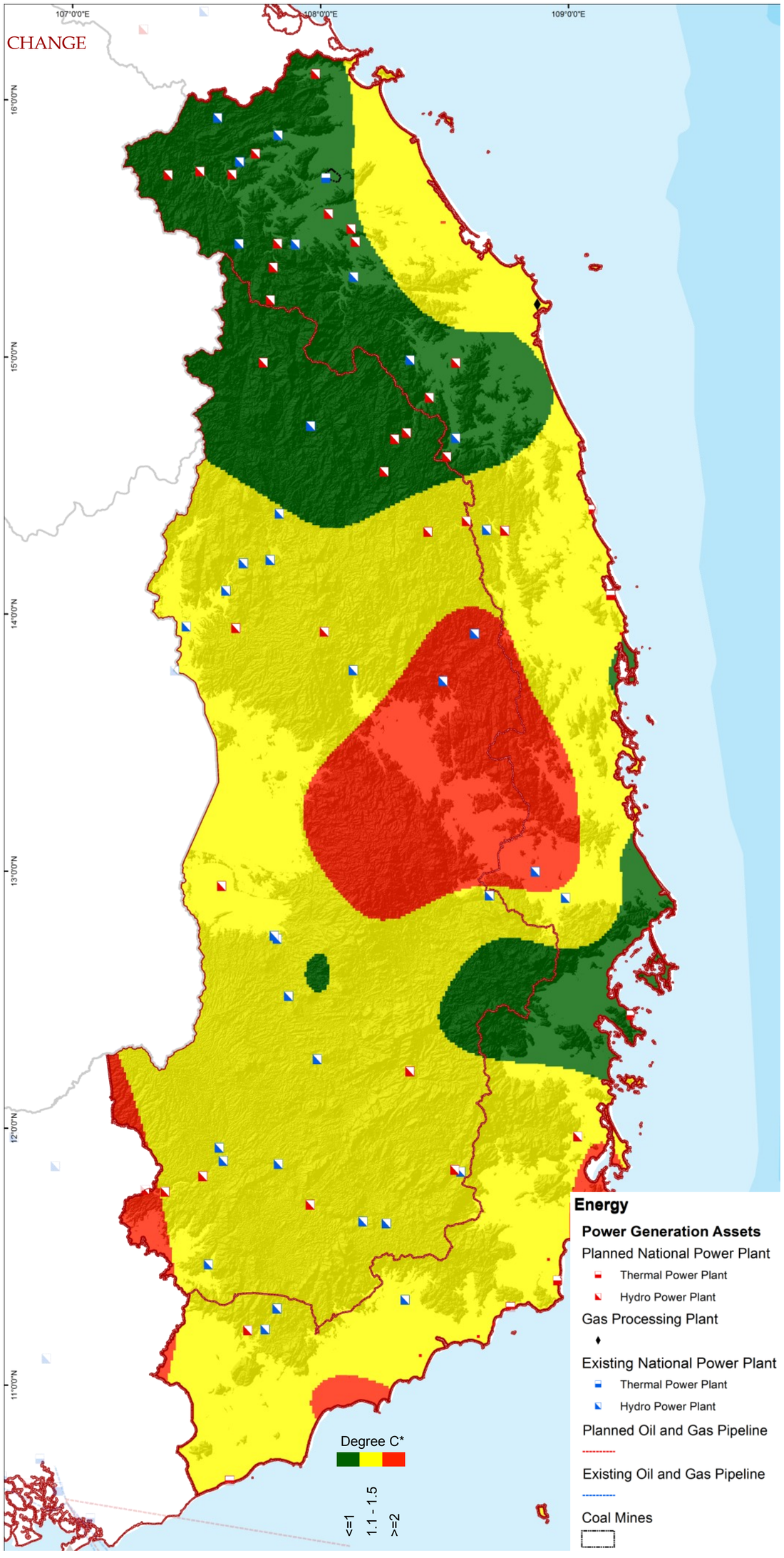
Existing National Power Plant

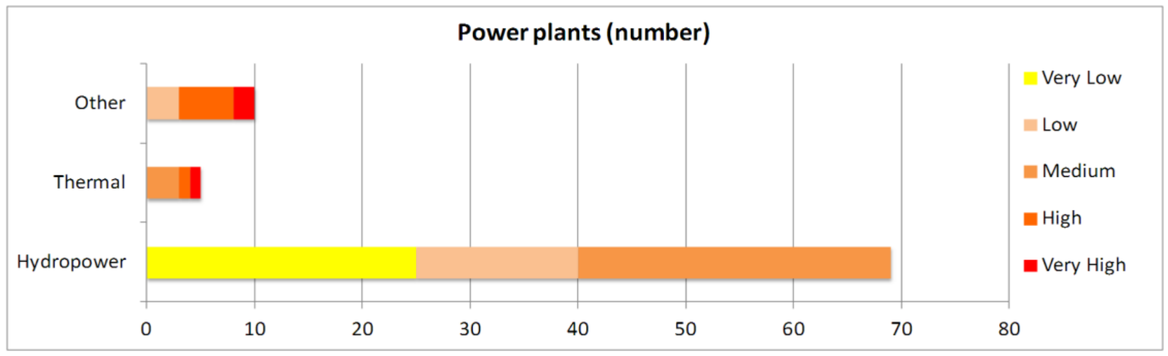
- Thermal Power Plant
- Hydro Power Plant

Planned Oil and Gas Pipeline

Existing Oil and Gas Pipeline

Coal Mines





Region 3 includes the following provinces: Bình Định, Bình Thuận, Đà Nẵng, Đăk Lăk, Đăk Nông, Gia Lai, Khánh Hoà, Kon Tum, Lâm Đồng, Ninh Thuận, Phú Yên, Quảng Nam, Quảng Ngãi.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

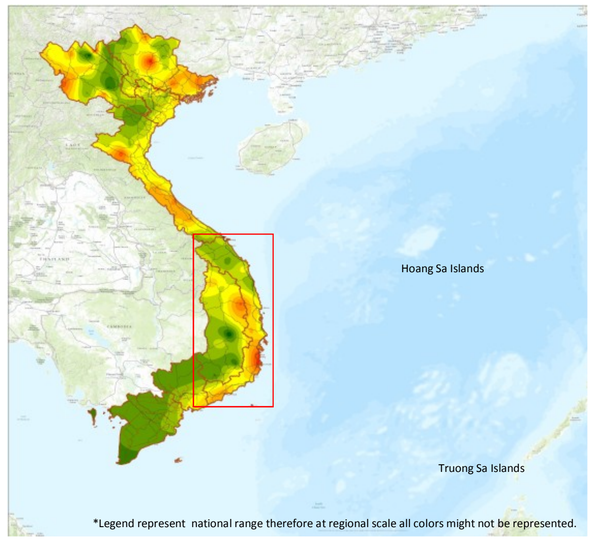
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

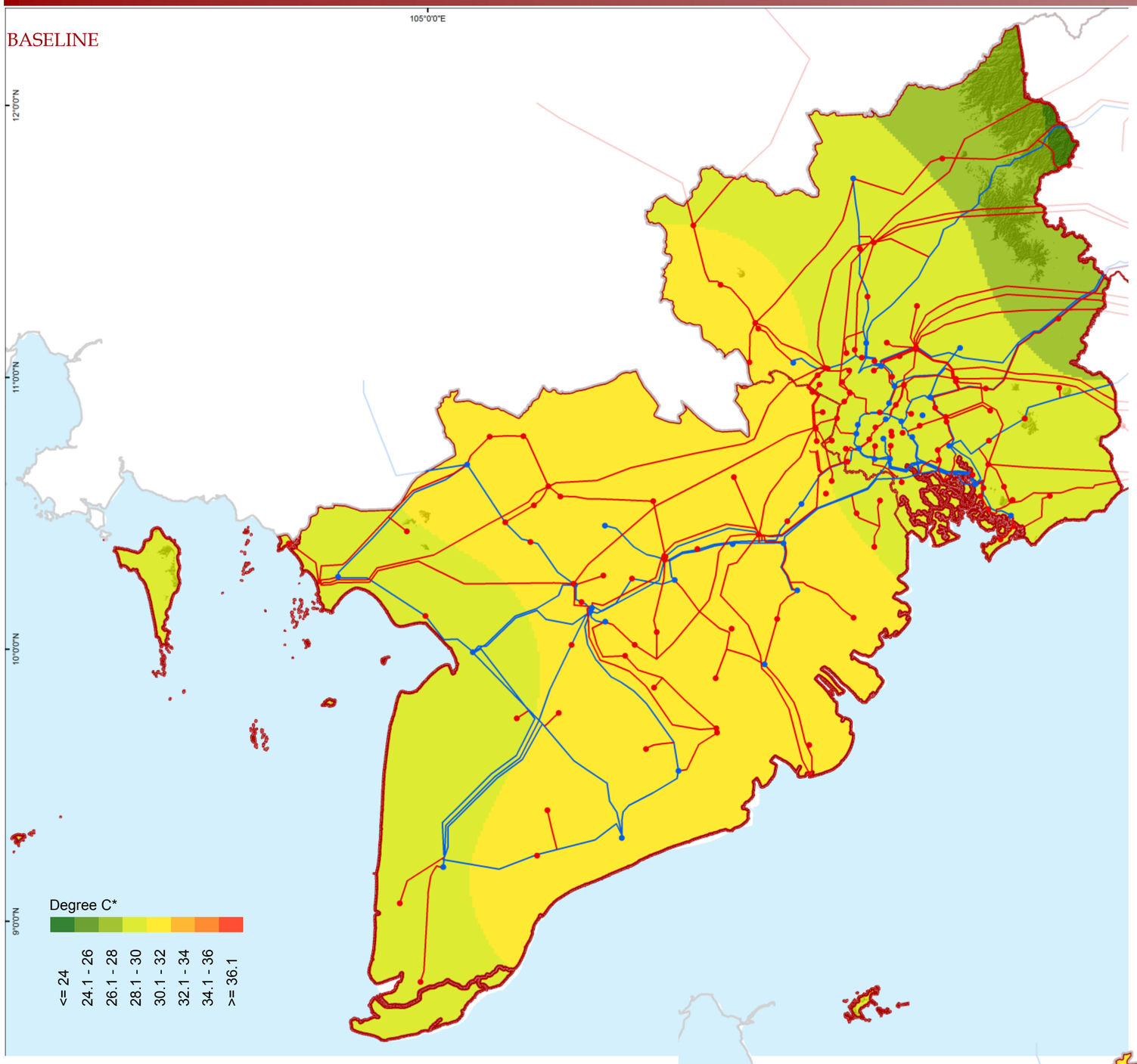
MAP SCALE - 1: 1,200,000

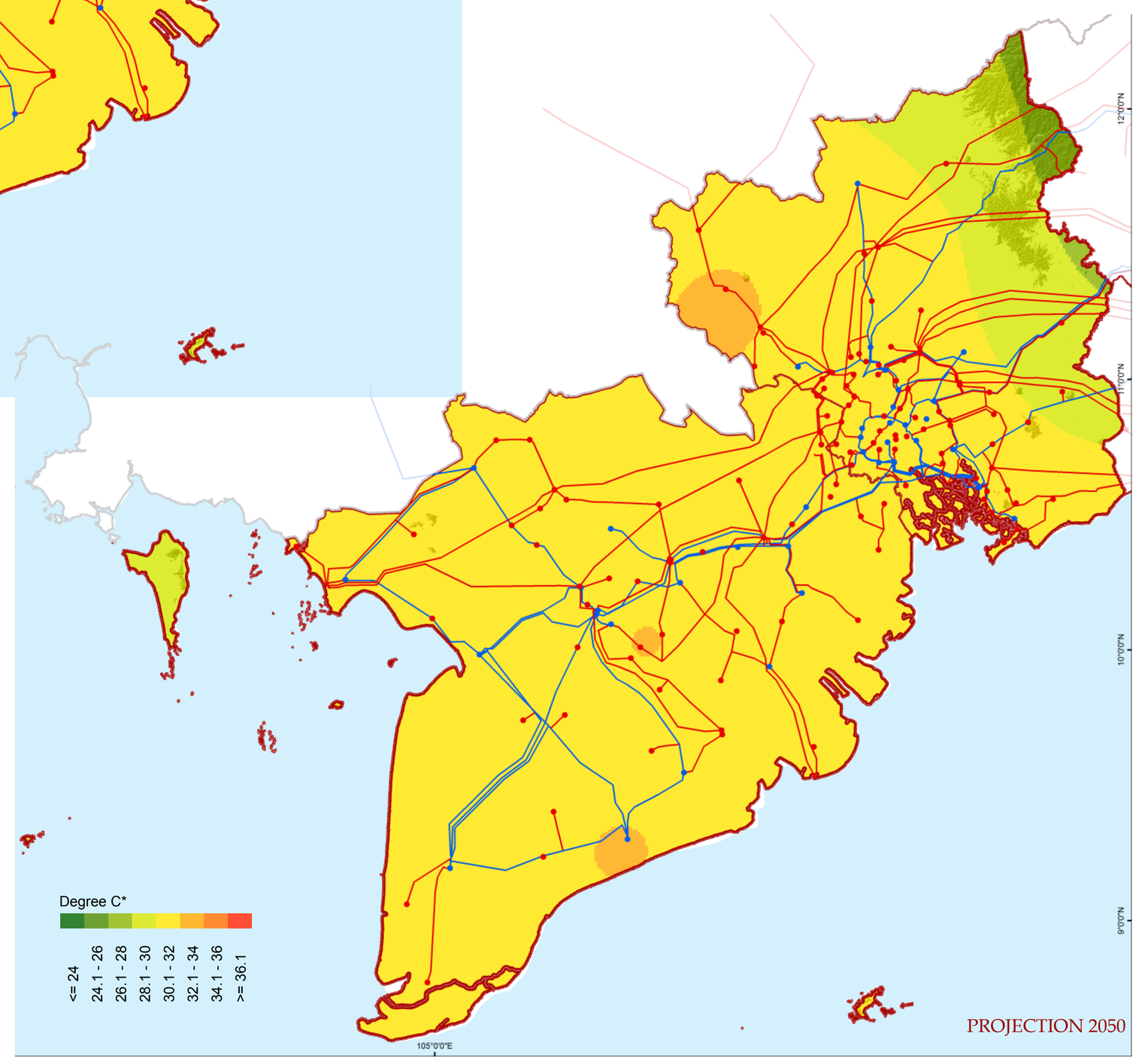
INDEX MAP



REGION 4 - TRANSMISSION LINE AND SUBSTATION (AVERAGE MAXIMUM TEMPERATURE JUNE - AUGUST)

BASELINE





Energy

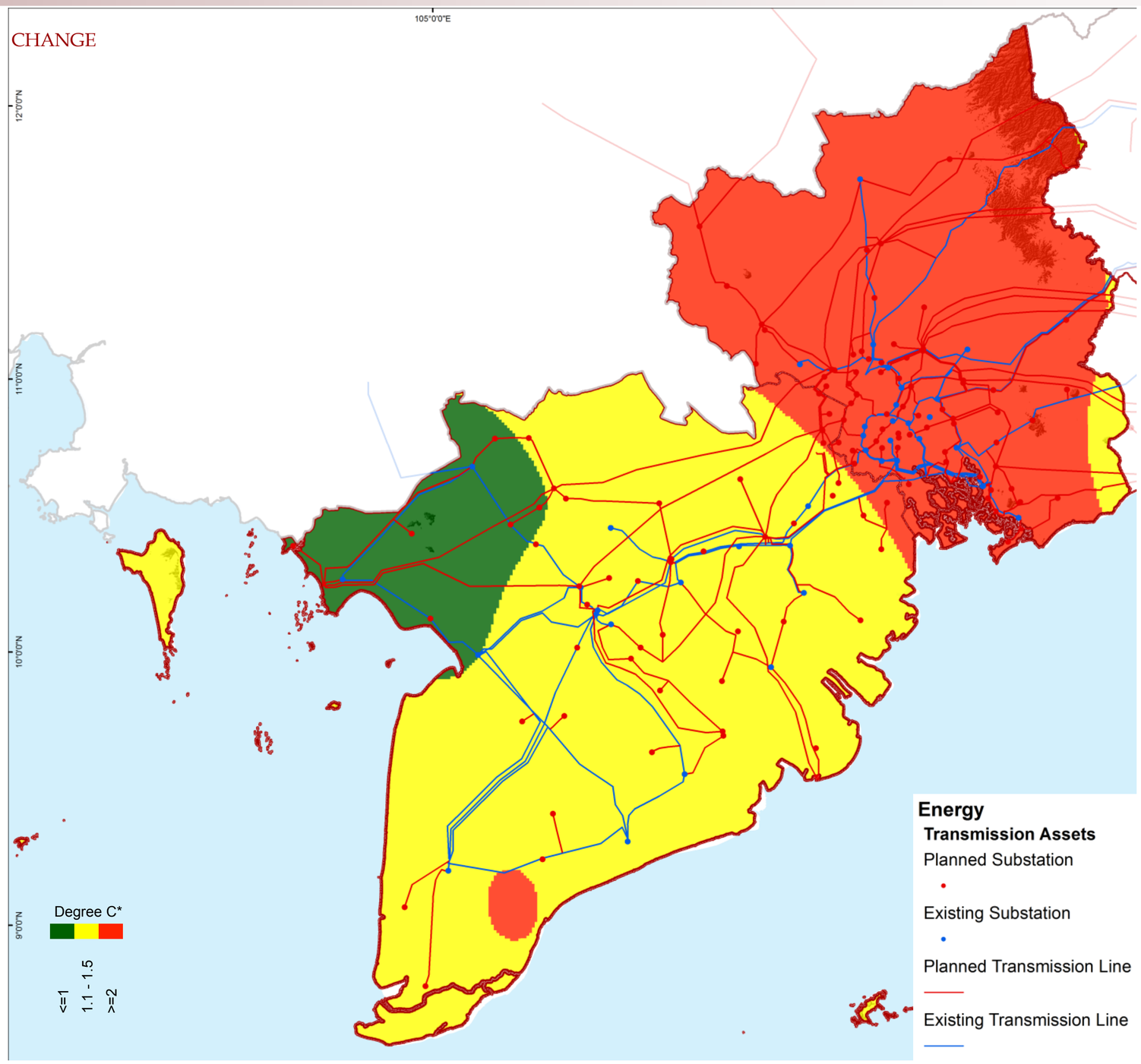
Transmission Assets

Planned Substation

Existing Substation

Planned Transmission Line

Existing Transmission Line



Energy

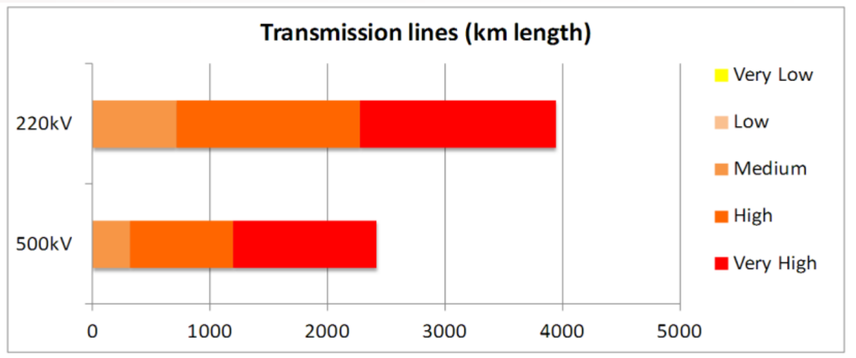
Transmission Assets

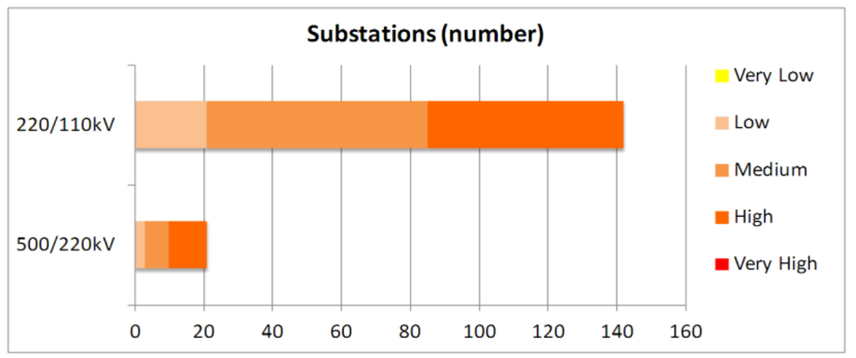
Planned Substation

Existing Substation

Planned Transmission Line

Existing Transmission Line





Region 4 includes the following provinces: An Giang, Bà Rịa Vũng Tàu, Bạc Liêu, Bến Tre, Bình Dương, Bình Phước, Cà Mau, Đồng Nai, Đồng Tháp, Hậu Giang, Kiên Giang, Long An, Sóc Trăng, Tây Ninh, Tiền Giang, TP Cần Thơ, TP Hồ Chí Minh, Trà Vinh, Vinh Long.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

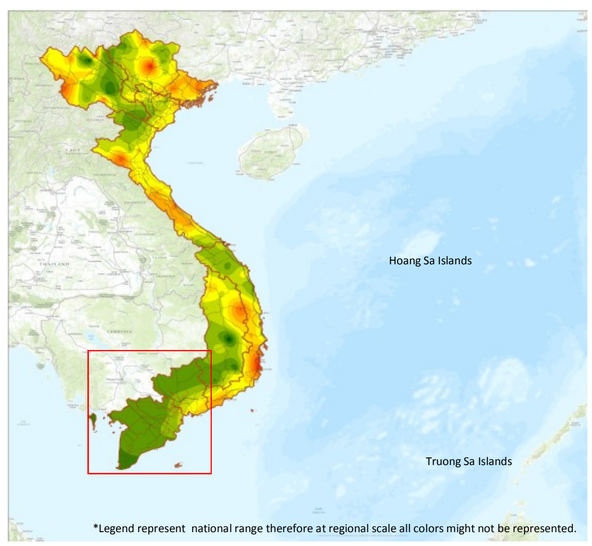
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

MAP SCALE - 1: 1,200,000

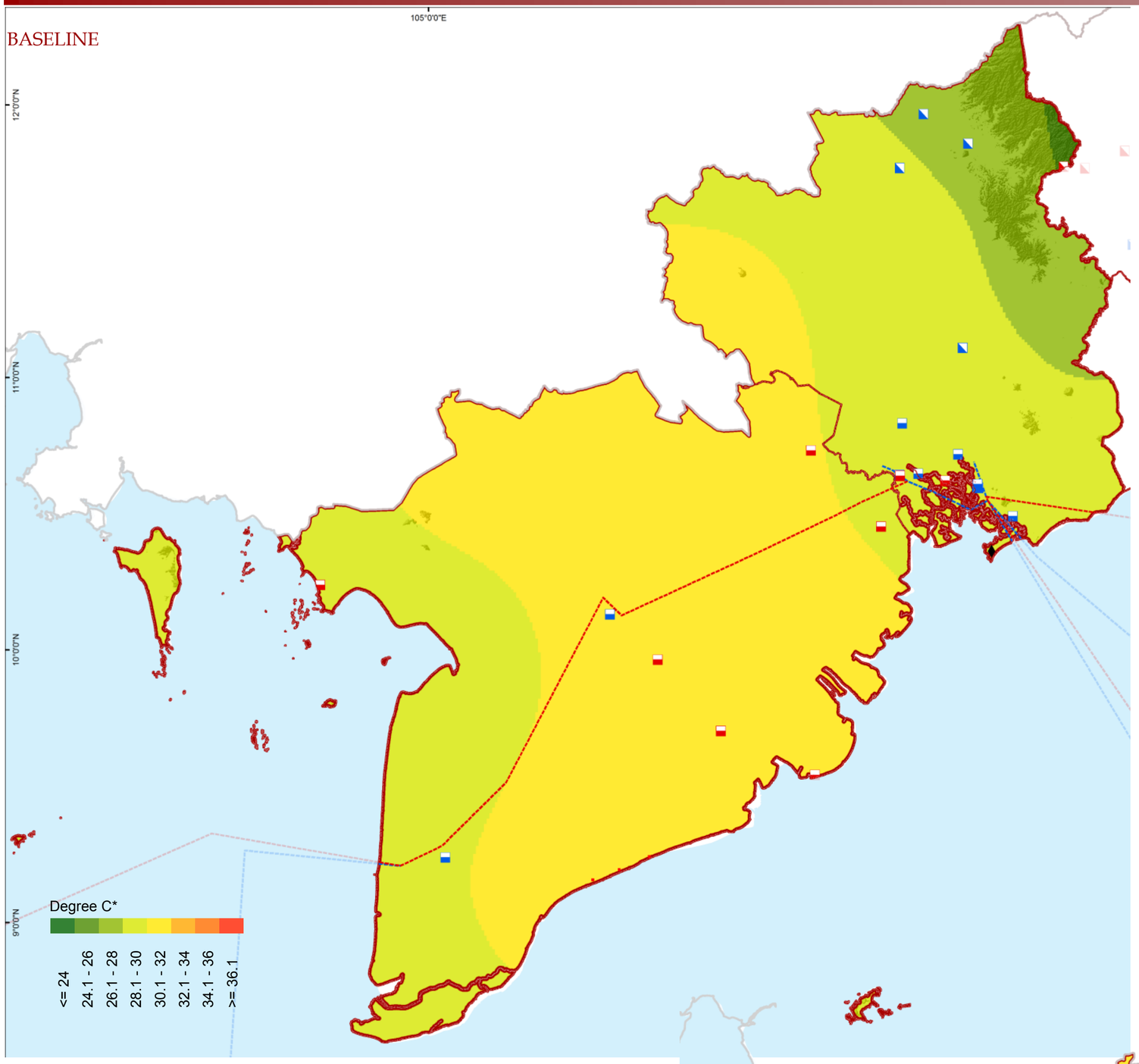
INDEX MAP

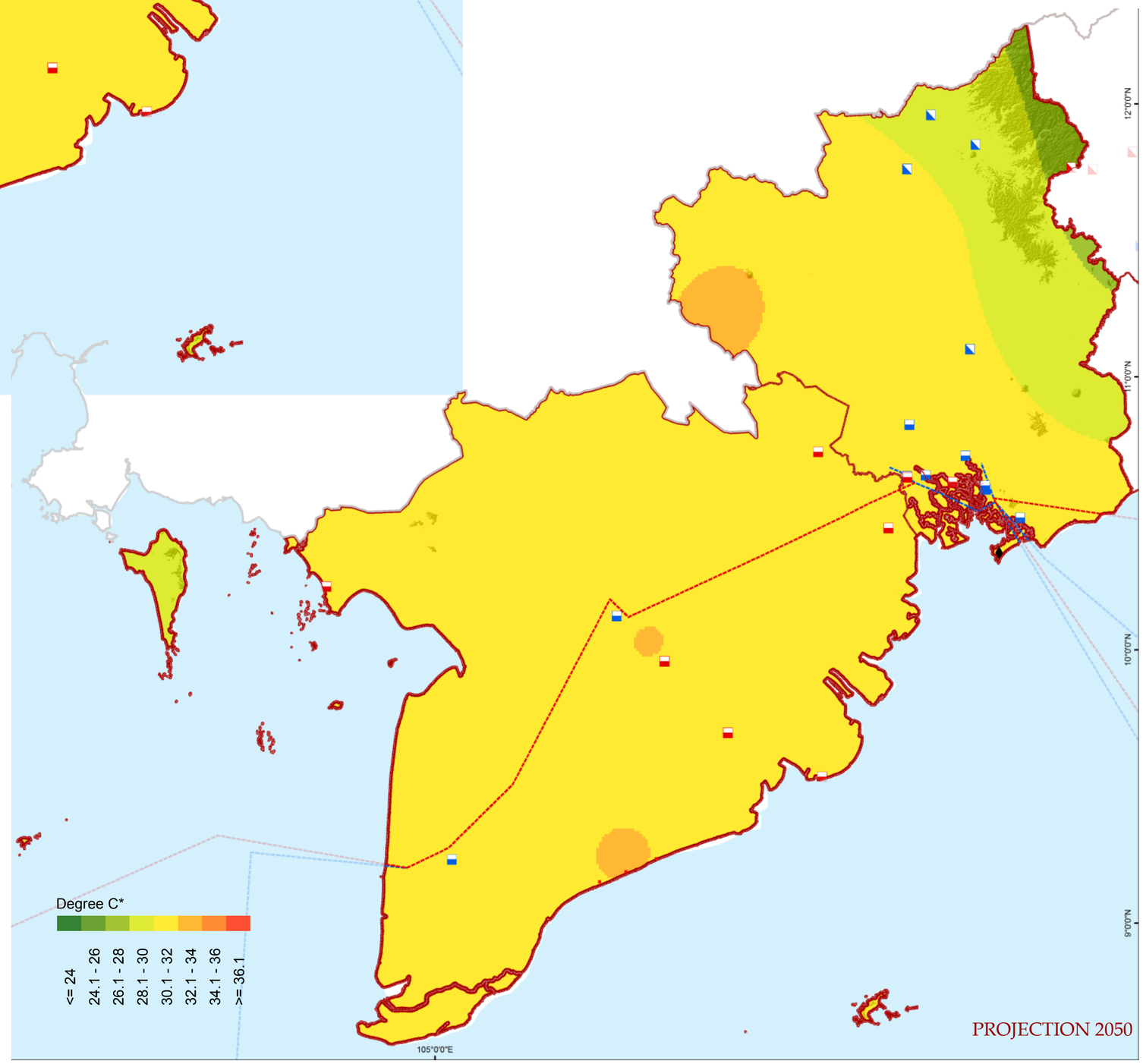


*Legend represent national range therefore at regional scale all colors might not be represented.

REGION 4 - POWER PLANTS (AVERAGE MAXIMUM TEMPERATURE JUNE - AUGUST)

BASELINE





Energy

Power Generation Assets

Planned National Power Plant

- Thermal Power Plant
- Hydro Power Plant

Gas Processing Plant

Existing National Power Plant

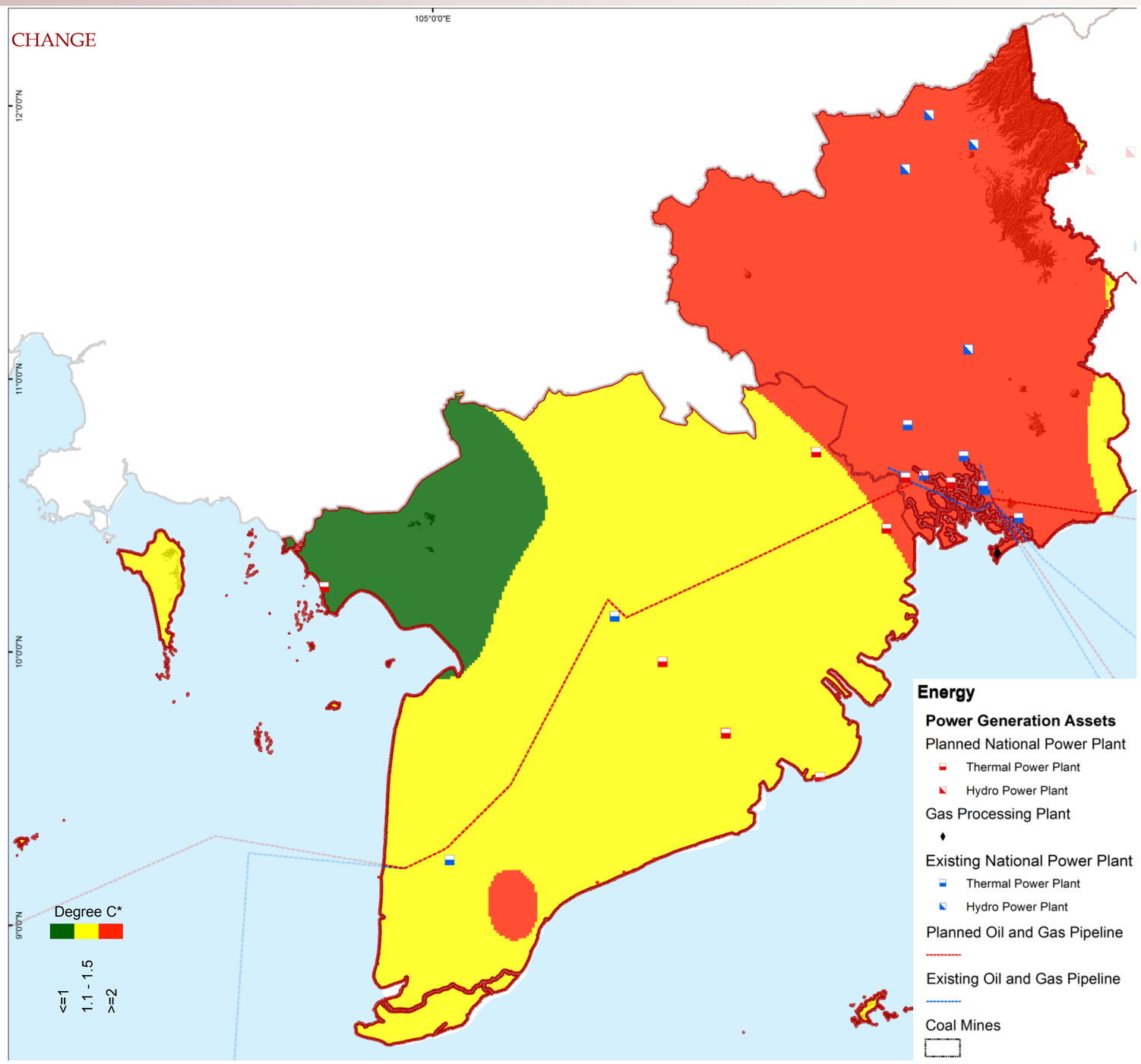
- Thermal Power Plant
- Hydro Power Plant

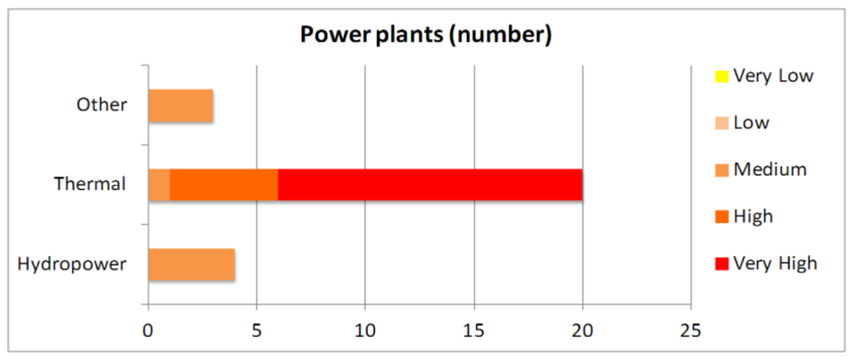
Planned Oil and Gas Pipeline

Existing Oil and Gas Pipeline

Coal Mines

CHANGE





Region 4 includes the following provinces: An Giang, Bà Rịa Vũng Tàu, Bạc Liêu, Bến Tre, Bình Dương, Bình Phước, Cà Mau, Đồng Nai, Đồng Tháp, Hậu Giang, Kiên Giang, Long An, Sóc Trăng, Tây Ninh, Tiền Giang, TP Cần Thơ, TP Hồ Chí Minh, Trà Vinh, Vinh Long.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

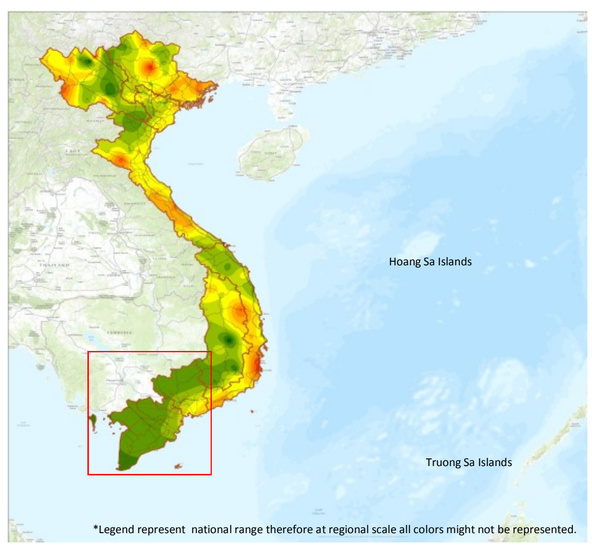
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

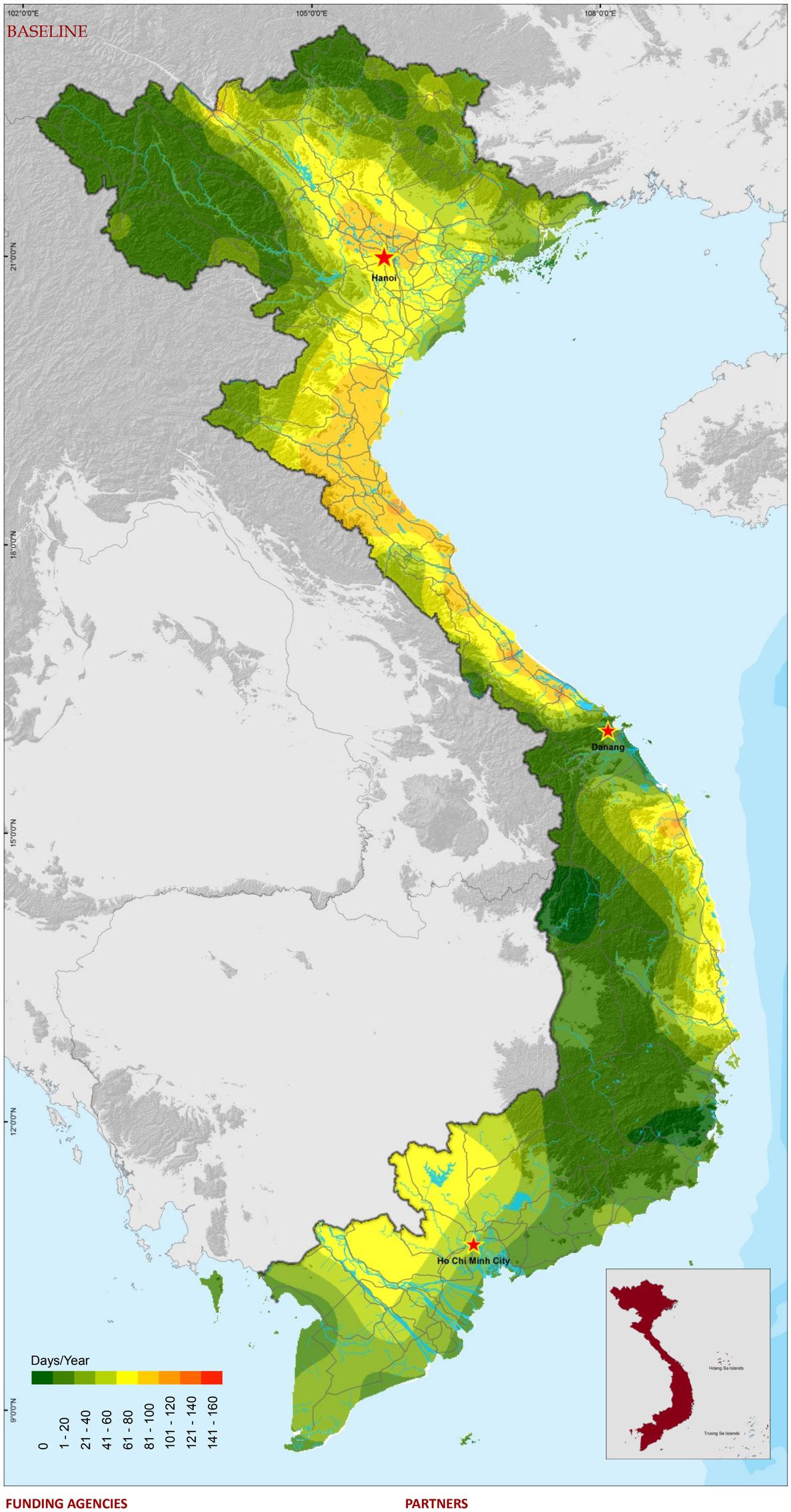
GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

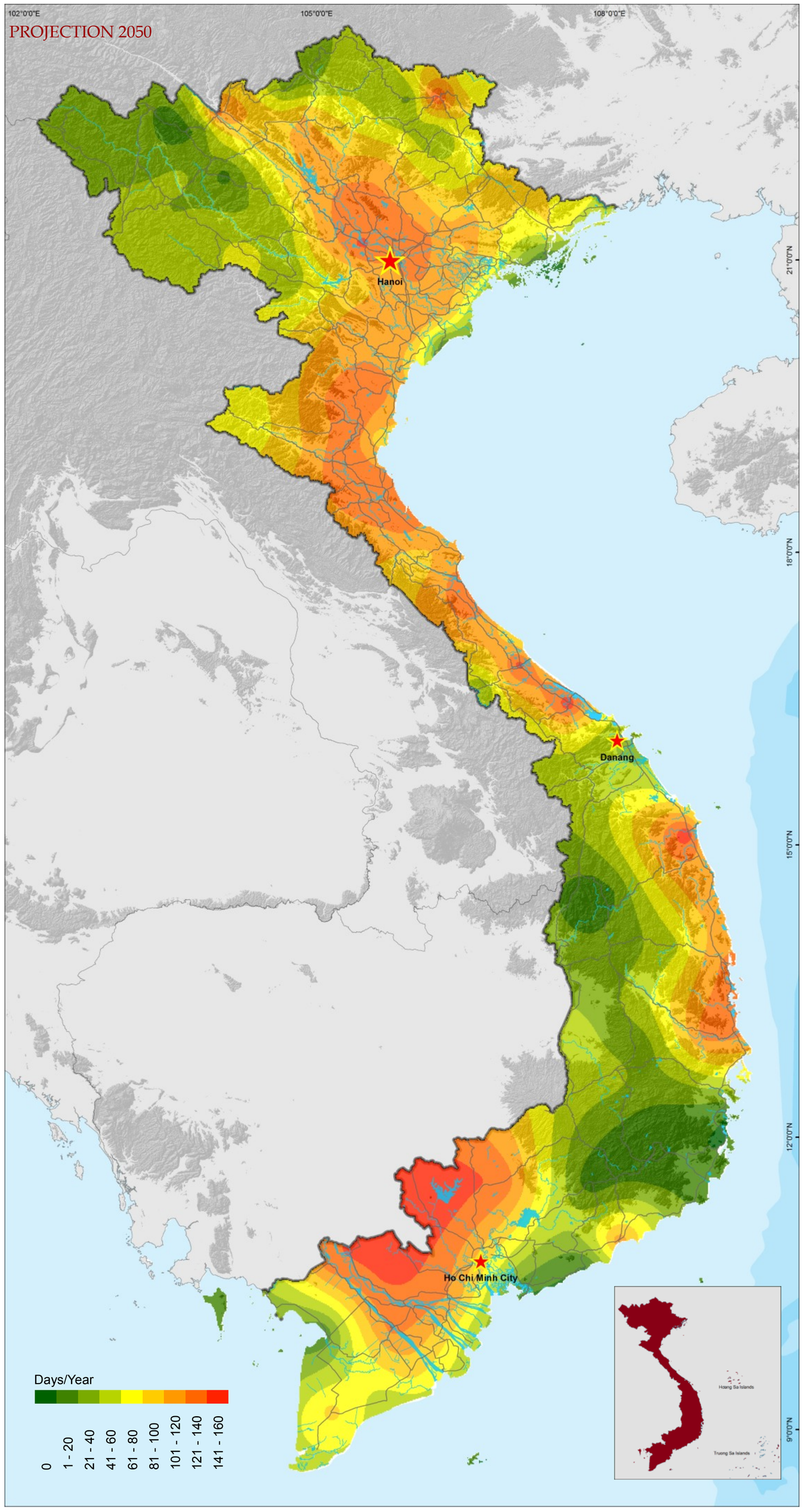
MAP SCALE - 1: 1,200,000

INDEX MAP



NUMBER OF HOT DAYS





SUMMARY OF NATIONAL ASSESSMENT OF THREAT

Similar to sustained heat, extreme heat, the number of days annually with a temperature higher than 35°C – is projected to increase in low-lying areas. The Red River Delta is forecast to experience up to 60 more hot days annually by 2050 where some areas already have up to 100 hot days in the baseline. The Mekong River Delta is projected to have up to 80 more hot days where some areas have up to 80 hot days per year now. The lower central provinces are forecast to see up to 80 more hot days annually as well.

From the analysis of energy assets against this threat in the national assessment, it has been found that fewer than 20% of existing thermal power plants are rated in the High category (and none in Very High) as a result of these large forecast increases in the number of hot days, however around 30% of planned thermal power plants will be highly affected in the future.

Substations and transmission lines are more vulnerable highly affected by this increase in the number of hot days, with about 30-40% of substations and 60% of transmission lines (by length) in the High and Very High range. While the total number of highly affected transmission assets in the baseline and 2050 around the same, it is noteworthy that an additional 460 km of planned 500 kV transmission lines in the Very High category in 2050 than the baseline, which is a 55% increase from the baseline. These high voltage lines provide the backbone of the national transmission system and as such potential impacts would affect large parts of the grid and significant numbers of customers.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

IE - ENERGY INFRASTRUCTURE

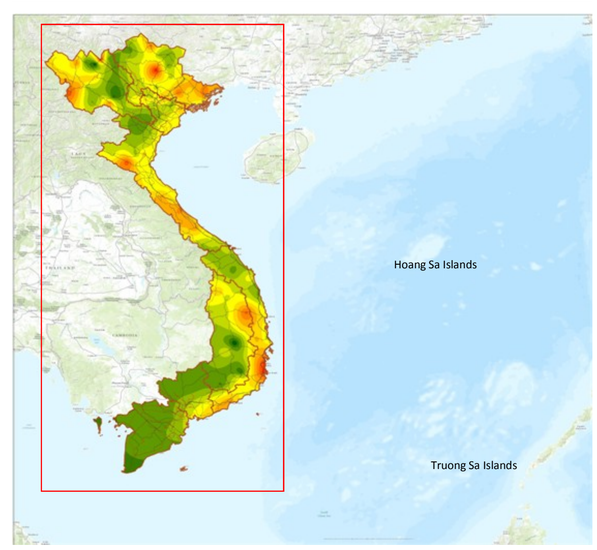
GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

N
W
E
S

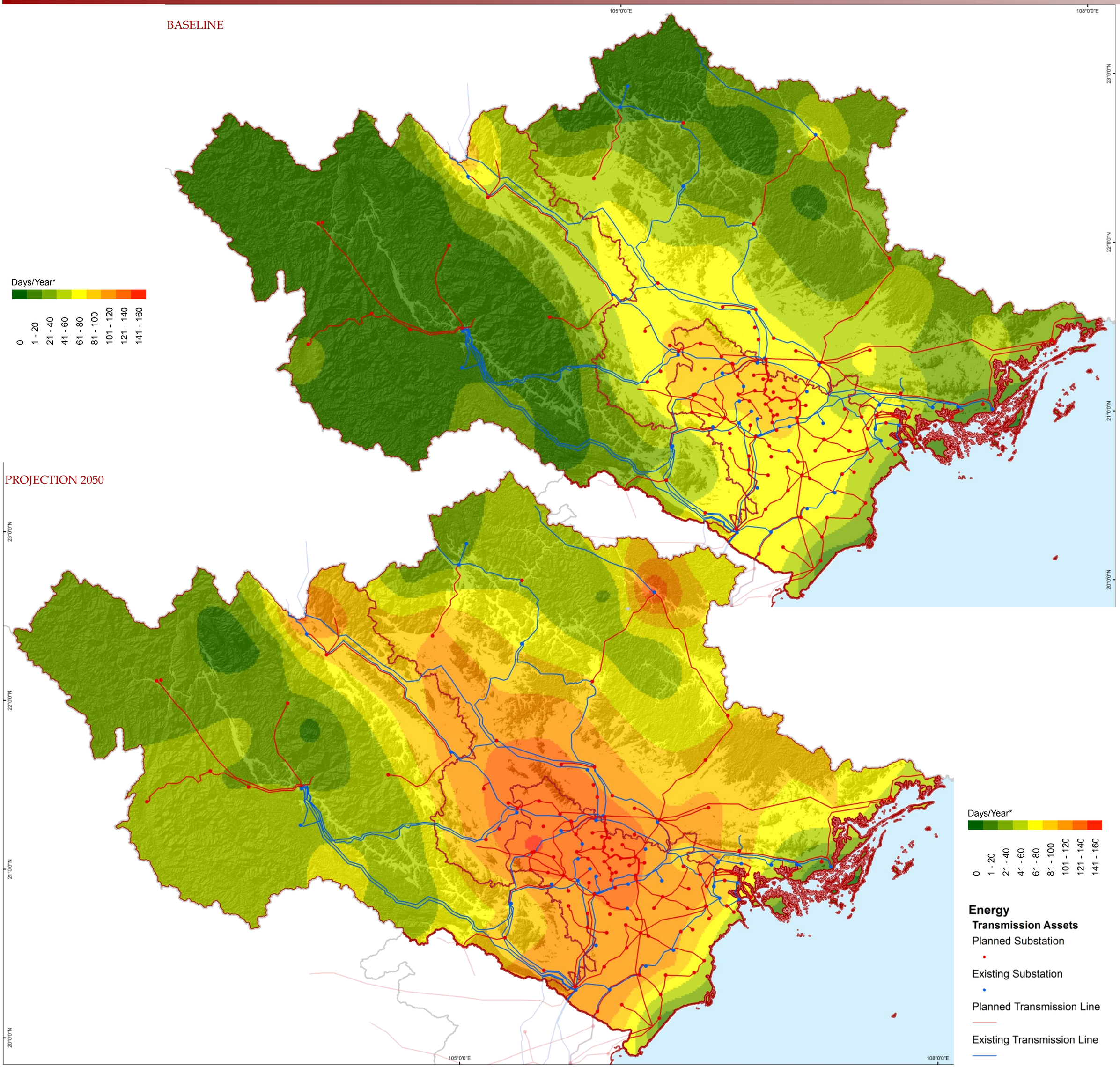
MAP SCALE - 1: 3,000,000

INDEX MAP



REGION 1 - TRANSMISSION LINE AND SUBSTATION (NUMBER OF HOT DAYS)

BASELINE

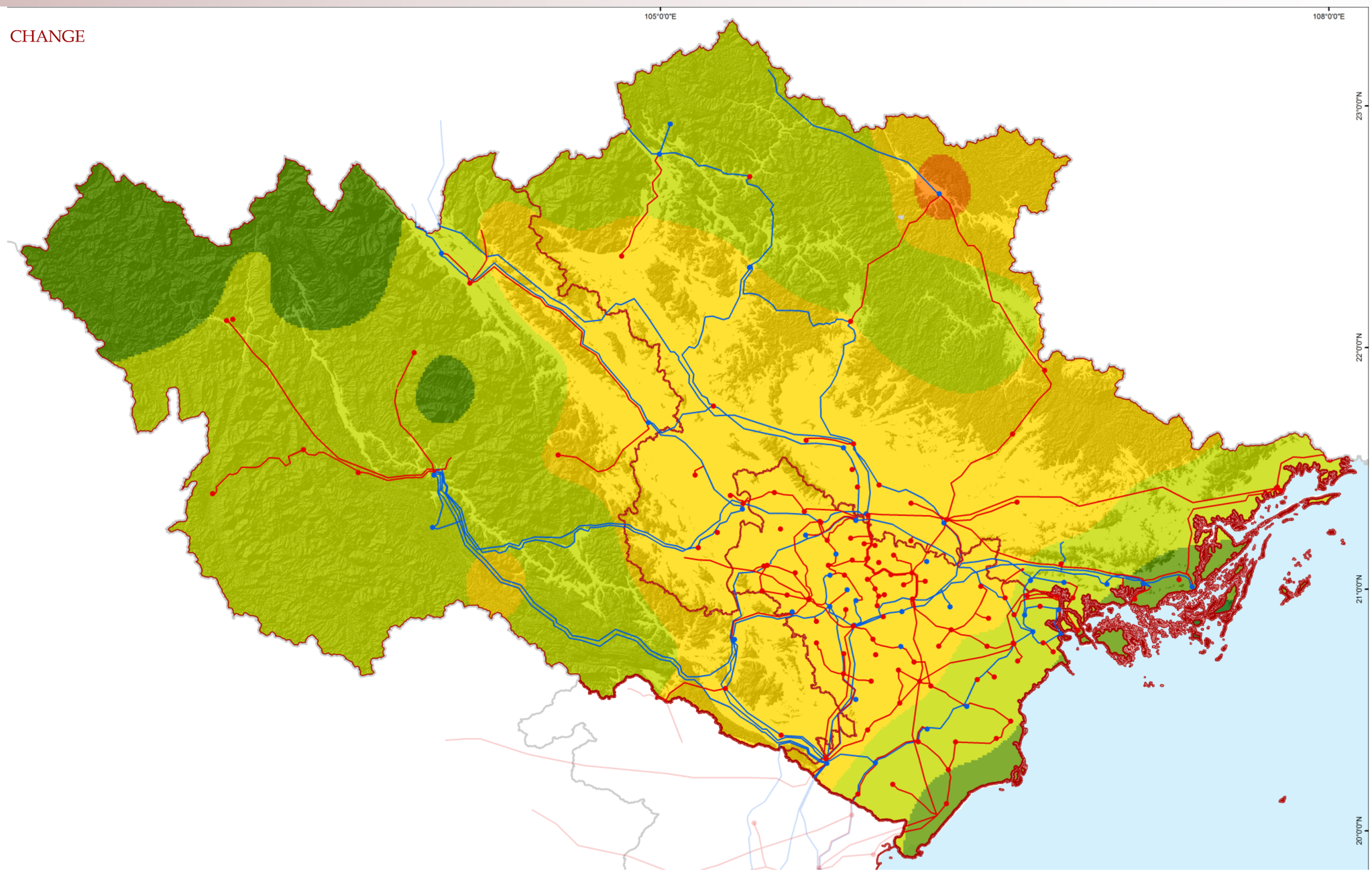


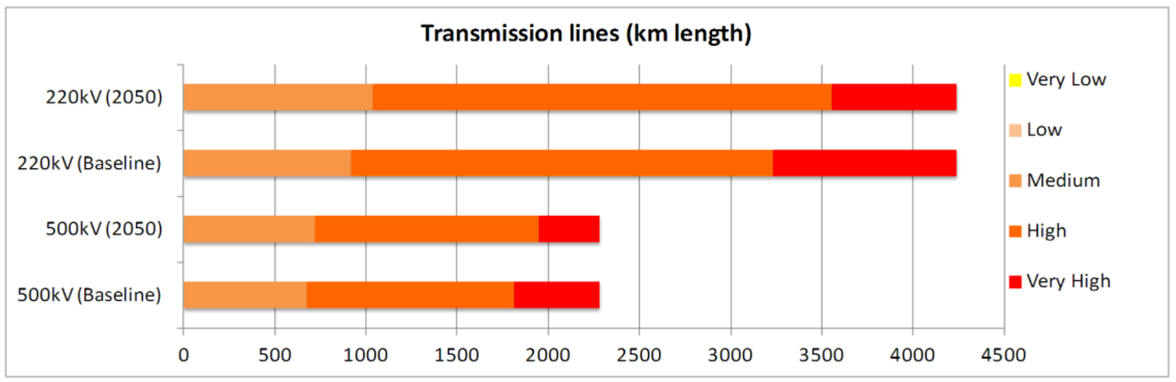
PROJECTION 2050

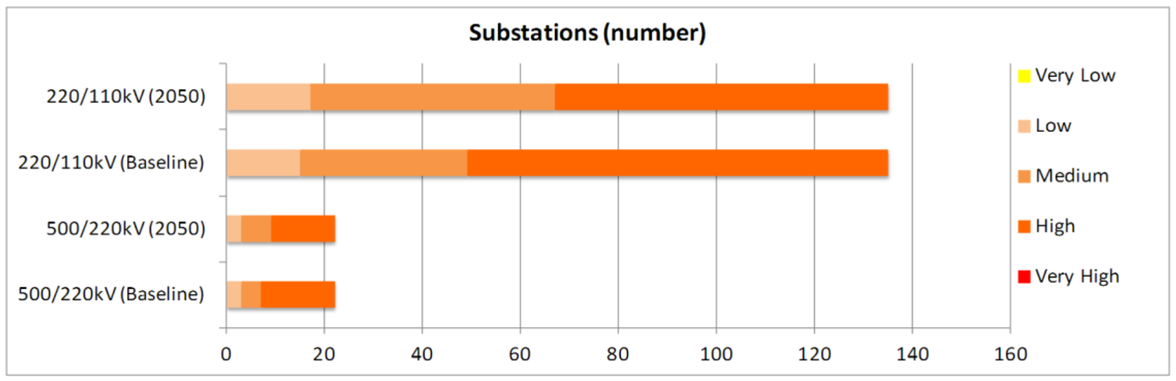
FUNDING AGENCIES

PARTNERS

COMPANIES







Region 1 includes the following provinces: Bắc Cạn, Bắc Giang, Bắc Ninh, Cao Bằng, Điện Biên, Hà Giang, Hà Nam, Hà Nội, Hải Dương, Hải Phòng, Hoà Bình, Hưng Yên, Lai Châu, Lạng Sơn, Lào Cai, Nam Định, Ninh Bình, Phú Thọ, Quảng Ninh, Sơn La, Thái Bình, Thái Nguyên, Tuyên Quang, Vĩnh Phúc, Yên Bái.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

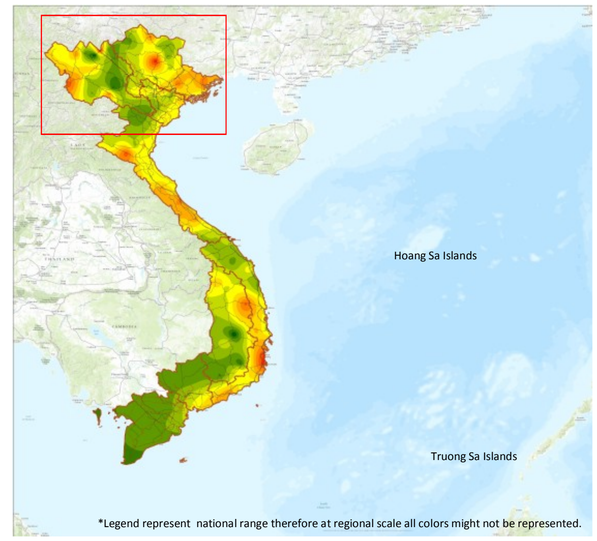
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

MAP SCALE - 1: 1,200,000

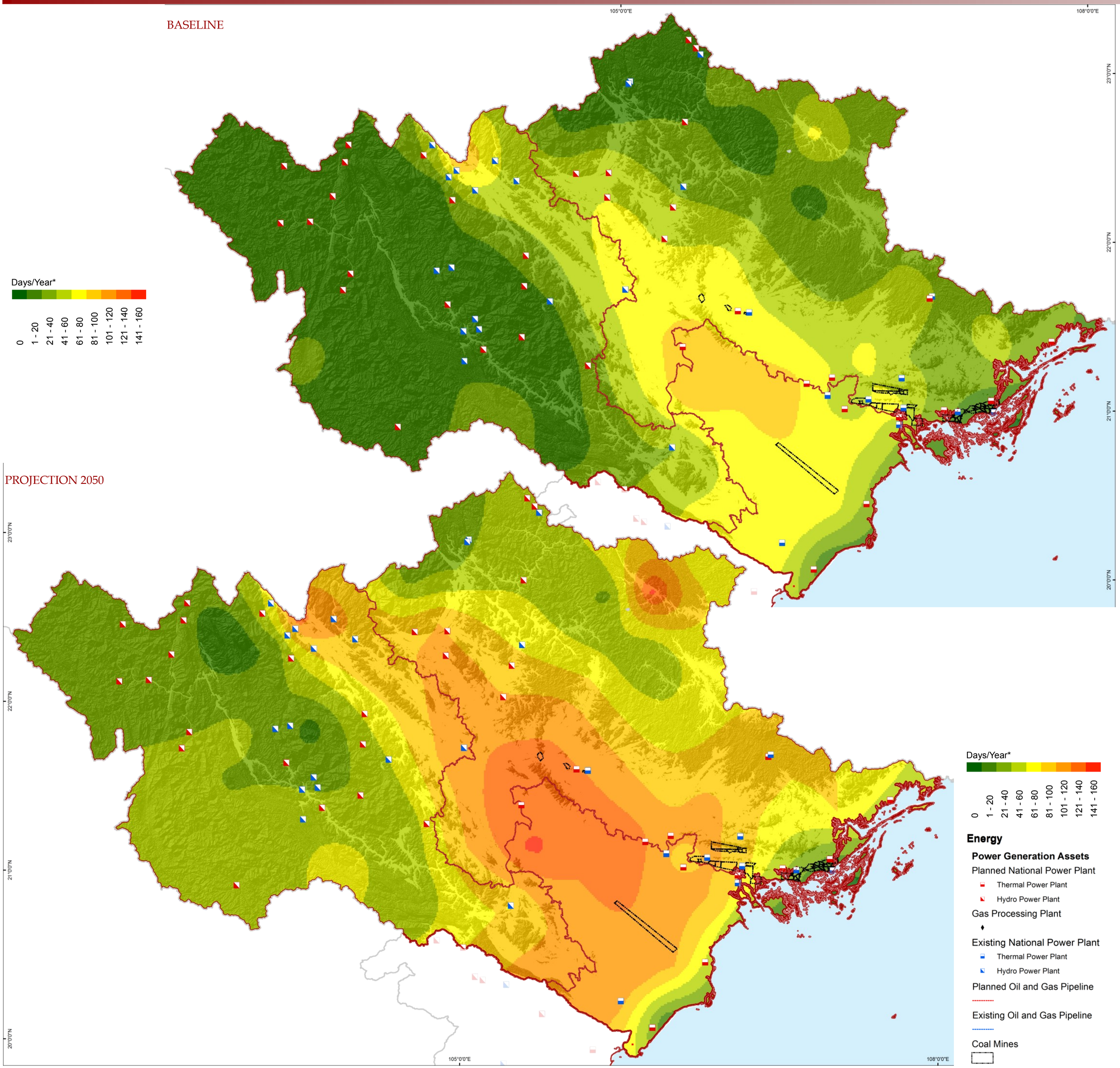
INDEX MAP



REGION 1 - POWER PLANTS (NUMBER OF HOT DAYS)

BASELINE

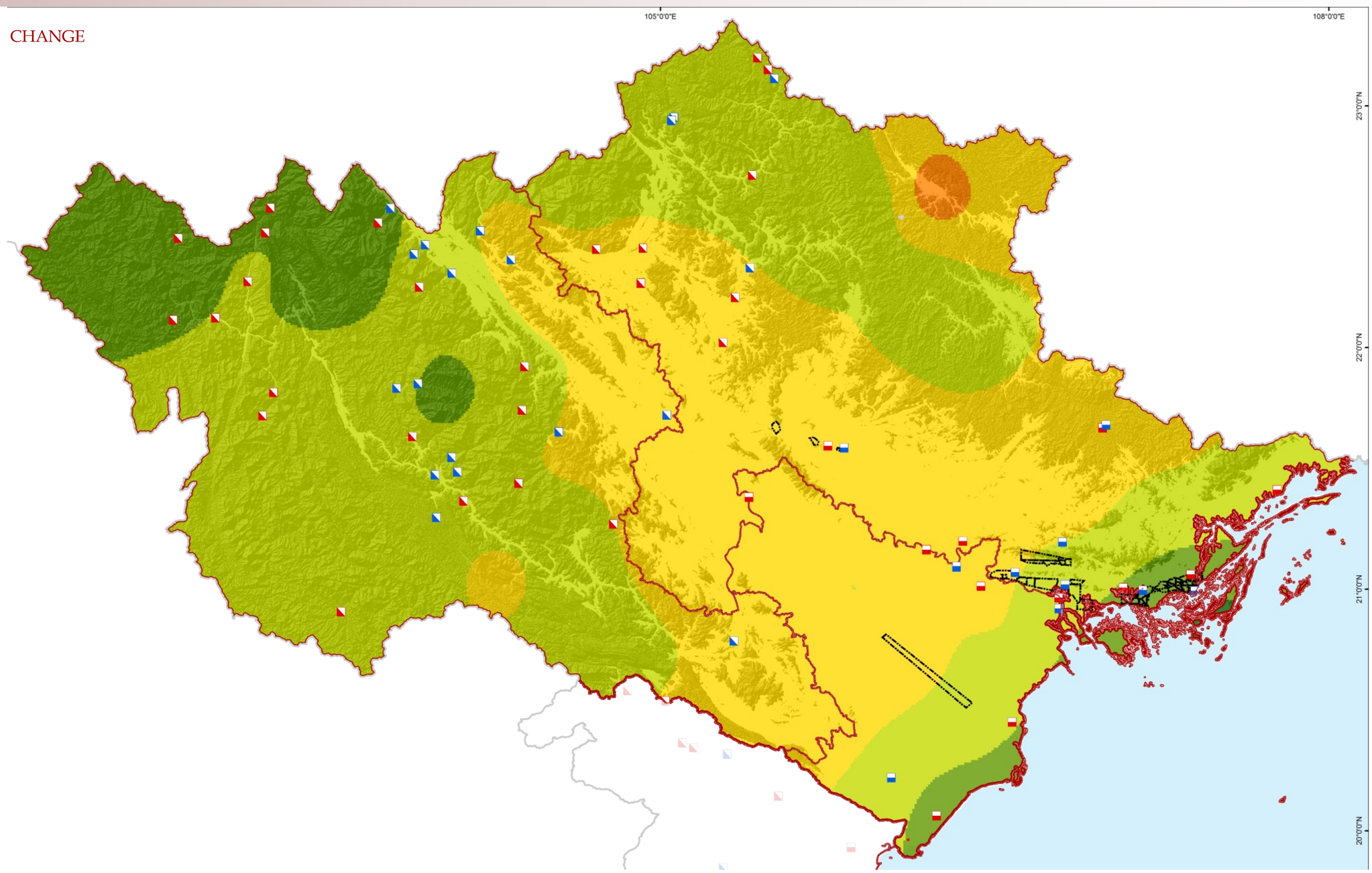
PROJECTION 2050

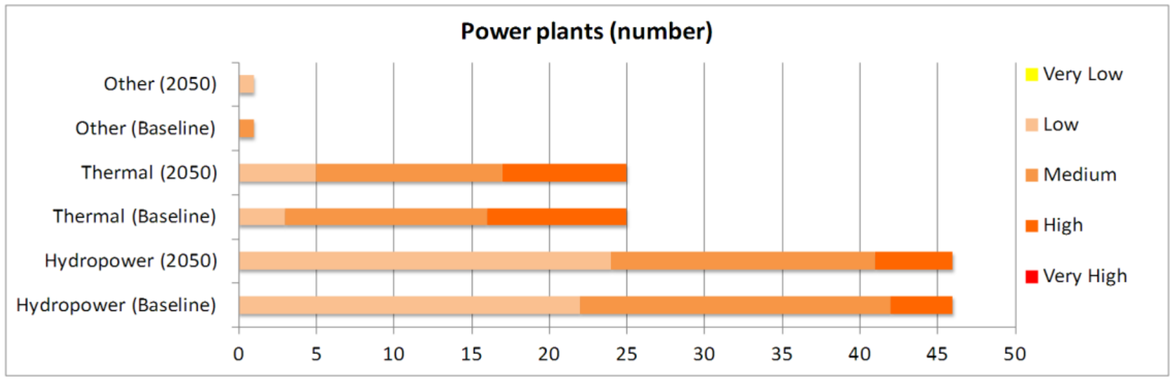


FUNDING AGENCIES

PARTNERS

COMPANIES





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DATA SOURCES

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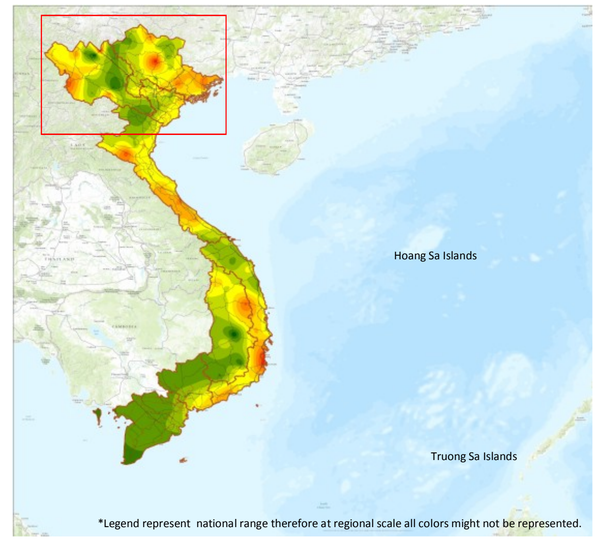
GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

MAP SCALE - 1: 1,200,000

INDEX MAP



REGION 2 - TRANSMISSION LINE AND SUBSTATION (NUMBER OF HOT DAYS)

BASELINE

PROJECTION 2050

Days/Year*

0
1 - 20
21 - 40
41 - 60
61 - 80
81 - 100
101 - 120
121 - 140
141 - 160

105°0'0"E
108°0'0"E
20°0'0"N
19°0'0"N
18°0'0"N
17°0'0"N
16°0'0"N

Energy

Transmission Assets

Planned Substation

Existing Substation

Planned Transmission Line

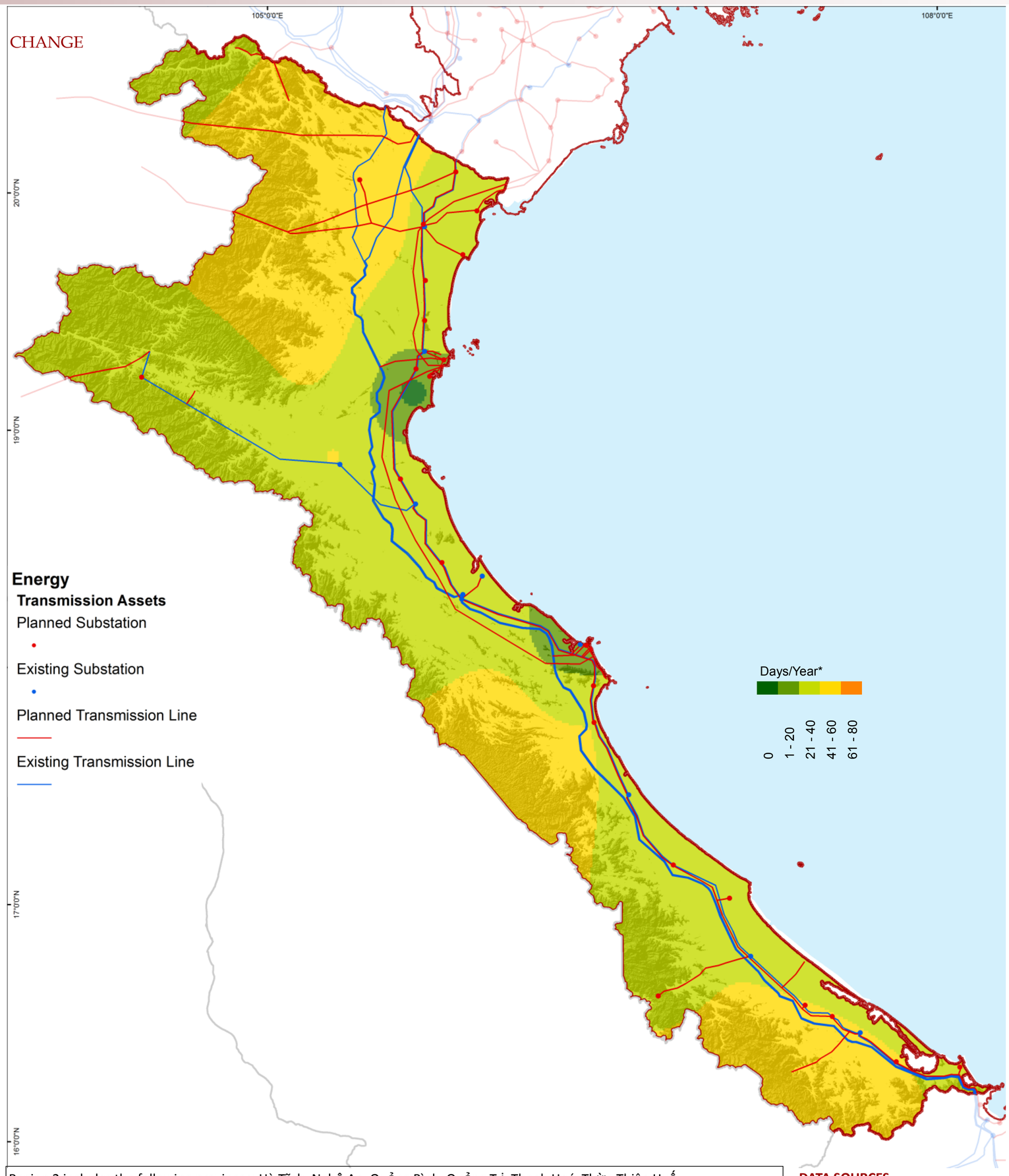
Existing Transmission Line

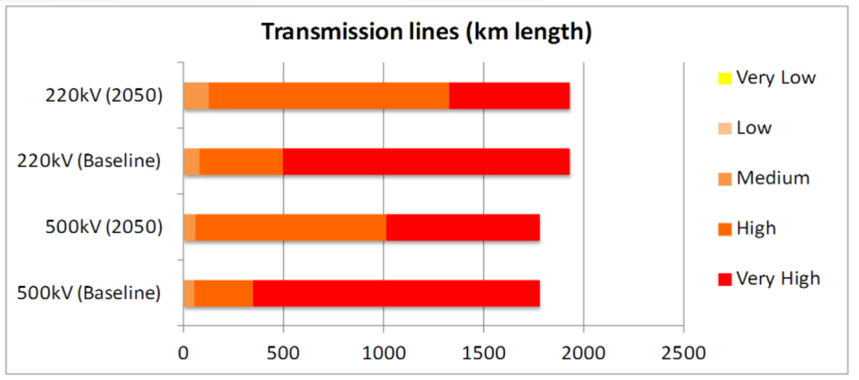
FUNDING AGENCIES

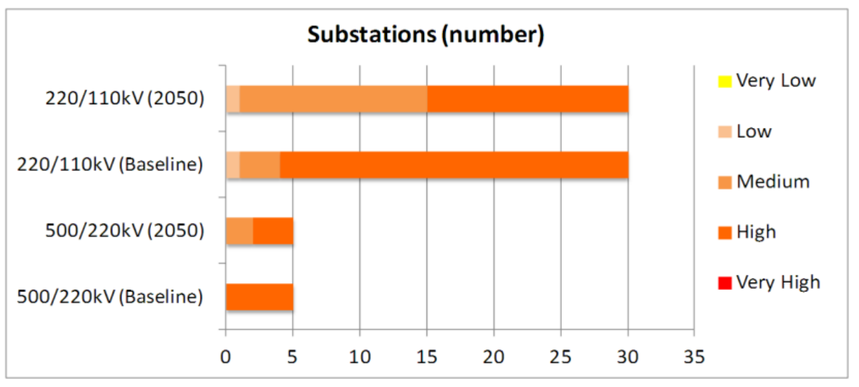
PARTNERS

COMPANIES

CHANGE







Region 2 includes the following provinces: Hà Tĩnh, Nghệ An, Quảng Bình, Quảng Trị, Thanh Hoá, Thừa Thiên Huế.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

IE - ENERGY INFRASTRUCTURE

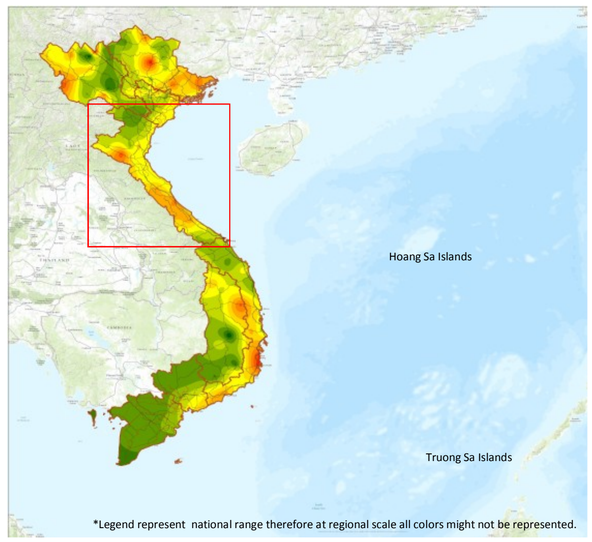
GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

N
W
E
S

MAP SCALE - 1: 1,200,000

INDEX MAP



REGION 2 - POWER PLANTS (NUMBER OF HOT DAYS)

BASELINE

PROJECTION 2050

105°0'0"E

108°0'0"E

20°0'0"N

19°0'0"N

18°0'0"N

17°0'0"N

16°0'0"N

Days/Year*

0

1 - 20

21 - 40

41 - 60

61 - 80

81 - 100

101 - 120

121 - 140

141 - 160

Energy

Power Generation Assets

Planned National Power Plant

Thermal Power Plant

Hydro Power Plant

Gas Processing Plant

Existing National Power Plant

Thermal Power Plant

Hydro Power Plant

Planned Oil and Gas Pipeline

Existing Oil and Gas Pipeline

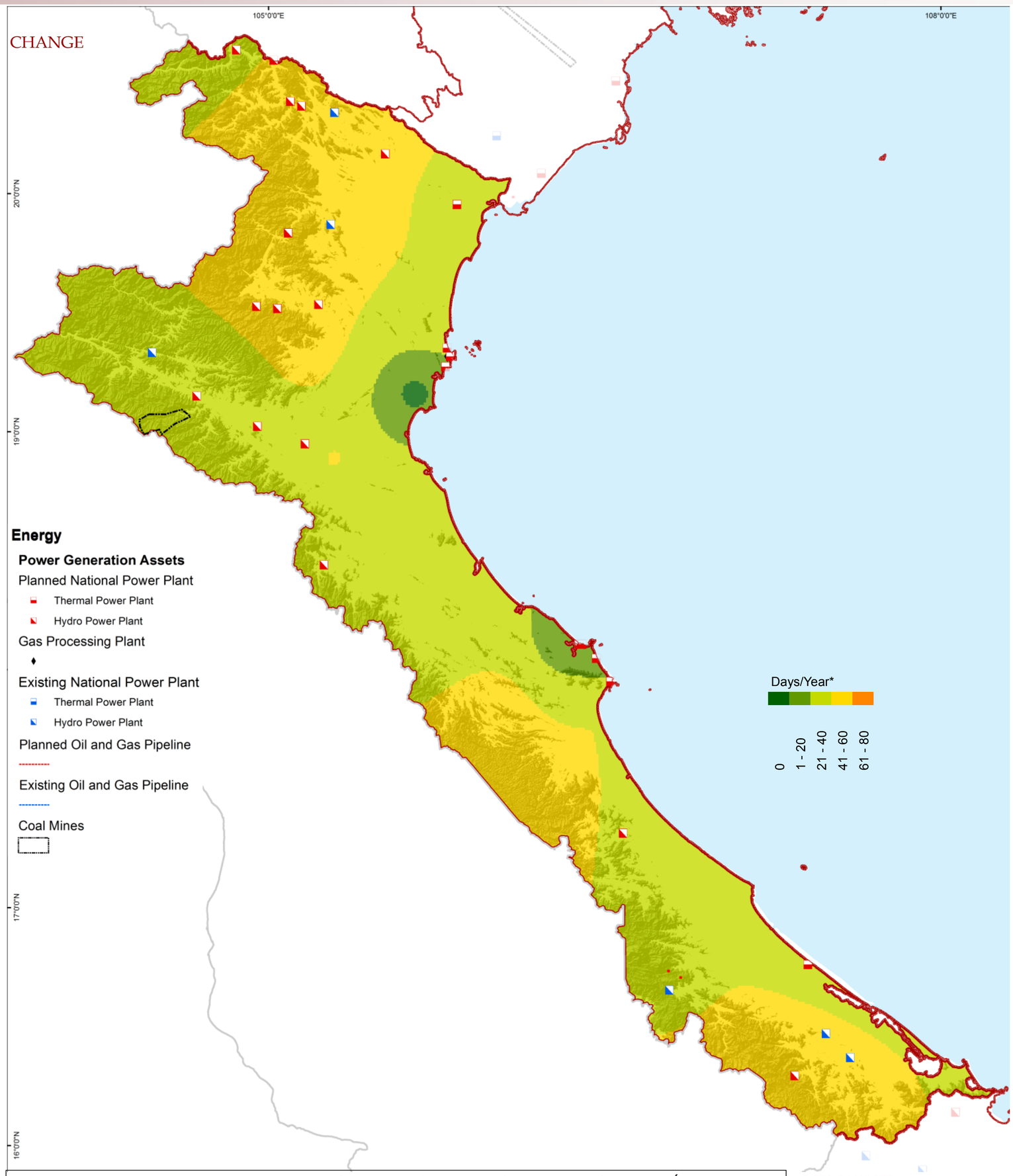
Coal Mines

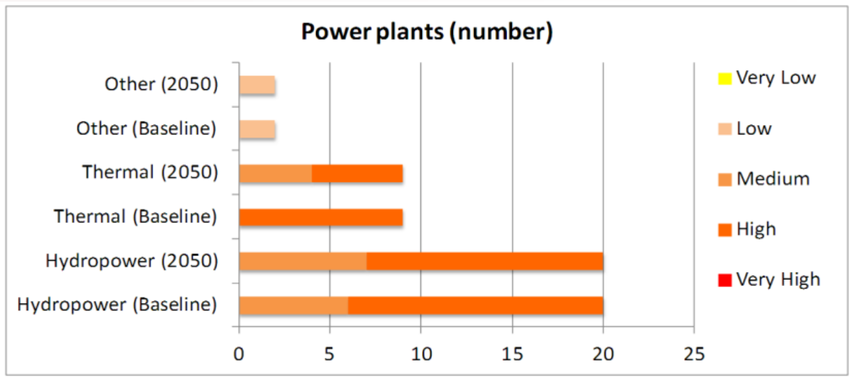
FUNDING AGENCIES

PARTNERS

COMPANIES

CHANGE





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DATA SOURCES

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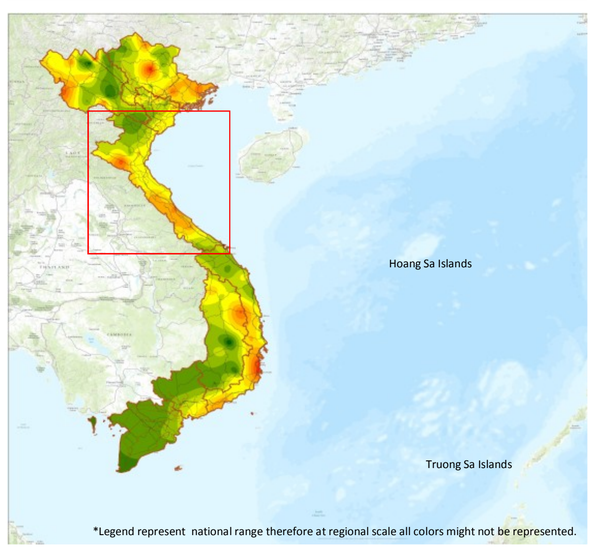
GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

MAP SCALE - 1: 1,200,000

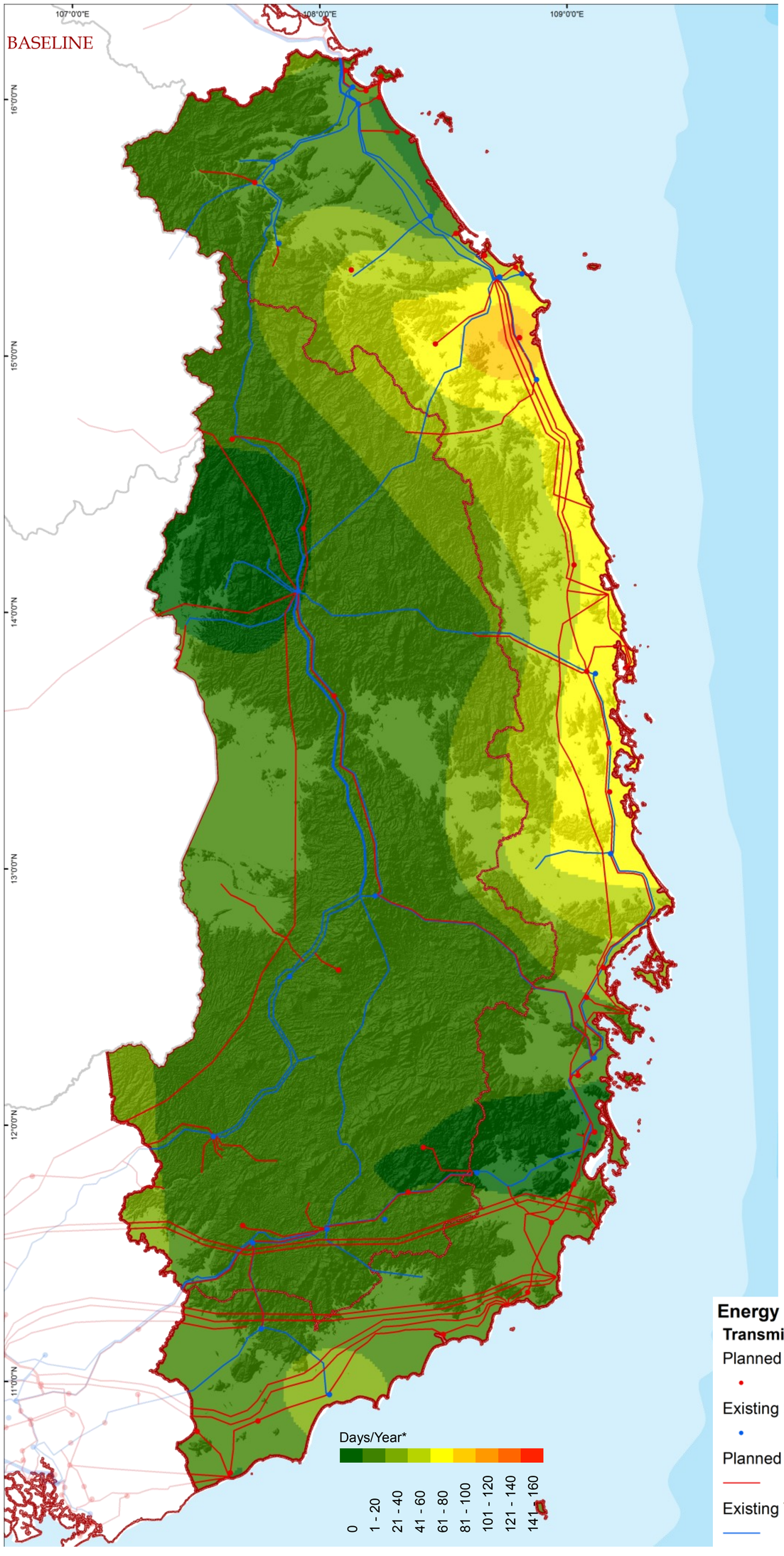
INDEX MAP



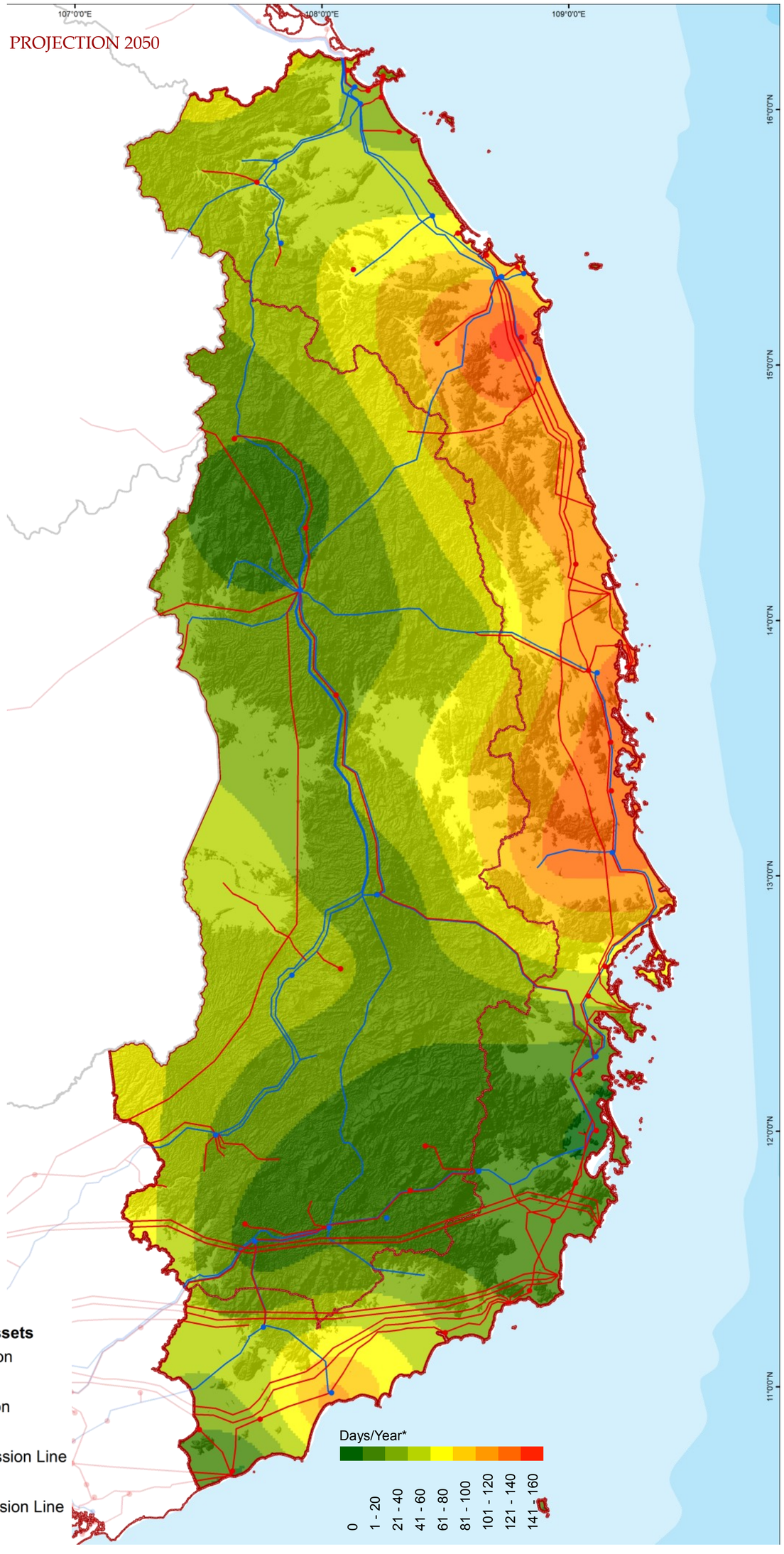
*Legend represent national range therefore at regional scale all colors might not be represented.

REGION 3 - TRANSMISSION LINE AND SUBSTATION (NUMBER OF HOT DAYS)

BASELINE



PROJECTION 2050



Energy

Transmission Assets

Planned Substation

Existing Substation

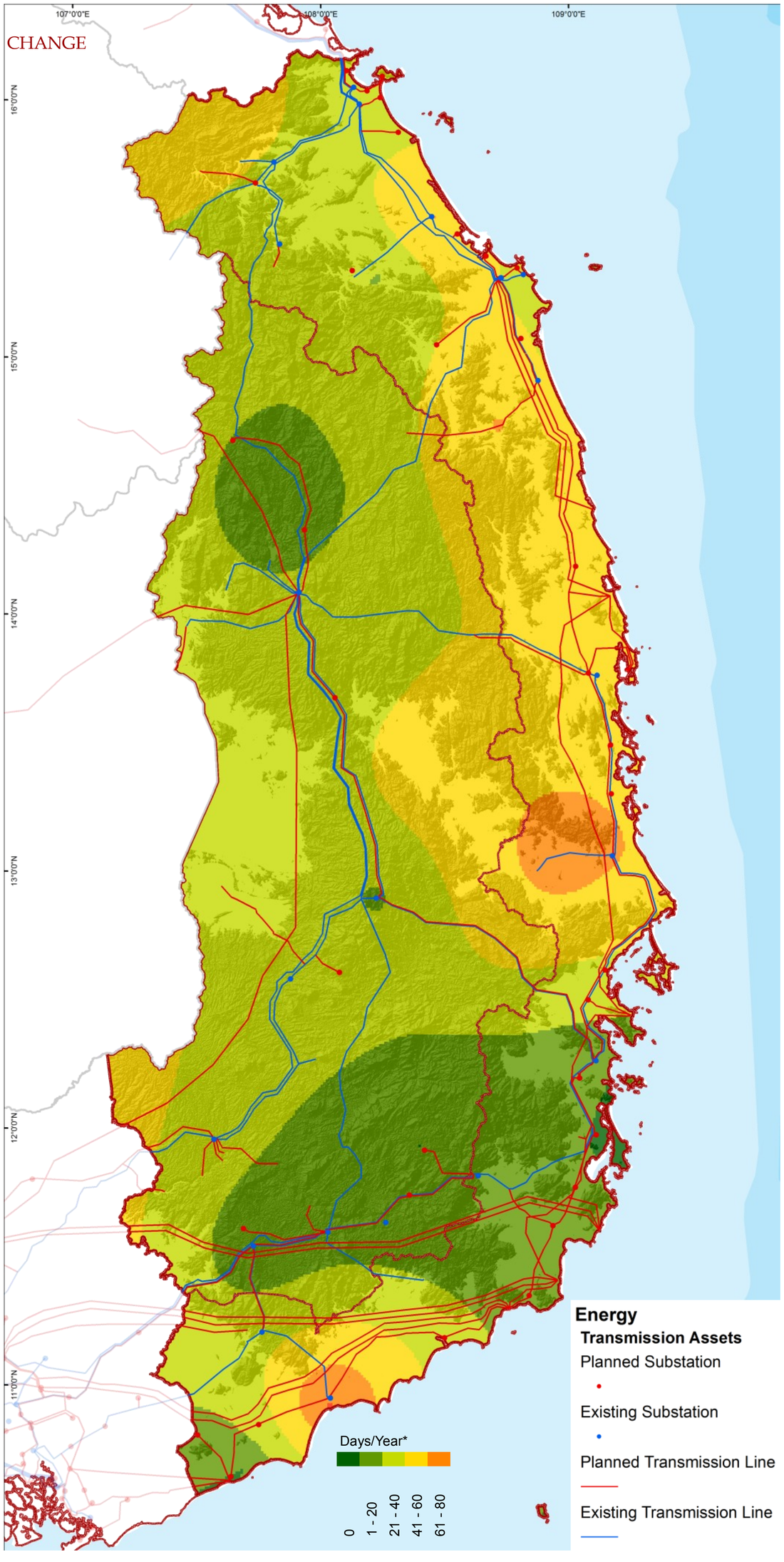
Planned Transmission Line

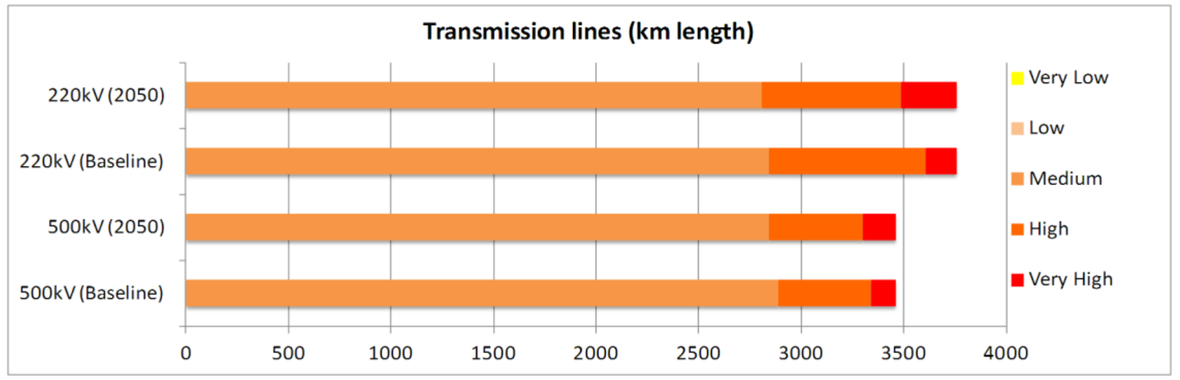
Existing Transmission Line

FUNDING AGENCIES

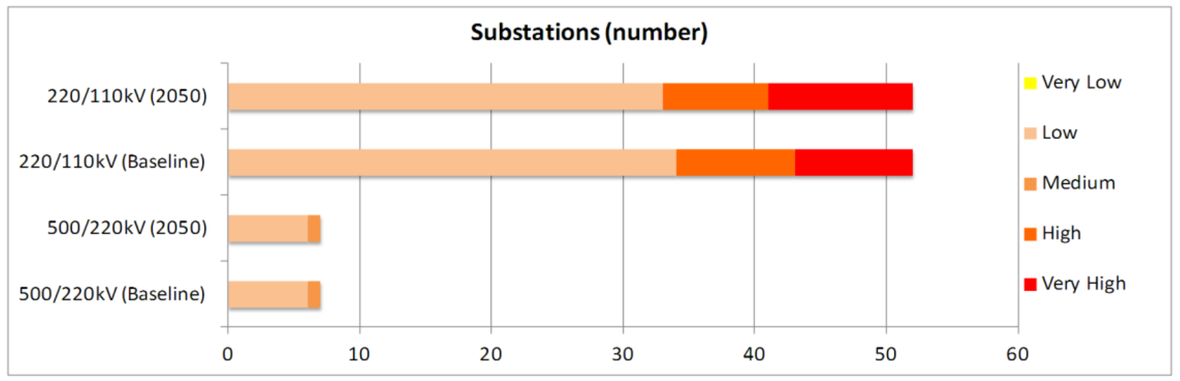
PARTNERS

COMPANIES





Region 3 includes the following provinces: Bình Định, Bình Thuận, Đà Nẵng, Đăk Lăk, Đăk Nông, Gia Lai, Khánh Hoà, Kon Tum, Lâm Đồng, Ninh Thuận, Phú Yên, Quảng Nam, Quảng Ngãi.



DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

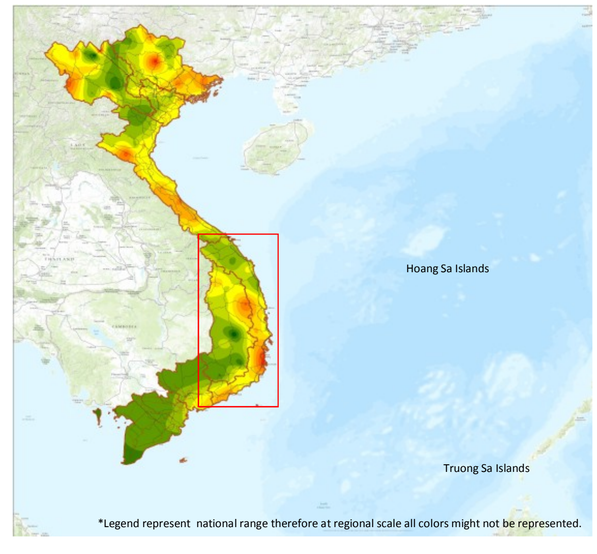
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

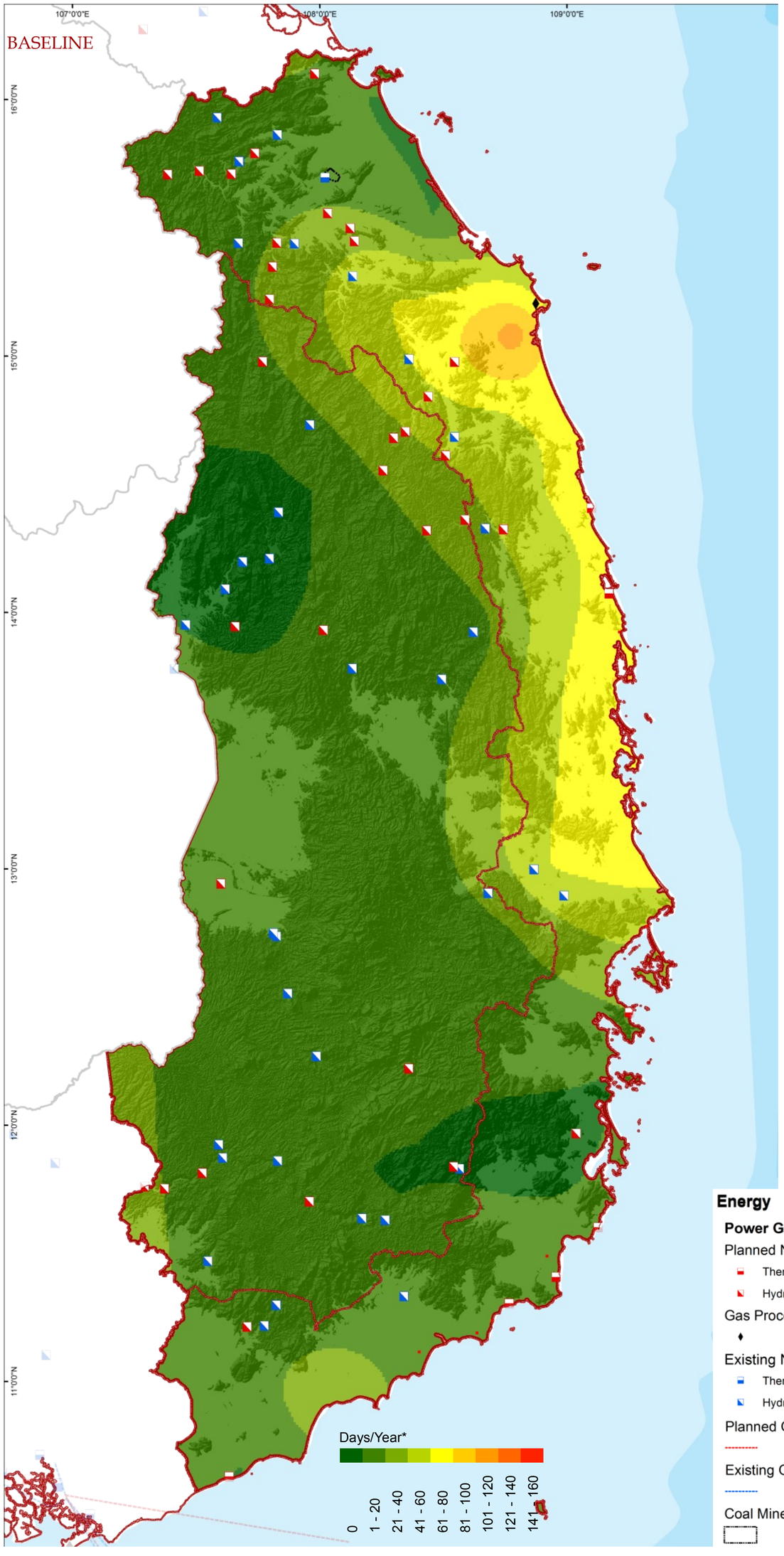
MAP SCALE - 1: 1,200,000

INDEX MAP

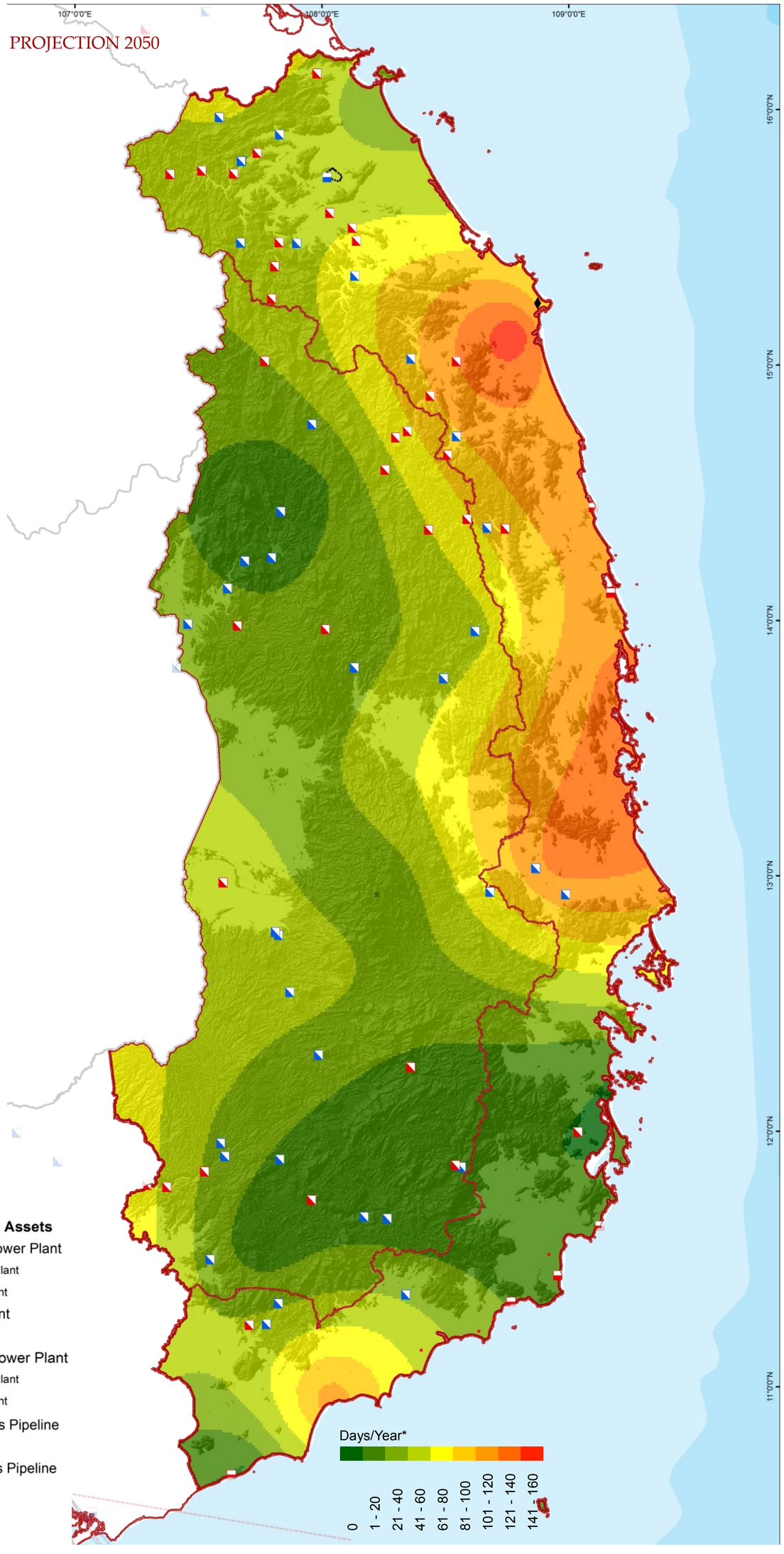


REGION 3 - POWER PLANTS (NUMBER OF HOT DAYS)

BASELINE



PROJECTION 2050



Energy

Power Generation Assets

Planned National Power Plant

- Thermal Power Plant
- Hydro Power Plant

Gas Processing Plant

Existing National Power Plant

- Thermal Power Plant
- Hydro Power Plant

Planned Oil and Gas Pipeline

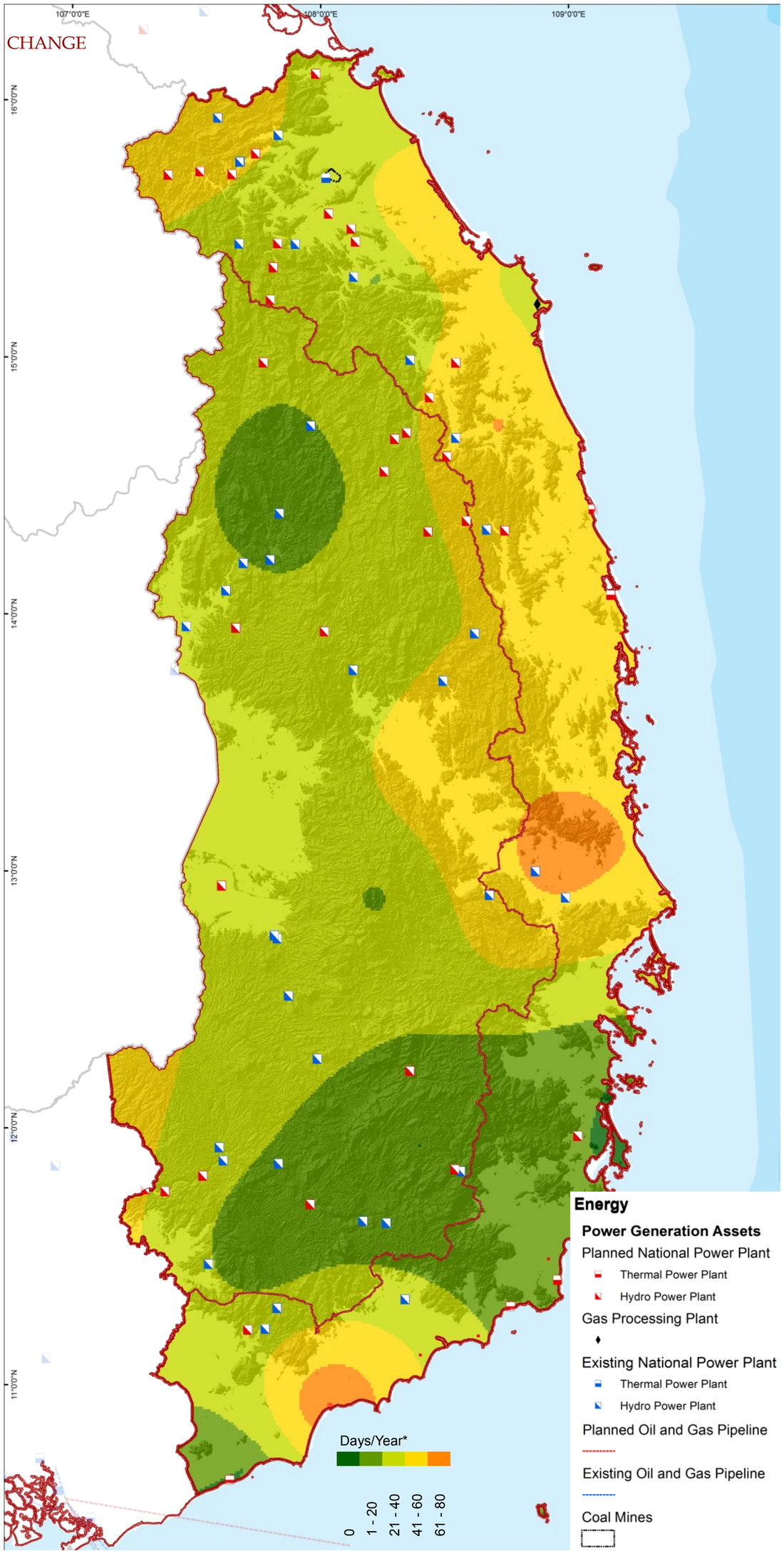
Existing Oil and Gas Pipeline

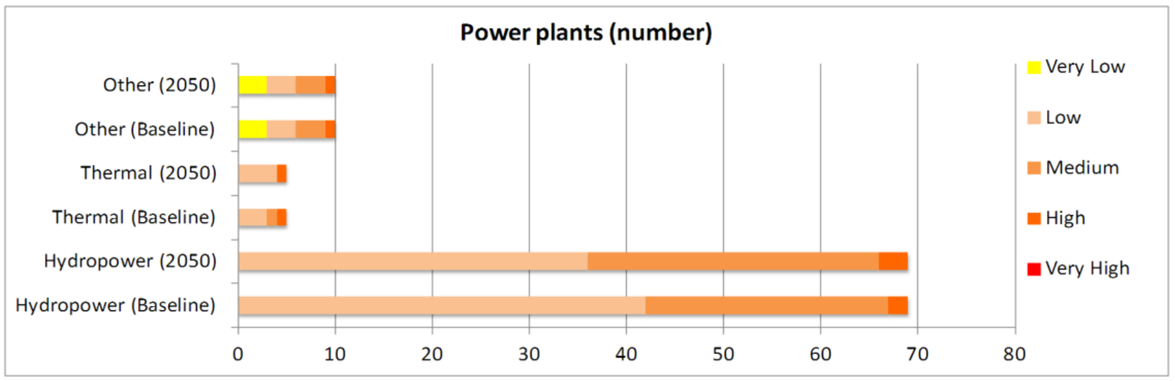
Coal Mines

FUNDING AGENCIES

PARTNERS

COMPANIES





Region 3 includes the following provinces: Bình Định, Bình Thuận, Đà Nẵng, Đăk Lăk, Đăk Nông, Gia Lai, Khánh Hoà, Kon Tum, Lâm Đồng, Ninh Thuận, Phú Yên, Quảng Nam, Quảng Ngãi.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

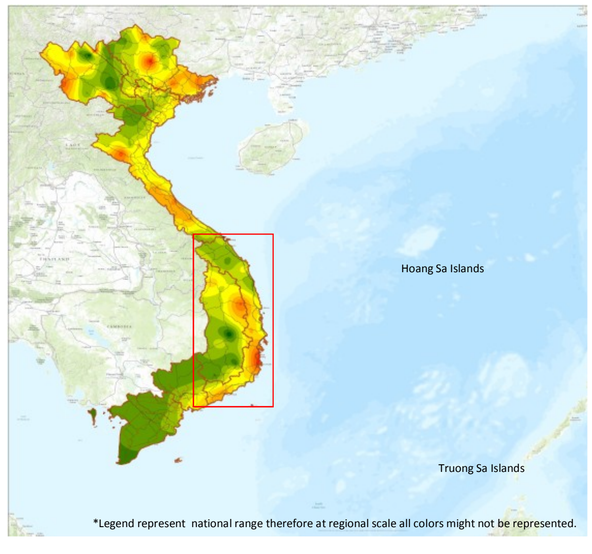
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

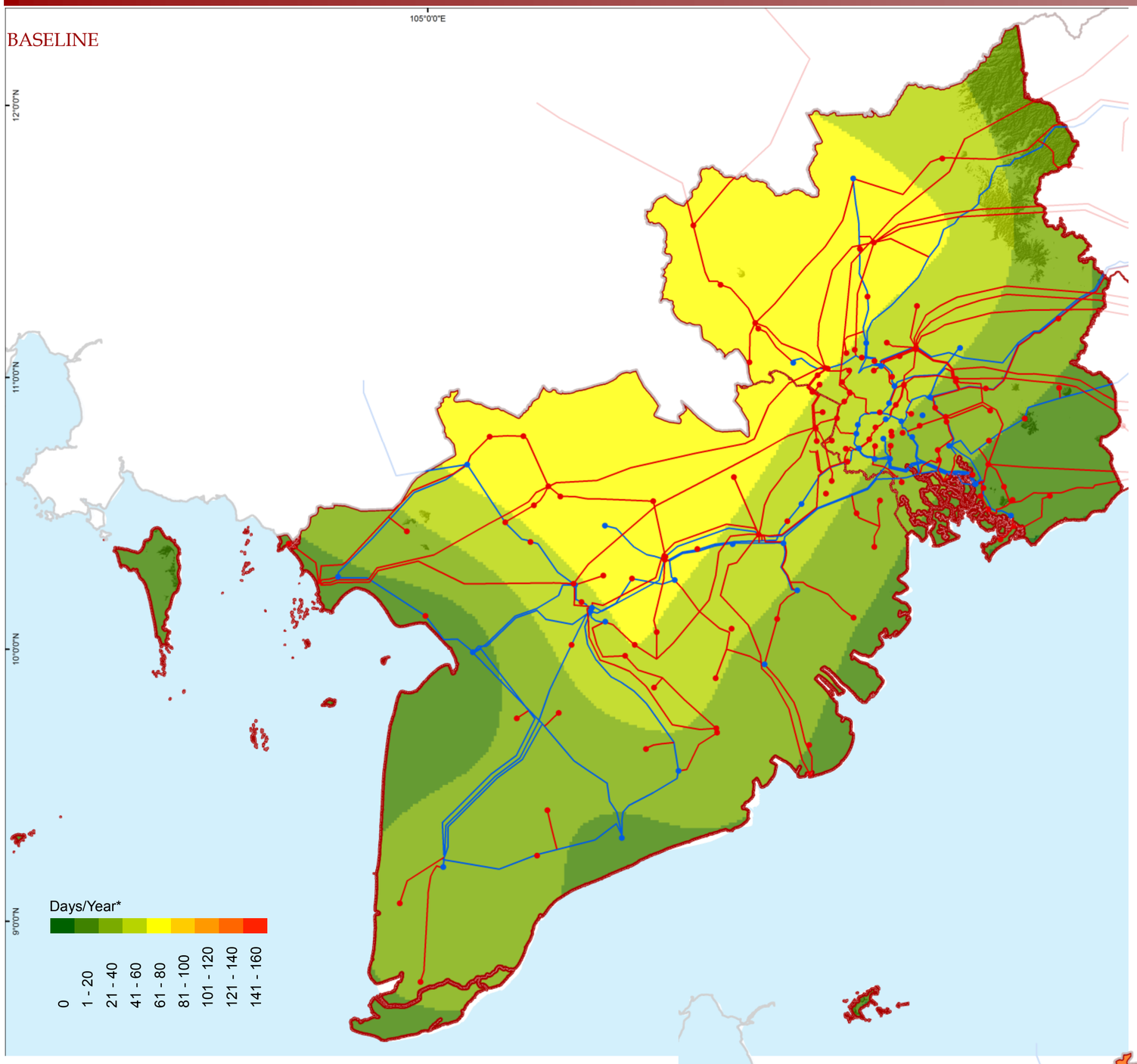
MAP SCALE - 1: 1,200,000

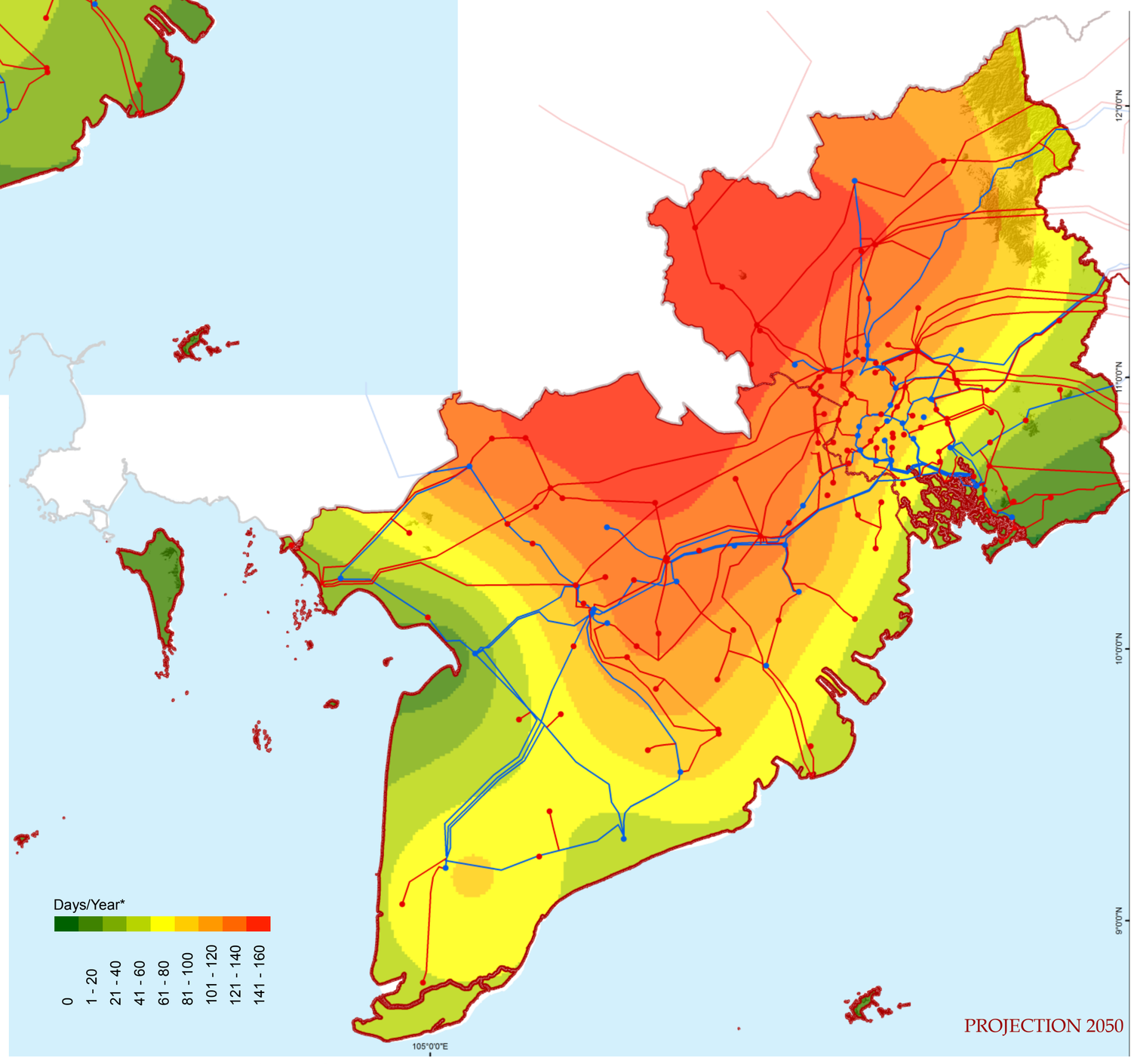
INDEX MAP



REGION 4 - TRANSMISSION LINE AND SUBSTATION (NUMBER OF HOT DAYS)

BASELINE





Energy

Transmission Assets

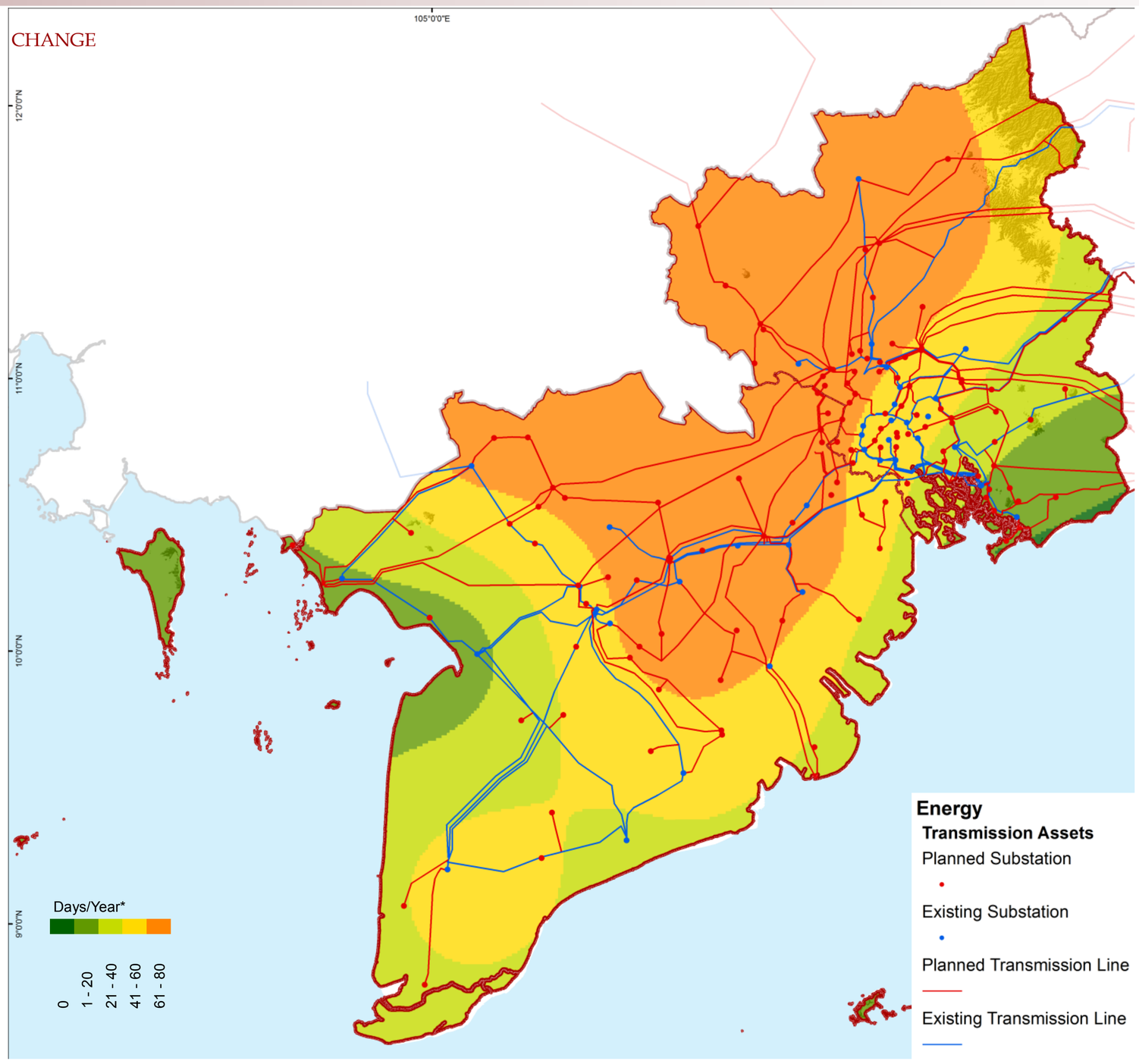
Planned Substation

Existing Substation

Planned Transmission Line

Existing Transmission Line

CHANGE



Energy

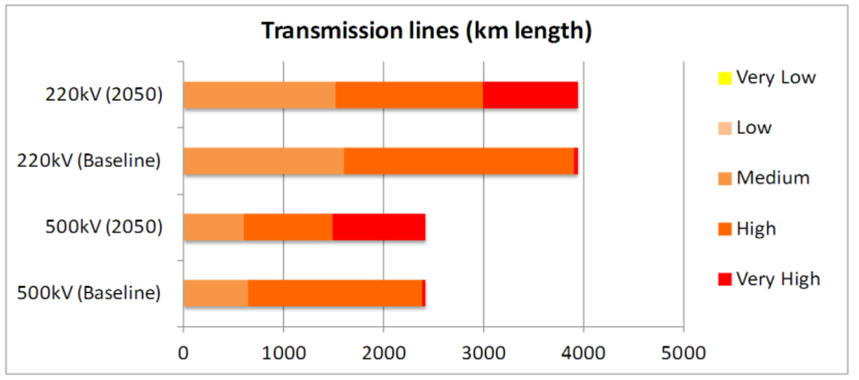
Transmission Assets

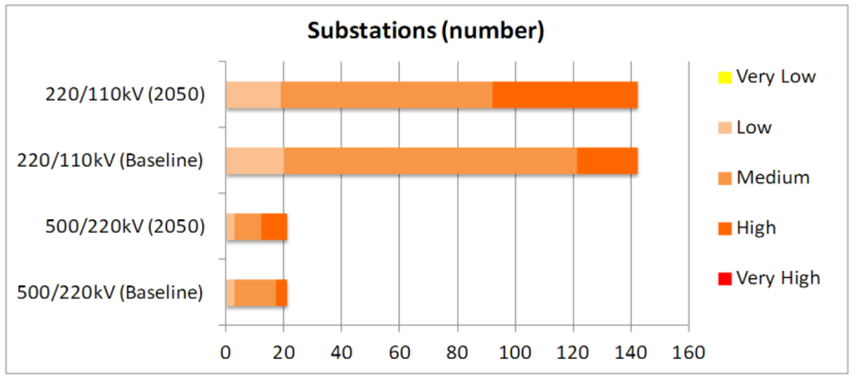
Planned Substation

Existing Substation

Planned Transmission Line

Existing Transmission Line





Region 4 includes the following provinces: An Giang, Bà Rịa Vũng Tàu, Bạc Liêu, Bến Tre, Bình Dương, Bình Phước, Cà Mau, Đồng Nai, Đồng Tháp, Hậu Giang, Kiên Giang, Long An, Sóc Trăng, Tây Ninh, Tiền Giang, TP Cần Thơ, TP Hồ Chí Minh, Trà Vinh, Vinh Long.

DATA SOURCES

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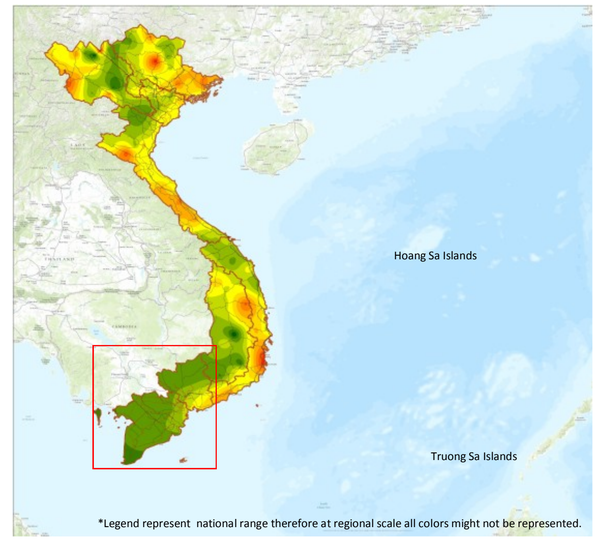
GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

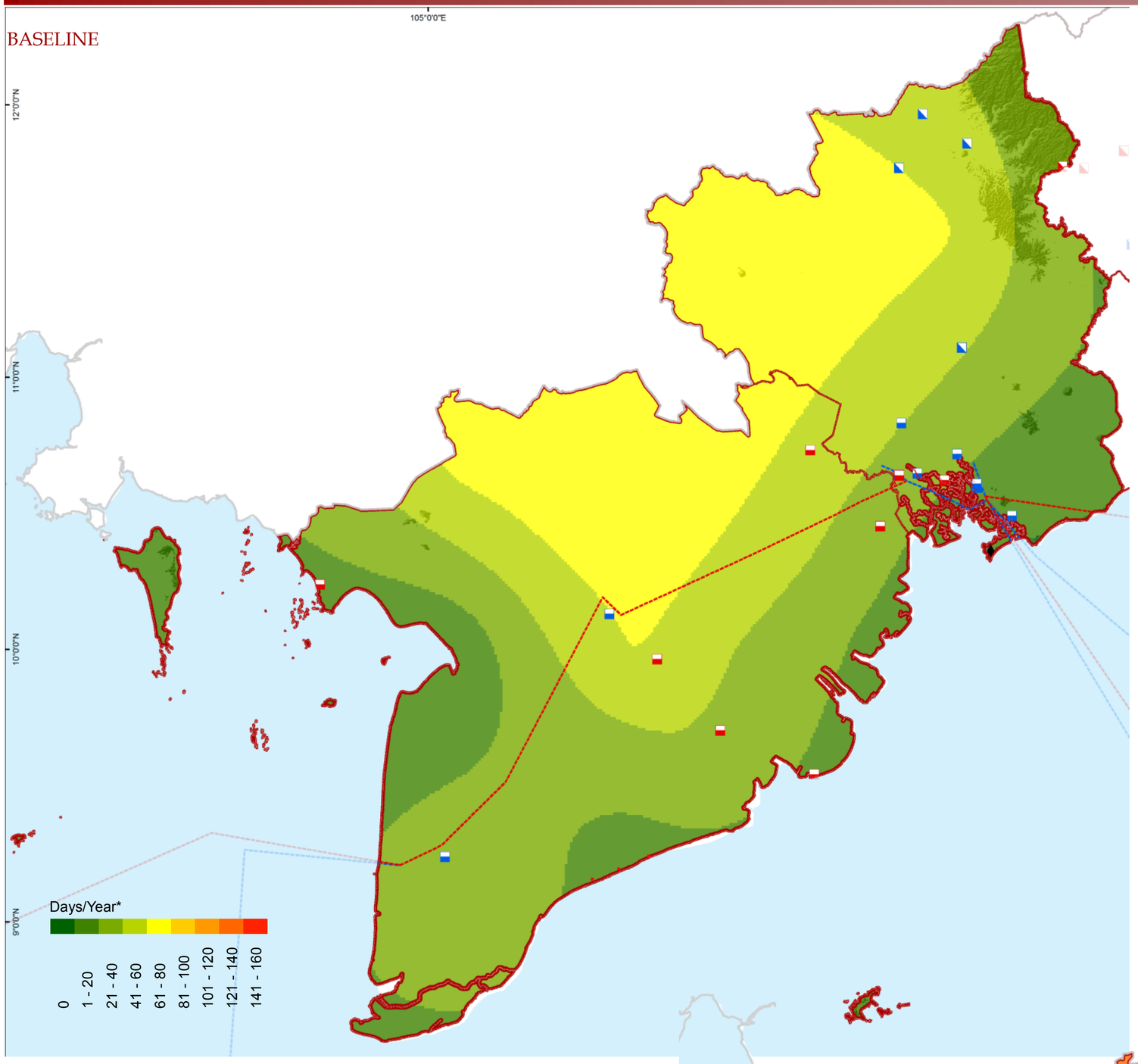
MAP SCALE - 1: 1,200,000

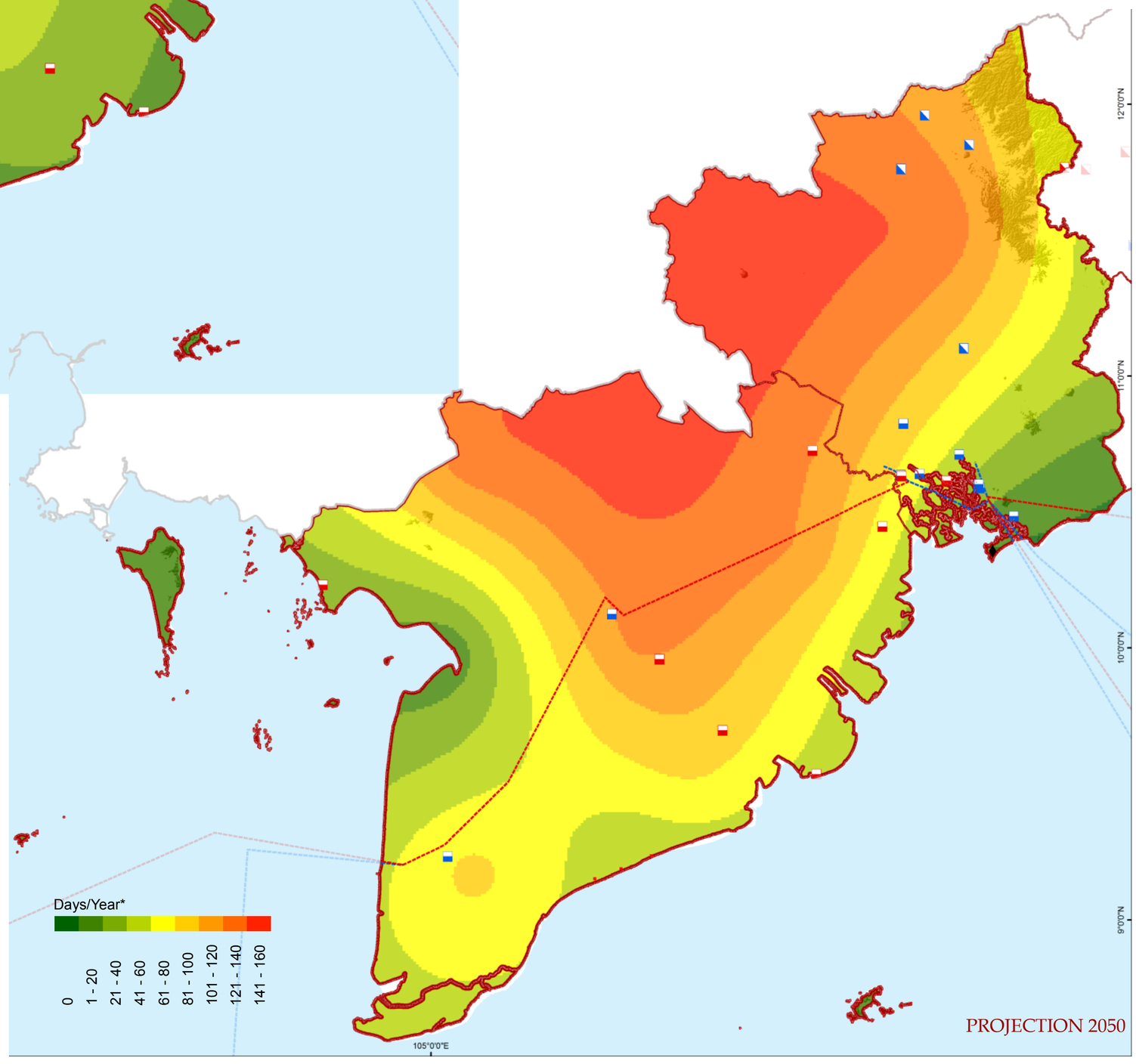
INDEX MAP



REGION 4 - POWER PLANTS (NUMBER OF HOT DAYS)

BASELINE





Energy

Power Generation Assets

Planned National Power Plant

- Thermal Power Plant
- Hydro Power Plant

Gas Processing Plant

Existing National Power Plant

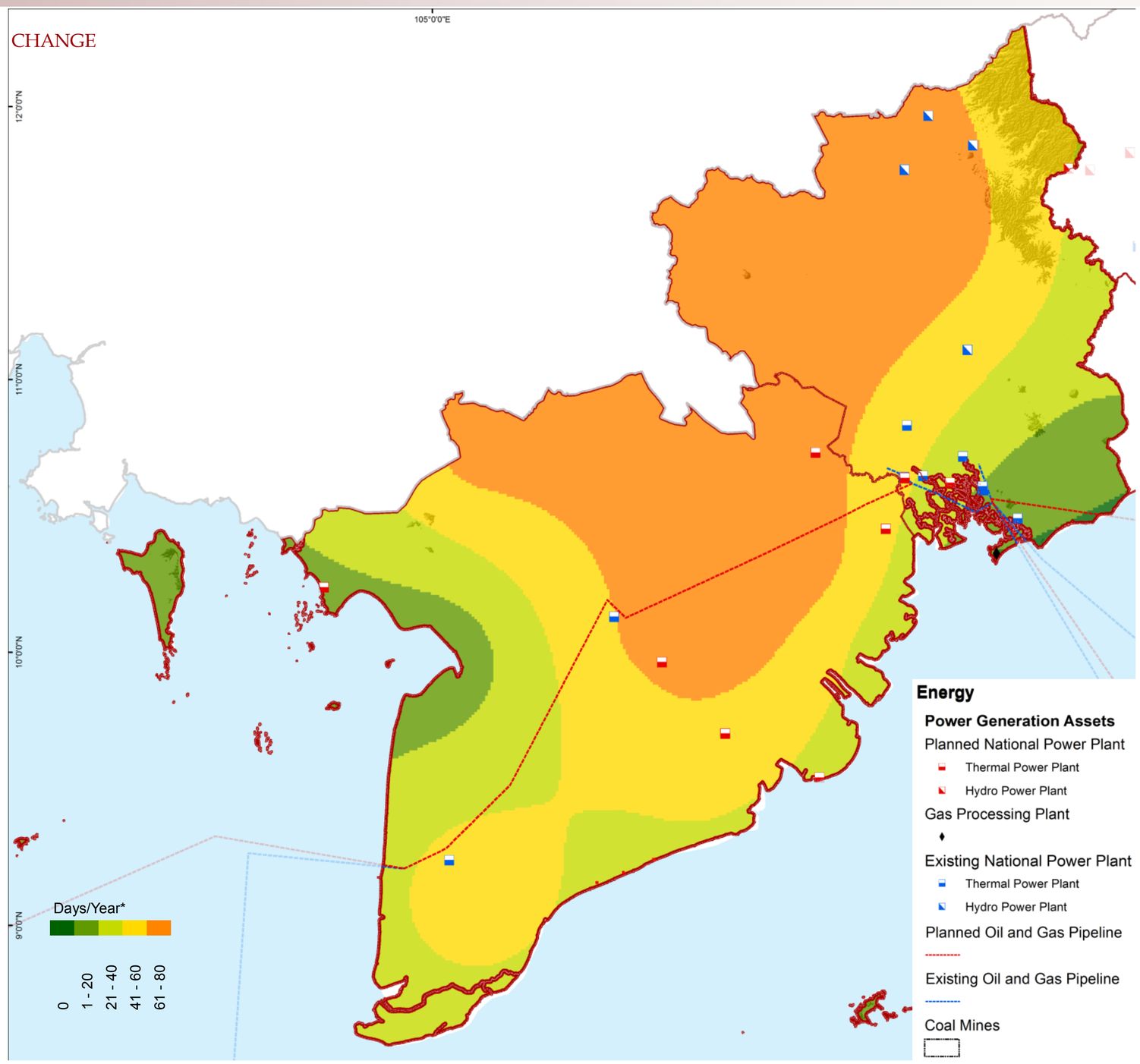
- Thermal Power Plant
- Hydro Power Plant

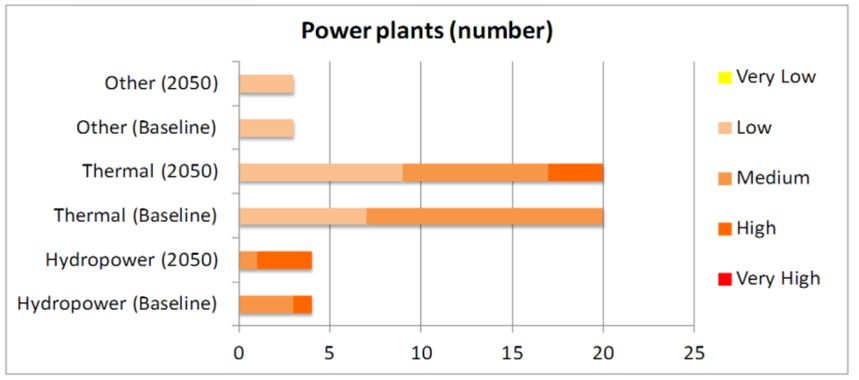
Planned Oil and Gas Pipeline

Existing Oil and Gas Pipeline

Coal Mines

CHANGE





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DATA SOURCES

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TDSI - TRANSPORTATION INFRASTRUCTURE

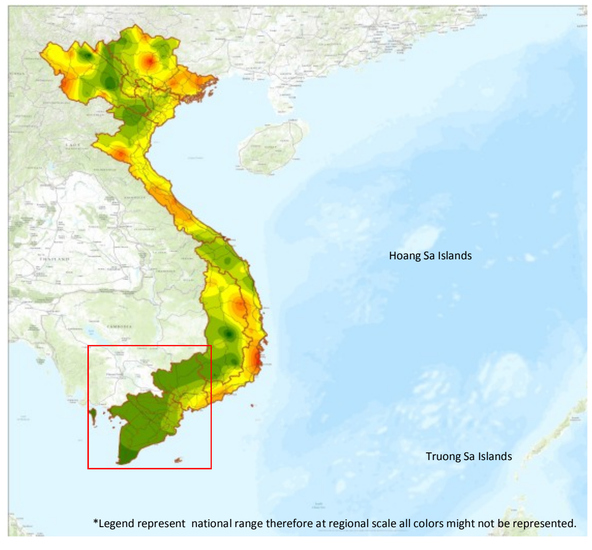
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

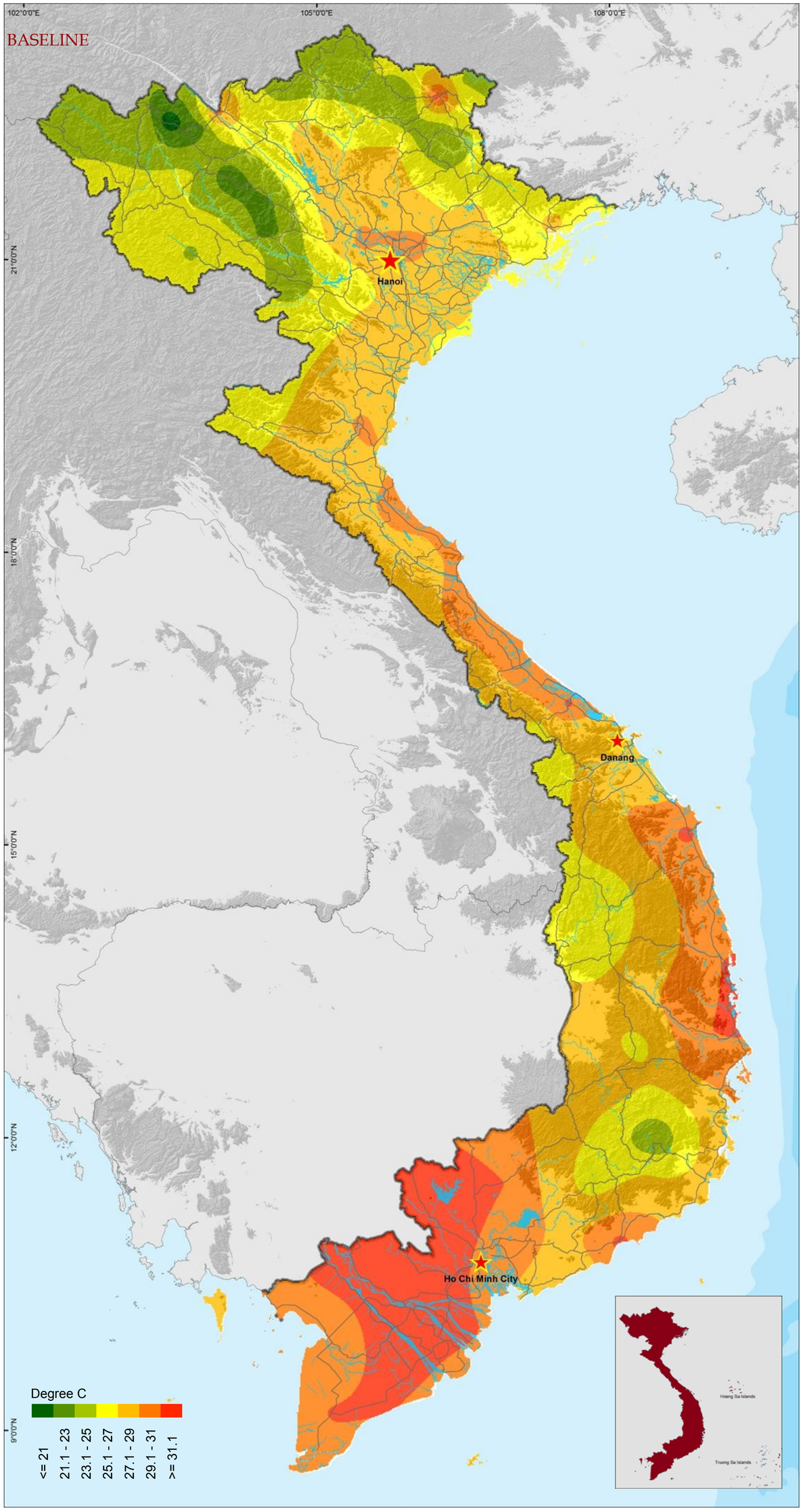
MAP SCALE - 1: 1,200,000

INDEX MAP



REGIONAL - TRANSPORTATION

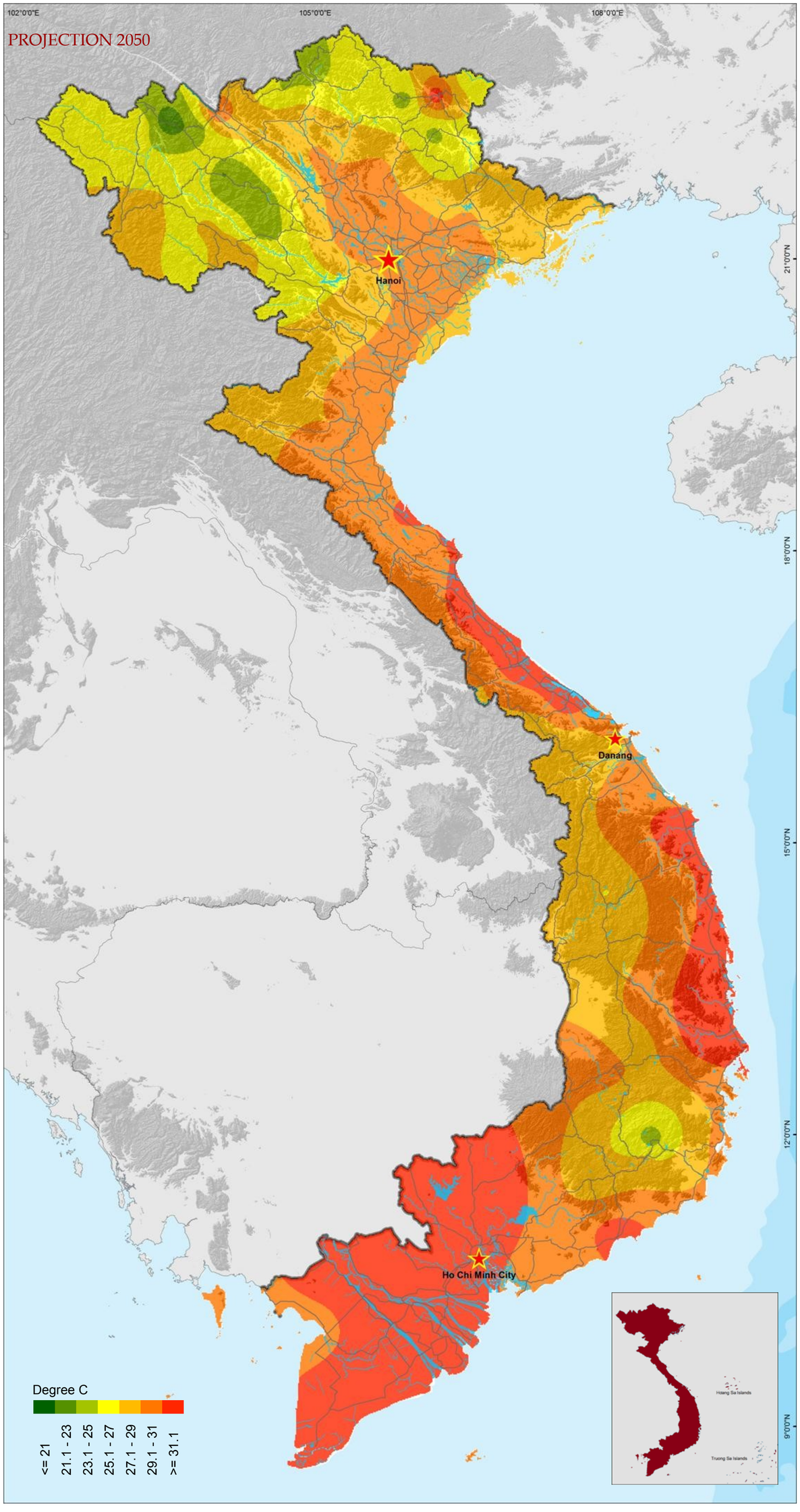
AVERAGE MAXIMUM DAILY TEMPERATURE



BASELINE

ROADS

Roads located in the Mekong Delta and south-central coastal areas experience the highest average maximum daily temperatures in the Baseline scenario. Temperature damage will not cause catastrophic failure. Major road assets in these areas will have issues such as surface deformation, rutting, melting, and warping of bridges that will slow and hinder traffic flow. This will especially be the case on roads with heavy vehicle traffic. In addition, damages from high temperatures are likely to be greater in major urban areas due to the urban heat island effect.



2050 SCENARIO

ROADS

Temperatures in 2050 are highest in the south-central coast and Mekong delta regions. Roads these areas will be impacted by rutting and melting of the surface. Increased traffic in the future will increase these damages unless design changes are made. This is particularly the case for roads connecting major urban centers to other provinces.

SUMMARY OF PROJECTED CHANGES

ROADS

Temperature increases in the north central coast are the highest in the country, ranging from 1.5oC to over 1.9oC, followed by the Dong Nai basin just north of HCMC which has temperatures of 1.5 to 1.8oC. The increase in temperature will result in new climatic conditions that will require changes to maintenance regimes to keep the road operating.

RAILWAYS

Temperature damage to railway lines are not expected in Vietnam as the tracks are not continuously welded. There is typically a gap of 2cm between sections of track, which allows for thermal expansion or contraction, although it does limit speed.

INLAND WATERWAYS

Temperatures will not significantly impact inland waterway transport assets, although hardstand areas in ports are subject to melting or rutting. There is however no evidence of this and these hardstand areas may be designed to carry heavier traffic and therefore are more resistant.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

N
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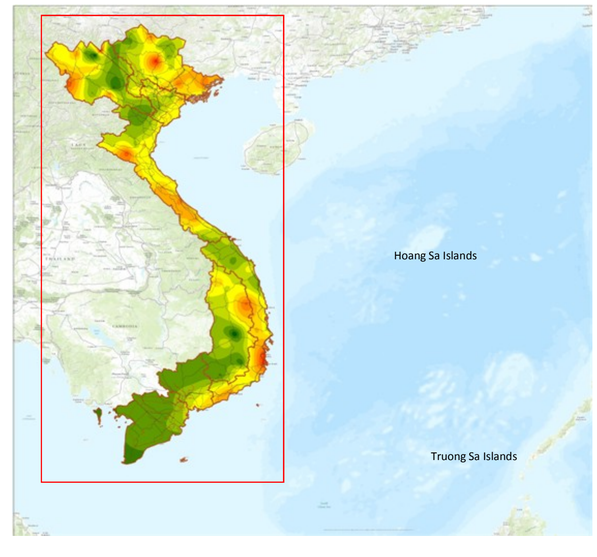
MAP SCALE - 1: 3,000,000

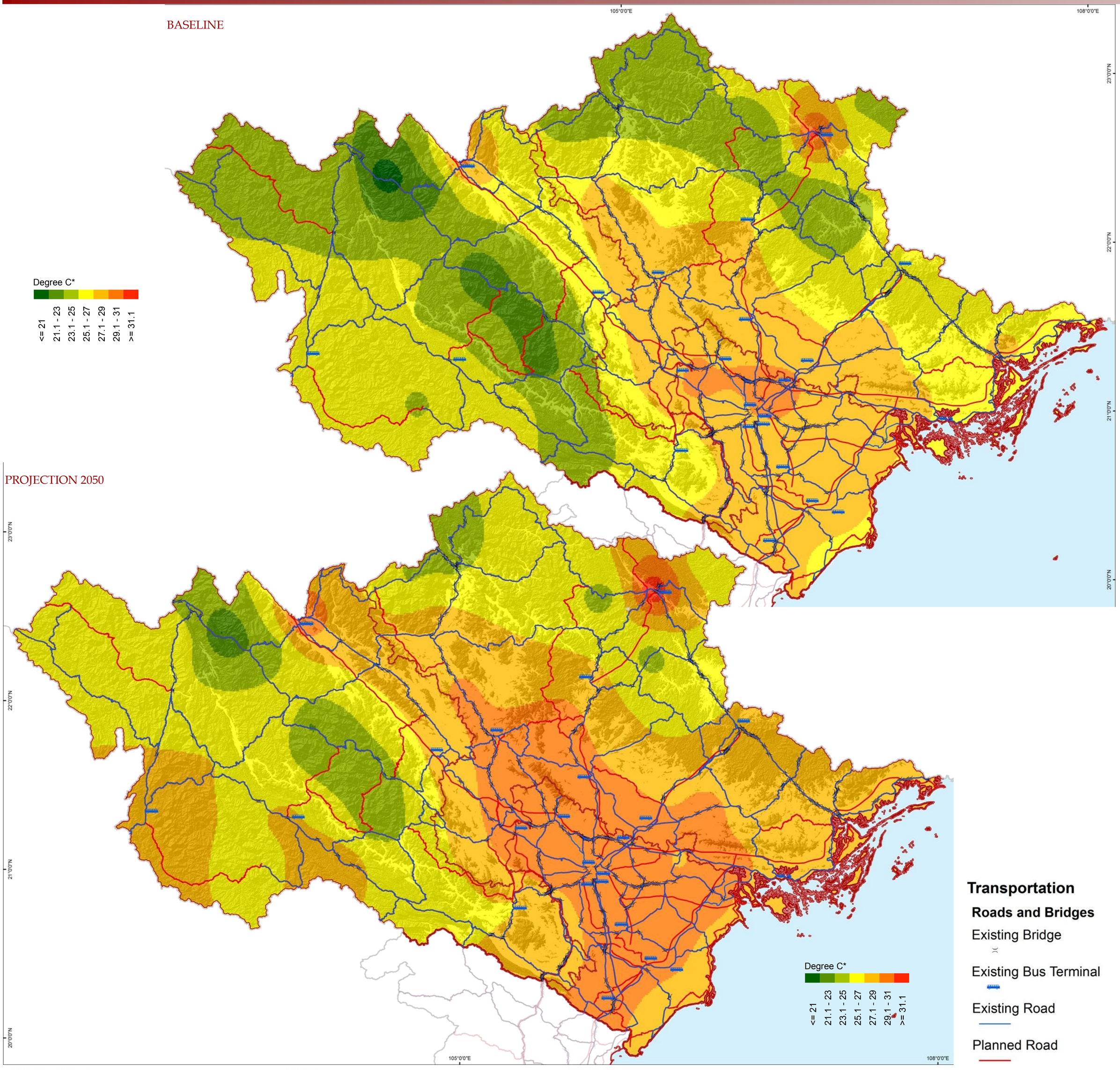
INDEX MAP



REGION 1 - ROADS AND BRIDGES (AVERAGE MAXIMUM DAILY TEMPERATURE)

BASELINE

PROJECTION 2050

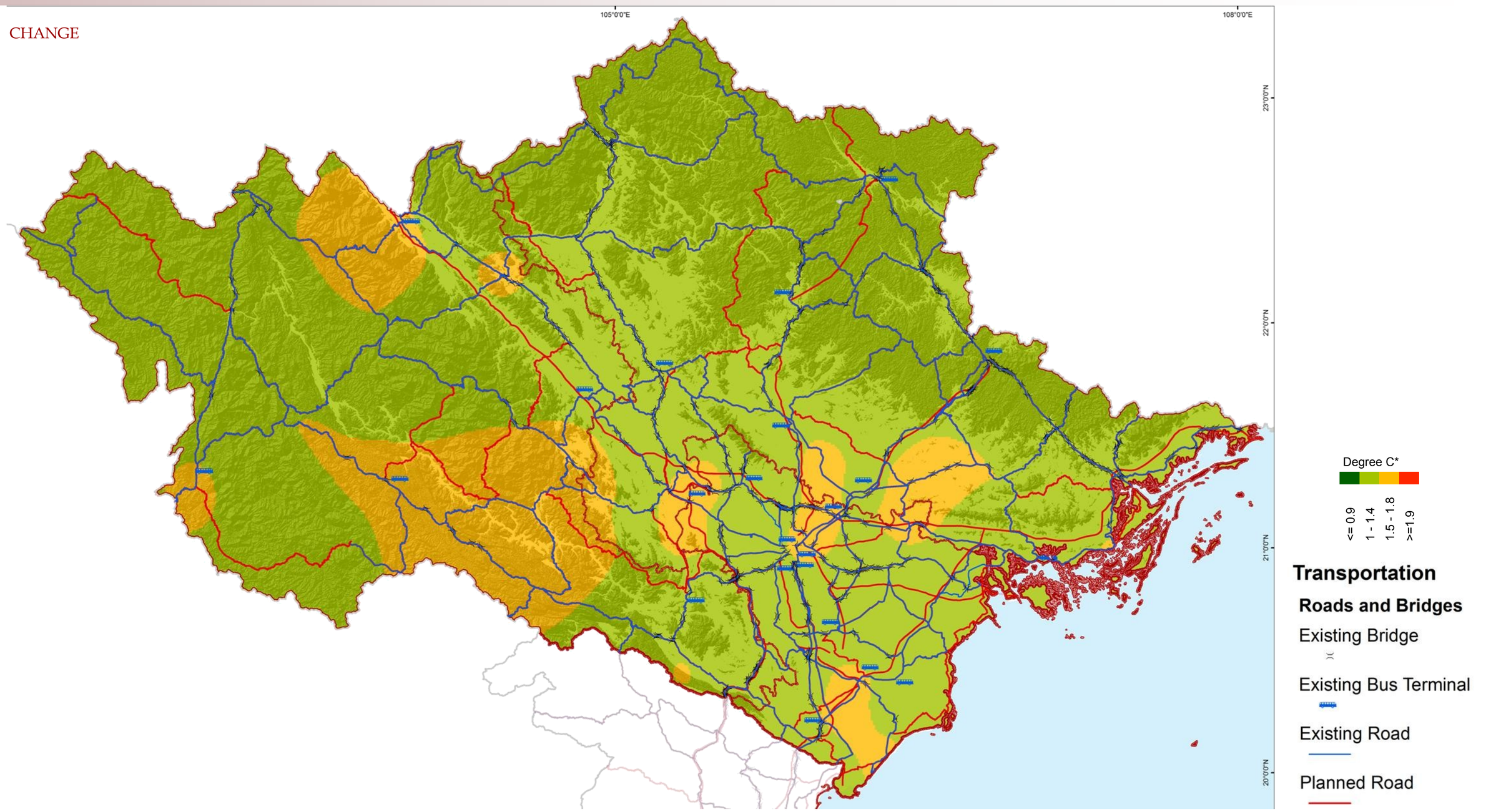


FUNDING AGENCIES

PARTNERS

COMPANIES

CHANGE



BASELINE

Impact scale	Possible Affected Region	Possible Affected Road
20 - 24 Degree Celsius	Lai Chau, Son La, Yen Bai, Hoa Binh, Ha Giang, Tuyen Quang, Cao Bang, Bac Can, Lang Son.	2,3 , 4, 12, 100, 279, 6, 37, 43, 32, 34, 15, HCM
25 - 28 Degree Celsius	Lai Chau, Lao Cai, Yen Bai, Ha Giang, Tuyen Quang, Bac Can, Lang Son, Quang Ninh, Bac Giang, Thai Binh, Nam Dinh, Hoa Binh, Phu Tho.	4, 70, 279, 2, 37, 32, 3,1, HCM, 31, 5, 18, 39, 10
29 - 34 Degree Celsius	Cao Bang , Ha Noi, Ha Tay, Vinh Phuc, Phu Tho, Thai Nguyen, Tuyen Quang, Bac Giang, Bac Ninh, Hung Yen, Hai Duong, Hai Phong, Thai Binh, Nam Dinh, Ha Nam, Ninh Binh.	6, 32, LHL, HCM, 2, 23, 3, 18, 37, 1, 38, 5, 39, PV-CG,

2050 SCENARIO

Impact scale	Possible Affected Region	Possible Affected Road
20 - 24 Degree Celsius	Lai Chau, Lao Cai, Yen Bai, Son La, Hoa Binh, Ha Giang, Bac Can, Cao Bang, Lang Son.	4, 12, 100, 32, 279, 37, 43, 6, 34, 2, HCM, 3.
25 - 28 Degree Celsius	Lai Chau, Lao Cai, Son La, Hoa Binh, Phu Tho, Yen Bai, Ha Giang, Tuyen Quang, Bac Can, Lang Son, Quang Ninh.	4, 12, 279, 37, 15, 32, 70, HCM, 3, 1, 31, 18
29 - 34 Degree Celsius	Nam Dinh, Thai Binh, Ha Nam, Ha Tay, Hai Phong, Hai Duong, Hung Yen, Ha Noi, Bac Giang, Quang Ninh, Thai Nguyen, Vinh Phuc, Phu Tho, Tuyen Quang, Yen Bai, Ha Giang. Bac Can, Lang Son.	2, 70, 279, HCM, 3, 1, 31, 18, 10, 5, 37, 38, 39, PV-CG, 12, 21, LHL, 32.

Region 1 includes the following provinces: Bắc Cạn, Bắc Giang, Bắc Ninh, Cao Bằng, Điện Biên, Hà Giang, Hà Nam, Hà Nội, Hải Dương, Hải Phòng, Hoà Bình, Hưng Yên, Lai Châu, Lạng Sơn, Lào Cai, Nam Định, Ninh Bình, Phú Thọ, Quảng Ninh, Sơn La, Thái Bình, Thái Nguyên, Tuyên Quang, Vĩnh Phúc, Yên Bái.

SUMMARY OF PROJECTED CHANGES

Hotpots in Climate change impacting on road assets are projected in two main areas: Son La and Lao Cai. These provinces have an average maximum temperature increase up to 3^{o}C. Possible affected highways are 4D in Lao Cai and 2B, 43, 6, 37.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

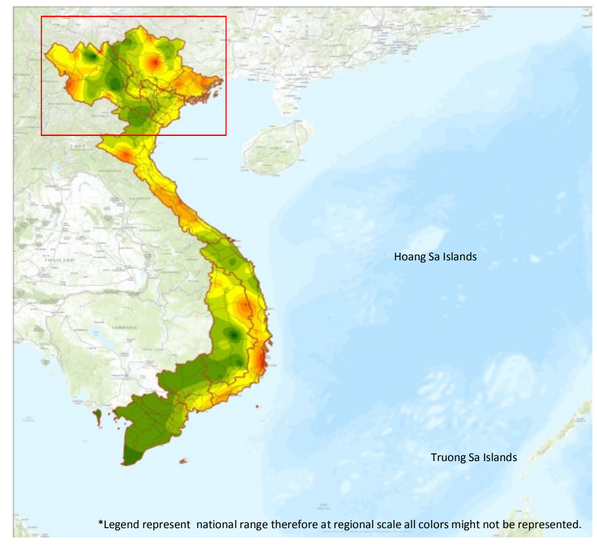
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

MAP SCALE - 1: 1,200,000

INDEX MAP



REGION 1 - OTHER TRANSPORT (AVERAGE MAXIMUM DAILY TEMPERATURE)

BASELINE

PROJECTION 2050

Degree C*

<= 21
21.1 - 23
23.1 - 25
25.1 - 27
27.1 - 29
29.1 - 31
>= 31.1

105°0'0"E
108°0'0"E
23°0'0"N
22°0'0"N
21°0'0"N
20°0'0"N

Transportation

Other Assets

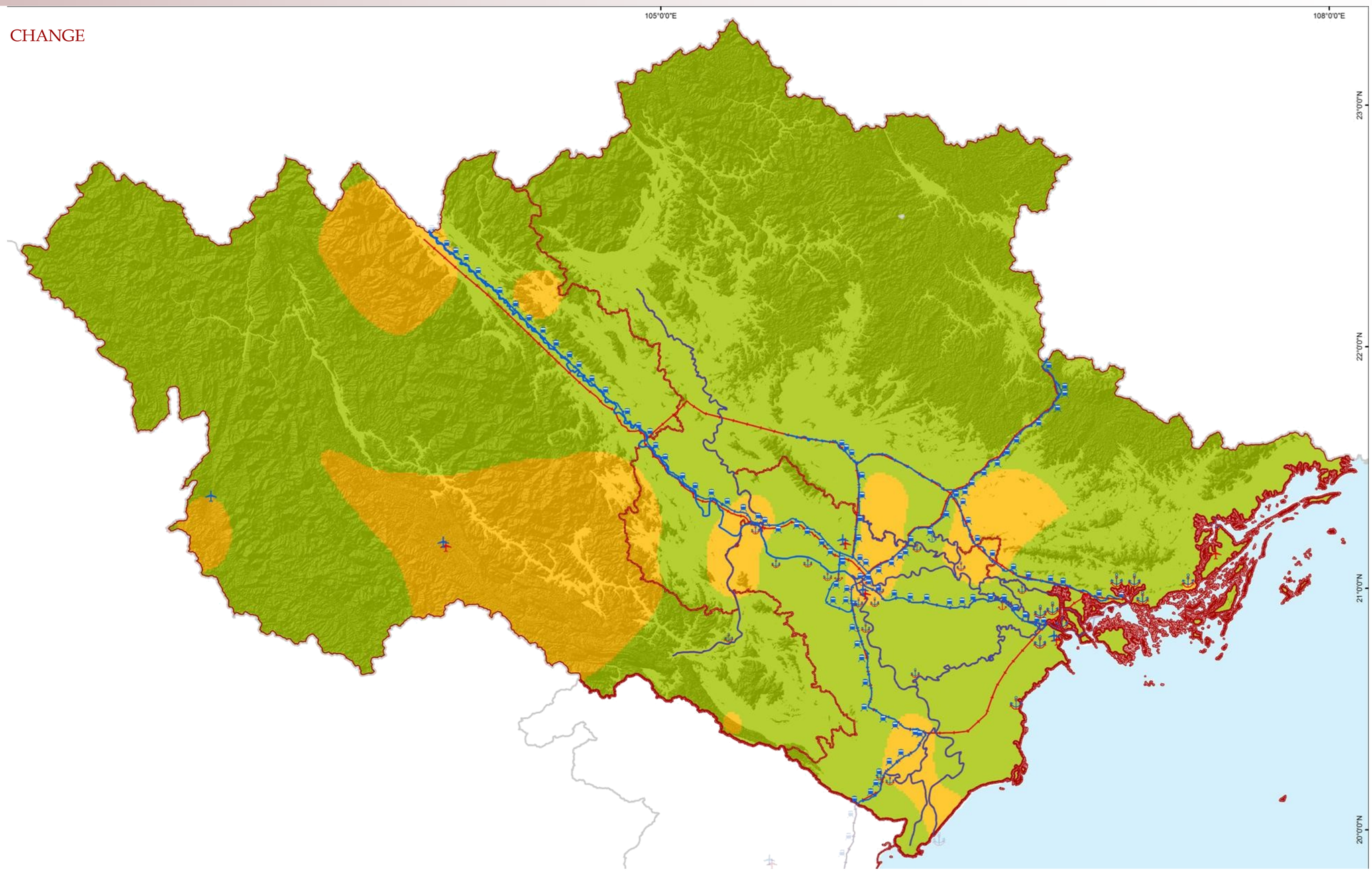
- Existing Civil Airport
- Planned Civil Airport
- Existing IWT Port
- Planned IWT Port
- Existing Sea Port
- Planned Sea Port
- Existing Rail Station
- Existing IWT Route
- Planned IWT Route
- Existing Rail Track
- Planned Rail Track

FUNDING AGENCIES

PARTNERS

COMPANIES

CHANGE



BASELINE

Impact scale	Possible Affected Region	Possible Affected Assets
20 - 24 Degree Celsius	Lai Chau, Son La, Yen Bai, Hoa Binh, Ha Giang, Tuyen Quang, Cao Bang, Bac Can, Lang Son.	Rail: Ha Noi- Lao Cai, Ha Noi-Dong Dang. IWT: Ha Noi-Lao Cai
25 - 28 Degree Celsius	Lai Chau, Lao Cai, Yen Bai, Ha Giang, Tuyen Quang, Bac Can, Lang Son, Quang Ninh, Bac Giang, Thai Binh, Nam Dinh, Hoa Binh, Phu Tho.	Rail: Dong Anh-Quan Trieu, Kep-Ha Long, Hai Phong-Thai Binh-Nam Dinh, Ha Noi- Dong Dang, Ha Noi-Lao Cai. IWT: Ha Noi-Lao Cai, Viet Tri-TuyenQuang, Ha Noi-Hai Phong, Quang Ninh-PhaLai, Lach Giang-Ha Noi, Cua Day-Ninh Binh, Hong Da-Hoa Binh.
29 - 34 Degree Celsius	Cao Bang , Ha Noi, Ha Tay, Vinh Phuc, Phu Tho, Thai Nguyen, Tuyen Quang, Bac Giang, Bac Ninh, Hung Yen, Hai Duong, Hai Phong, Thai Binh, Nam Dinh, Ha Nam, Ninh Binh.	Rail: Dong Anh-Quan Trieu, Ha Noi-Lao Cai, Ha Noi-Dong Dang, Kep-Ha Long, Ha Noi-Sai Gon. IWT: Ha Noi-Lao Cai, Viet Tri-TuyenQuang, Ha Noi-Hai Phong, Quang Ninh-PhaLai, Pha Lai-A lu, Pha Lai-Da Phuc, Lach Giang-Ha Noi, Quang Ninh-Ninh Binh, Cua Day-Ninh Binh, Hong Da-Hoa Binh.

2050 SCENARIO

Impact scale	Possible Affected Region	Possible Affected Assets
20 - 24 Degree Celsius	Lai Chau, Lao Cai, Yen Bai, Son La, Hoa Binh, Ha Giang, Bac Can, Cao Bang, Lang Son.	
25 - 28 Degree Celsius	Lai Chau, Lao Cai, Son La, Hoa Binh, Phu Tho, Yen Bai, Ha Giang, Tuyen Quang, Bac Can, Lang Son, Quang Ninh.	Rail: Ha Noi-Lao Cai, Ha Noi-Dong Dang. IWT: Ha Noi-Lao Cai, Hong Da-Hoa Binh
29 - 34 Degree Celsius	Nam Dinh, Thai Binh, Ha Nam, Ha Tay, Hai Phong, Hai Duong, Hung Yen, Ha Noi, Bac Giang, Quang Ninh, Thai Nguyen, Vinh Phuc, Phu Tho, Tuyen Quang, Yen Bai, Ha Giang. Bac Can, Lang Son.	Rail: Ha Noi-Lao Cai, Ha Noi-Dong Dang, Dong Anh-Quan Trieu, Kep-Ha Long, Ha Noi-Hai Phong, Ha Noi-Sai Gon, Hai Phong-Thai Binh-Nam Dinh. IWT: Ha Noi-Lao Cai, Viet Tri-TuyenQuang, Ha Noi-Hai Phong, Quang Ninh-PhaLai, Pha Lai-A lu, Pha Lai-Da Phuc, Lach Giang-Ha Noi, Quang Ninh-Ninh Binh, Cua Day-Ninh Binh, Hong Da-Hoa Binh.

Region 1 includes the following provinces: Bắc Cạn, Bắc Giang, Bắc Ninh, Cao Bằng, Điện Biên, Hà Giang, Hà Nam, Hà Nội, Hải Dương, Hải Phòng, Hoà Bình, Hưng Yên, Lai Châu, Lạng Sơn, Lào Cai, Nam Định, Ninh Bình, Phú Thọ, Quảng Ninh, Sơn La, Thái Bình, Thái Nguyên, Tuyên Quang, Vĩnh Phúc, Yên Bái.

SUMMARY OF PROJECTED CHANGES

Hotpots in Climate change impacting on other transport assets are projected in two main areas: Son La and Lao Cai. These provinces have an average maximum temperature increase up to 3°C. Other transport assets is susceptible to the temperature impacts as Na San airport.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

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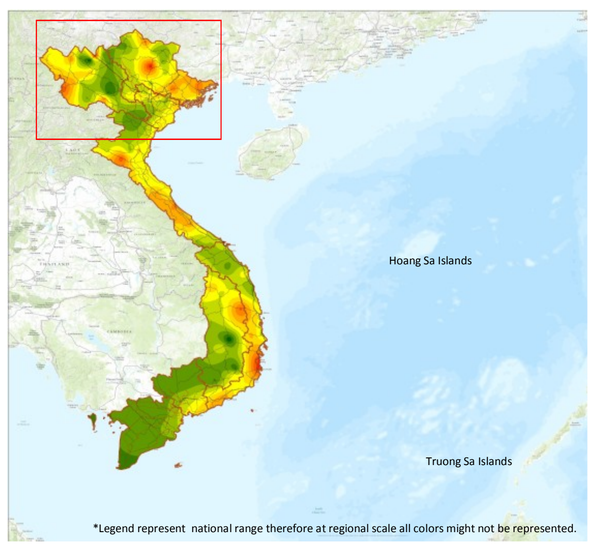
MAP SCALE - 1: 1,200,000

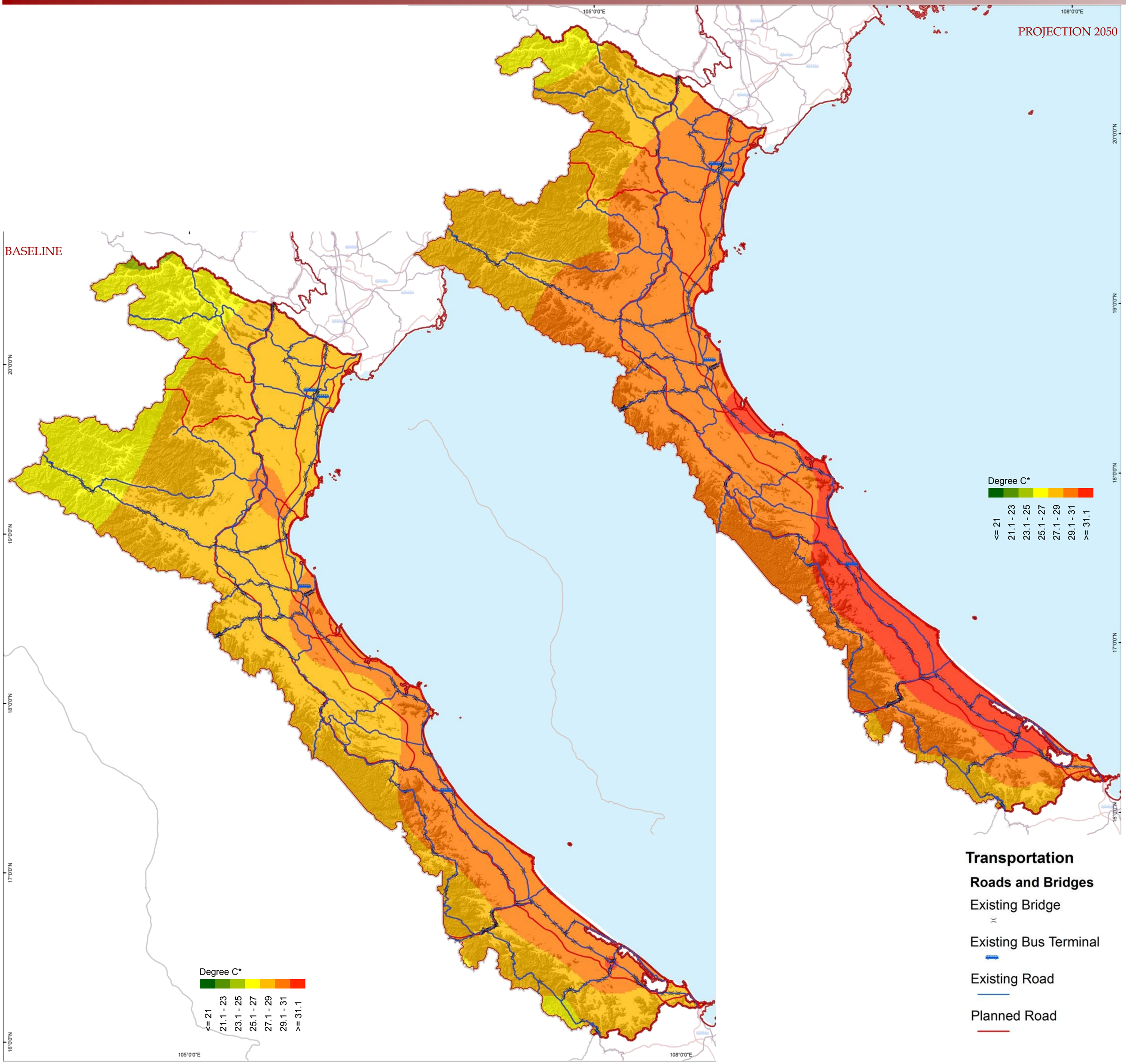
INDEX MAP



REGION 2 - ROADS AND BRIDGES (AVERAGE MAXIMUM DAILY TEMPERATURE)

BASELINE

PROJECTION 2050

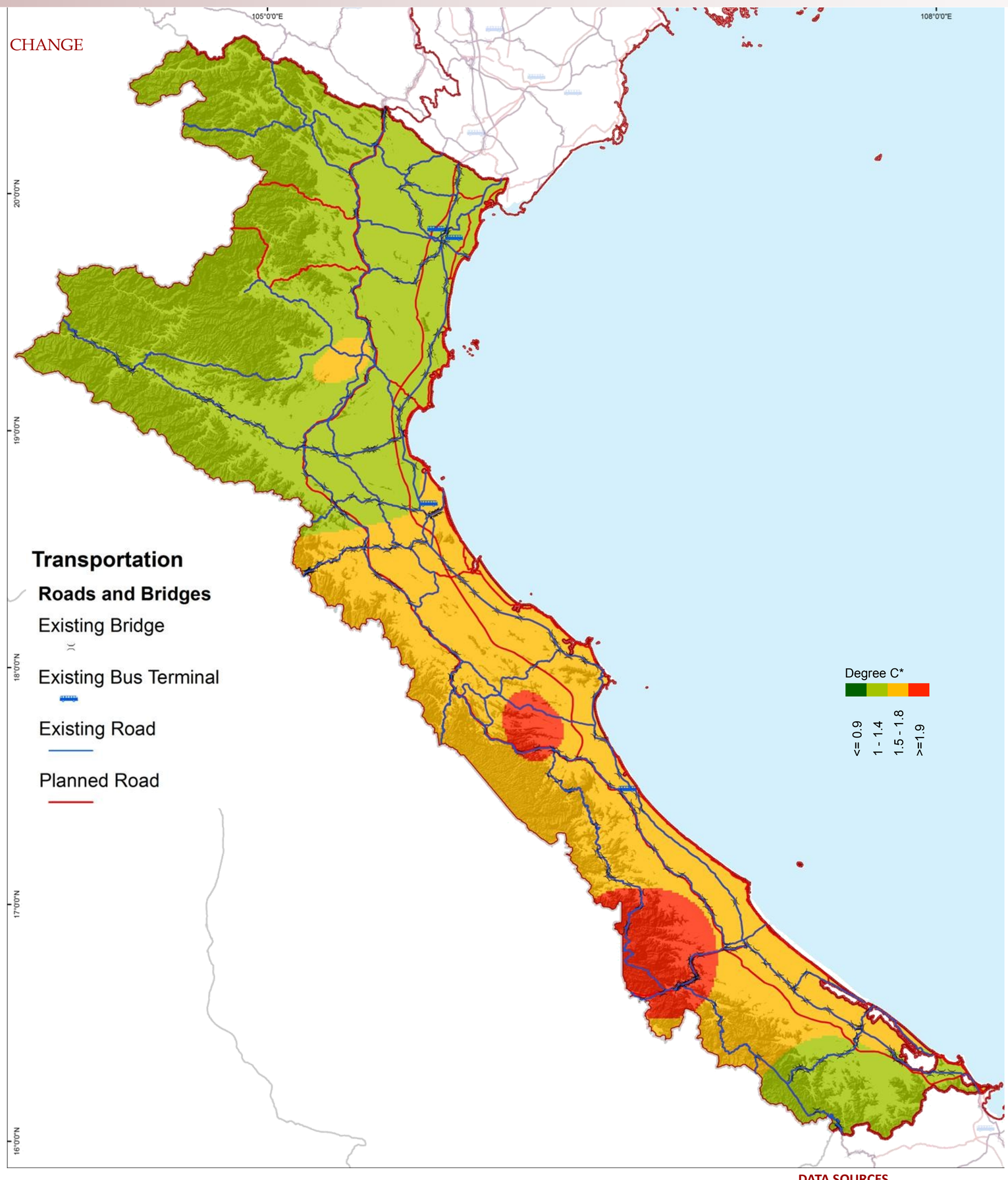


FUNDING AGENCIES

PARTNERS

COMPANIES

CHANGE



BASELINE

Impact scale	Possible Affected Region	Possible Affected Road
20 - 24 Degree Celsius	Thanh Hoa	15, 217.
25 - 28 Degree Celsius	Thanh Hoa, Nghe An, Quang Binh, Quang Tri, Thu Thien Hue	15, 217, HCM, 45, 47, 48, 7, 12, 49.
29 - 34 Degree Celsius	Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Tri, Thua Thien Hue	45, 217, 1, 10, 47, HCM, 15, 48, 7, 46, 8, 12, 9, 49.

2050 SCENARIO

Impact scale	Possible Affected Region	Possible Affected Road
20 - 24 Degree Celsius		
25 - 28 Degree Celsius	Thanh Hoa, Nghe An.	15, 217, 7, 48
29 - 34 Degree Celsius	Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Tri, Thua Thien Hue	45, 217, 1, 10, 47, HCM, 15, 48, 7, 46, 8, 12, 9, 49.

SUMMARY OF PROJECTED CHANGES

Hotpots in Climate change impacting on road assets are projected in main areas: Ha Tinh, Quang Binh, Quang Tri and a part of Hue. These provinces have an average maximum temperature increase up to 3°C. Possible affected highways are 8, 15, HCM, 1A, Expressway, 12C, 12A, 9, 49B.

Region 2 includes the following provinces: Hà Tĩnh, Nghệ An, Quảng Bình, Quảng Trị, Thanh Hoá, Thừa Thiên Huế.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

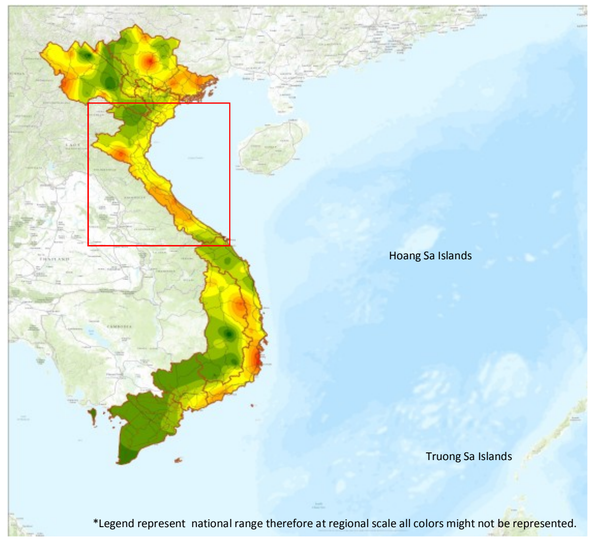
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

MAP SCALE - 1: 1,200,000

INDEX MAP



REGION 2 - OTHER TRANSPORT (AVERAGE MAXIMUM DAILY TEMPERATURE)

BASELINE

PROJECTION 2050

Transportation

Other Assets

- Existing Civil Airport
- Planned Civil Airport
- Existing IWT Port
- Planned IWT Port
- Existing Sea Port
- Planned Sea Port
- Existing Rail Station
- Existing IWT Route
- Planned IWT Route
- Existing Rail Track
- Planned Rail Track

Degree C*

<= 21
21.1 - 23
23.1 - 25
25.1 - 27
27.1 - 29
29.1 - 31
>= 31.1

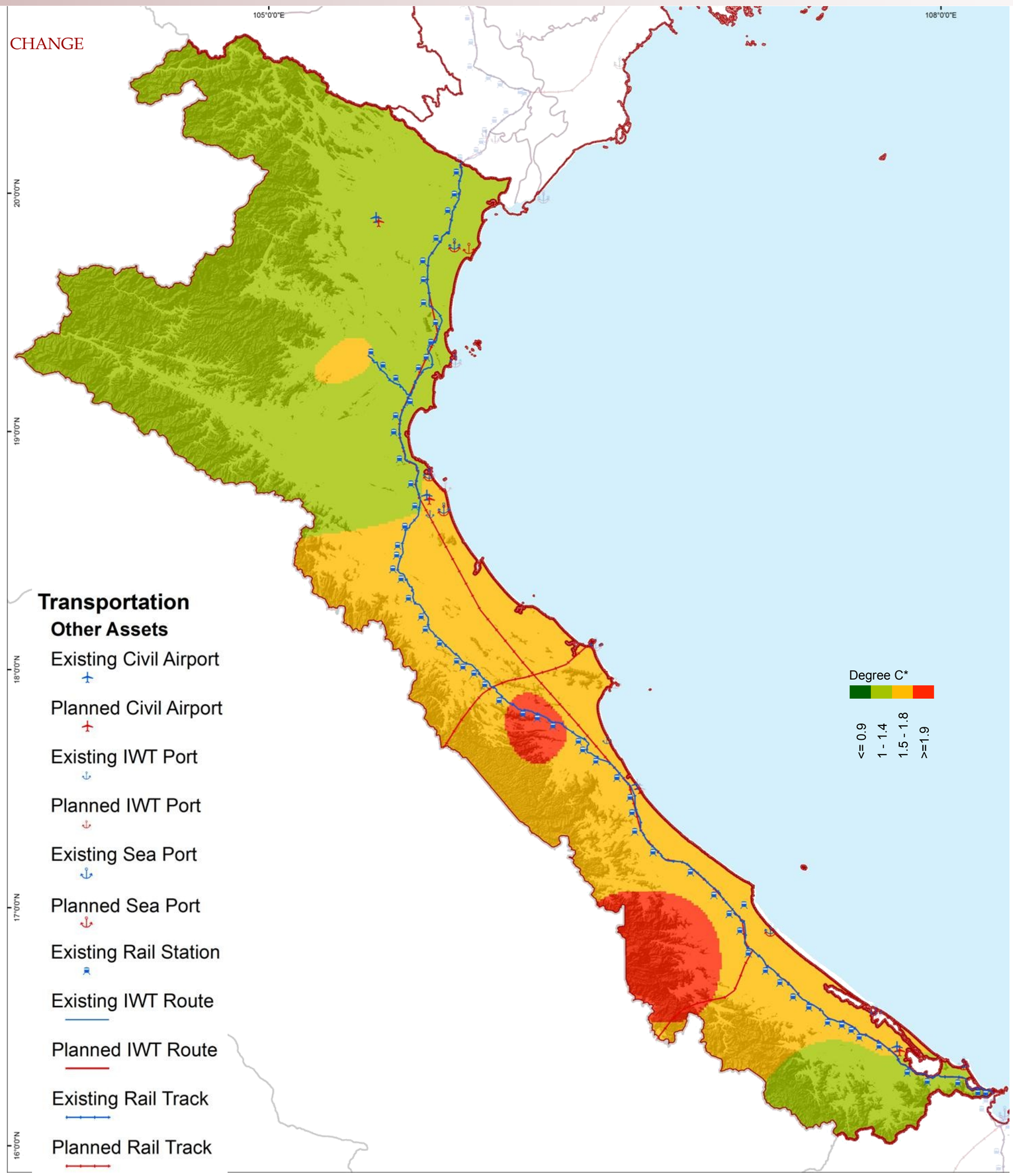
105°0'0"E
108°0'0"E
20°0'0"N
19°0'0"N
18°0'0"N
17°0'0"N
16°0'0"N

FUNDING AGENCIES

PARTNERS

COMPANIES

CHANGE



BASELINE

Impact scale	Possible Affected Region	Possible Affected Assets
20 - 24 Degree Celsius	Thanh Hoa	
25 - 28 Degree Celsius	Thanh Hoa, Nghe An, Quang Binh, Quang Tri, Thu Thien Hue	Rail: Vung Ang-Mu Gia
29 - 34 Degree Celsius	Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Tri, Thua Thien Hue	Rail: Ha Noi-Sai Gon, Vung Ang-Mu Gia, Dong Ha-Lao Bao.

2050 SCENARIO

Impact scale	Possible Affected Region	Possible Affected Assets
20 - 24 Degree Celsius		
25 - 28 Degree Celsius	Thanh Hoa, Nghe An.	
29 - 34 Degree Celsius	Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Tri, Thua Thien Hue	Rail: Ha Noi-Sai Gon, Vung Ang-Mu Gia, Dong Ha-Lao Bao.

SUMMARY OF PROJECTED CHANGES

Hotpots in Climate change impacting on road assets are projected in main areas: Ha Tinh, Quang Binh, Quang Tri and a part of Hue. These provinces have an average maximum temperature increase up to 3oC. Transport assets are susceptible as below:

- Railway: North-South railway and stations
- Aviation, seaport, and IWT

Region 2 includes the following provinces: Hà Tĩnh, Nghệ An, Quảng Bình, Quảng Trị, Thanh Hoá, Thừa Thiên Huế.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

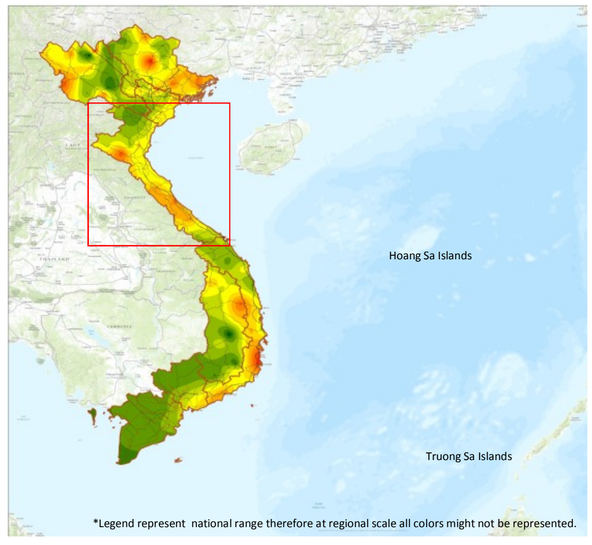
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

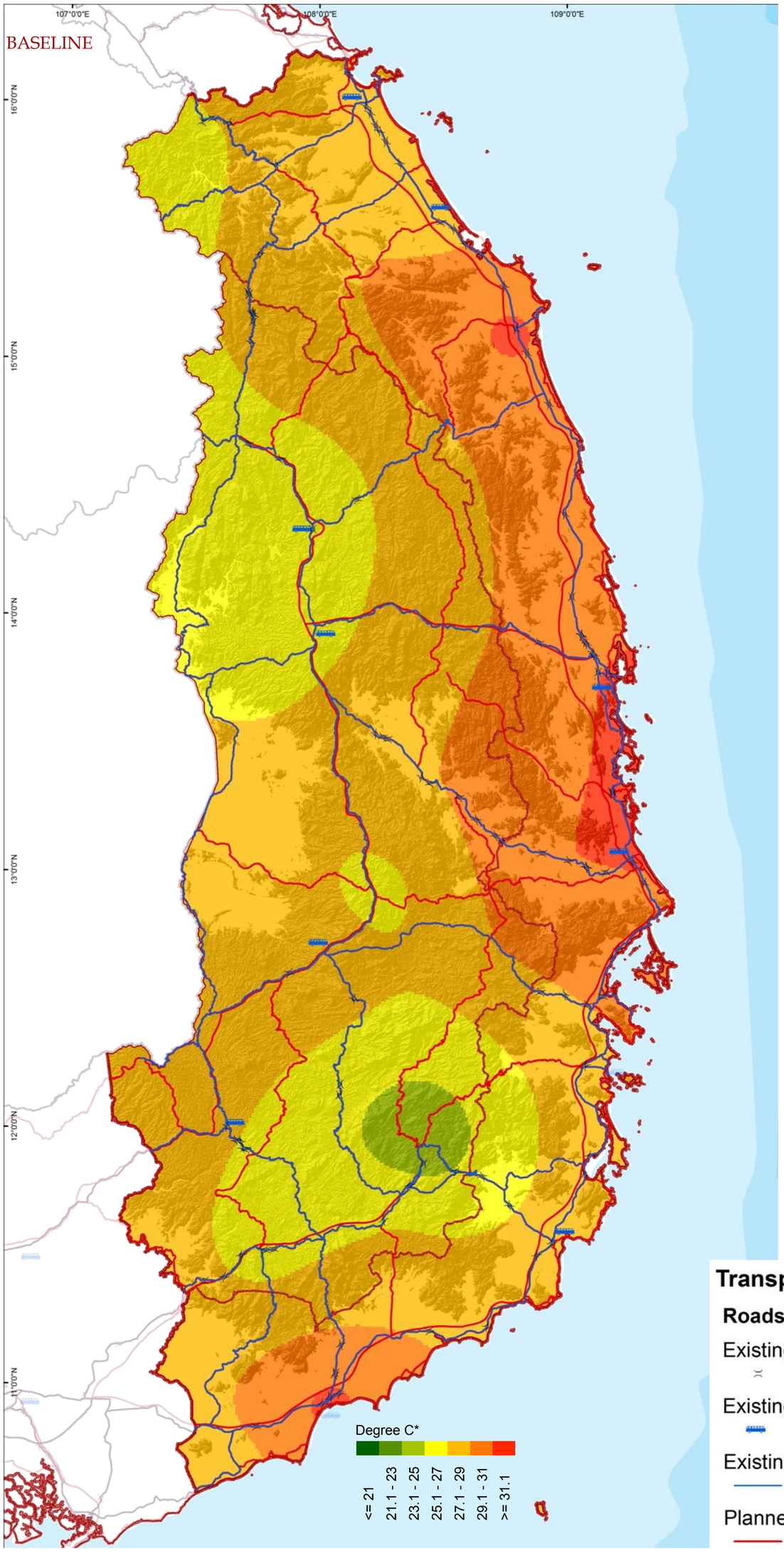
MAP SCALE - 1: 1,200,000

INDEX MAP

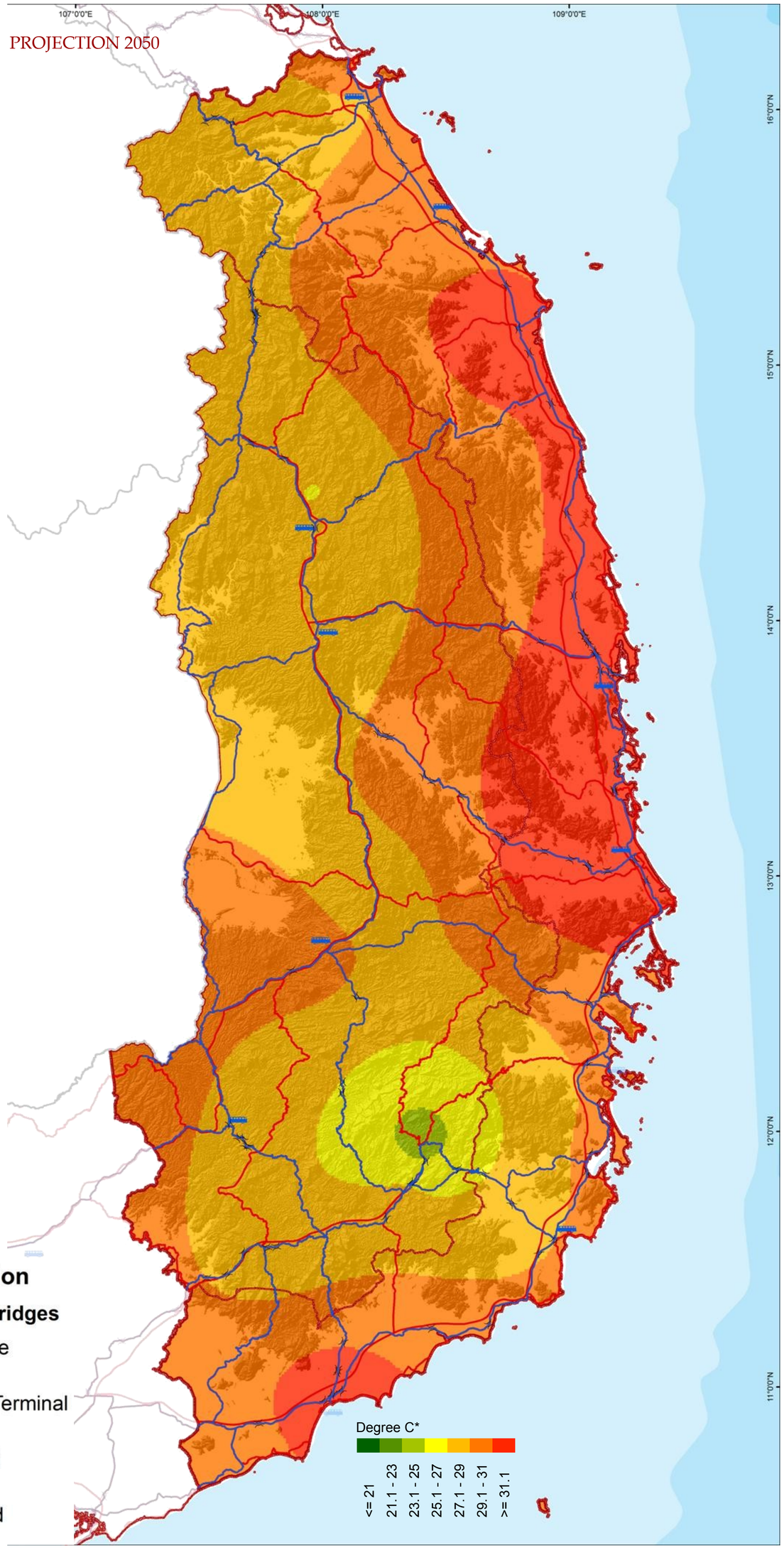


REGION 3 - ROADS AND BRIDGES (AVERAGE MAXIMUM DAILY TEMPERATURE)

BASELINE



PROJECTION 2050



Transportation

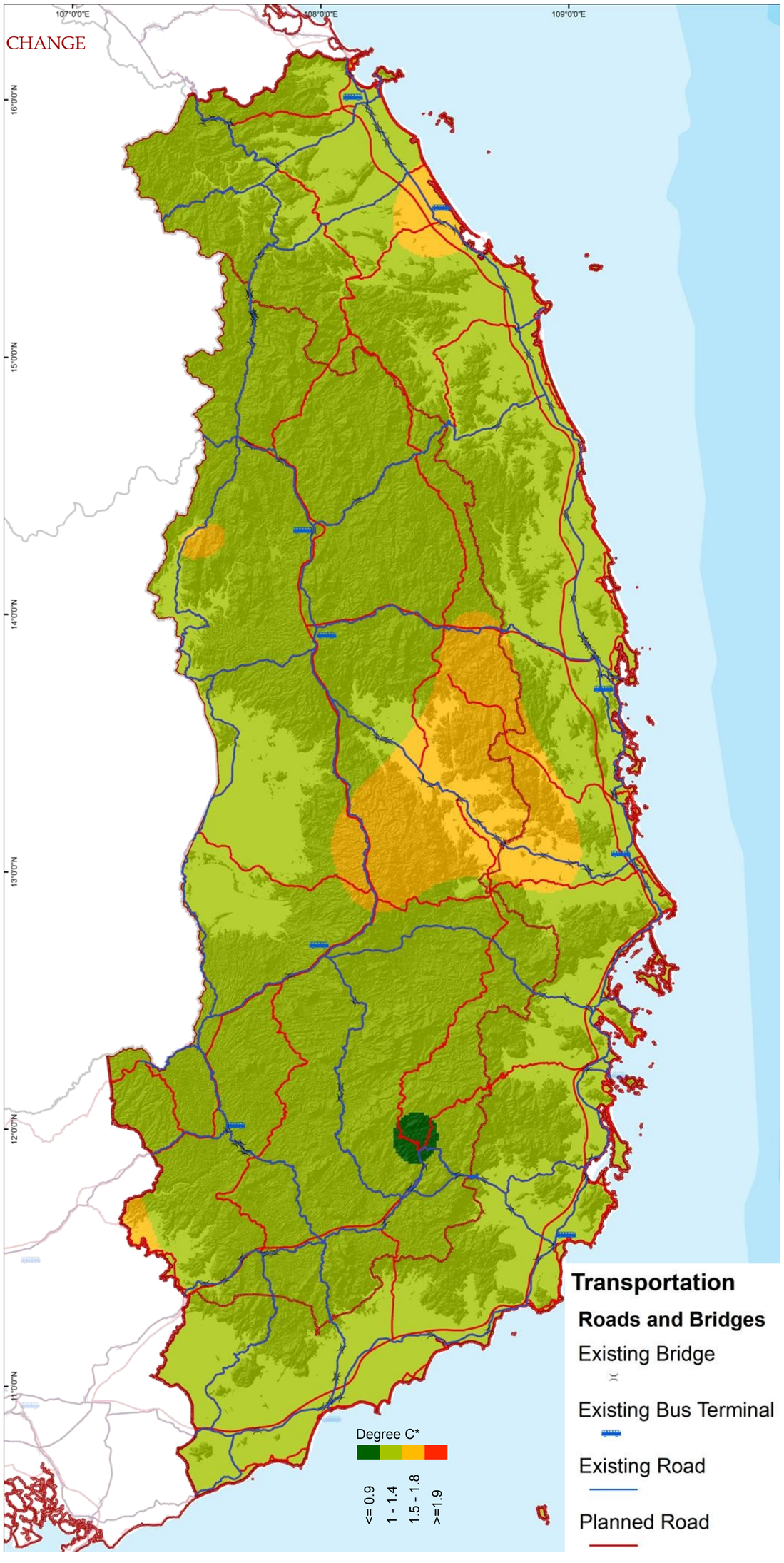
Roads and Bridges

Existing Bridge

Existing Bus Terminal

Existing Road

Planned Road



BASELINE

Baseline	Possible Affected Region	Possible Affected Road
20 - 24 Degree Celsius	Kom Tum, Lam Dong	HCM, 24, 20, 27
25 - 28 Degree Celsius	Da Nang, Quang Nam, Kom Tum, Gia Lai, Dak LaK, Khanh Hoa, Lam Dong, Ninh Thuan, Binh Thuan.	HCM, 14, 19, 24, 25, 26, 27, 28, 20, 55.
29 - 34 Degree Celsius	Quang Nam, Quang Ngai, Binh Dinh, Phu Yen, Gia Lai, Dak Lak, Khanh Hoa, Ninh Thuan, Binh Thuan, Lam Dong.	14, 1, 24, 19, 24, 25, 26, 27, 28, 55, 20, HCM.

2050 SCENARIO

2050	Possible Affected Region	Possible Affected Road
20 - 24 Degree Celsius	Lam Dong	20, 27.
25 - 28 Degree Celsius	Quang Nam, Kom Tum, Gia Lai, Lam Dong, Dak Lak, Binh Thuan.	14, HCM, 24, 19, 20, 27, 28, 55, 1.
29 - 34 Degree Celsius	Da Nang, Quang Nam, Quang Ngai, Kom Tum, Binh Dinh, Gia Lai, Dak Lak, Phu Yen, Khanh Hoa, Ninh Thuan, Binh Thuan, Lam Dong.	14, 1, 24, 19, 24, 25, 26, 27, 28, 55, 20, HCM.

SUMMARY OF PROJECTED CHANGES

Projected climate change impacts on road assets are not considerable with the 2°C average increase. Highest possible affected area is a part of No.25 HW in Phu Yen. Lam Dong is the lowest affected province by climate change with the highway: 20, 27, Lien Khuong - Da lat expressway

Region 3 includes the following provinces: Bình Định, Bình Thuận, Đà Nẵng, Đăk Lăk, Đăk Nông, Gia Lai, Khánh Hoà, Kon Tum, Lâm Đồng, Ninh Thuận, Phú Yên, Quảng Nam, Quảng Ngãi.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

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W
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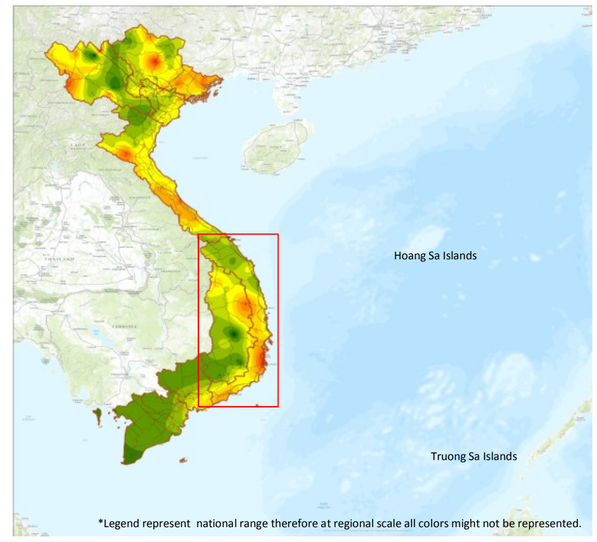
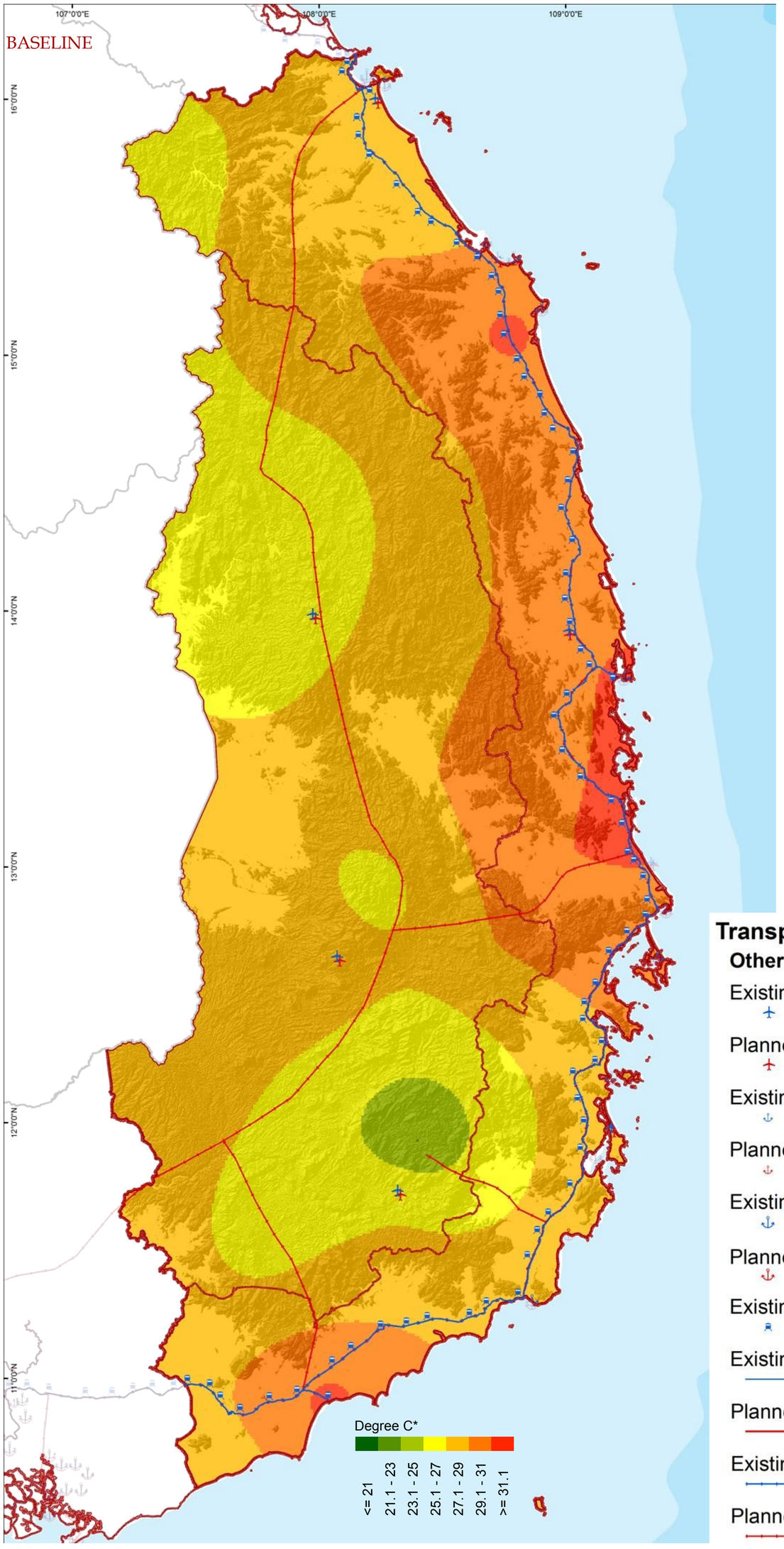
MAP SCALE - 1: 1,200,000

INDEX MAP

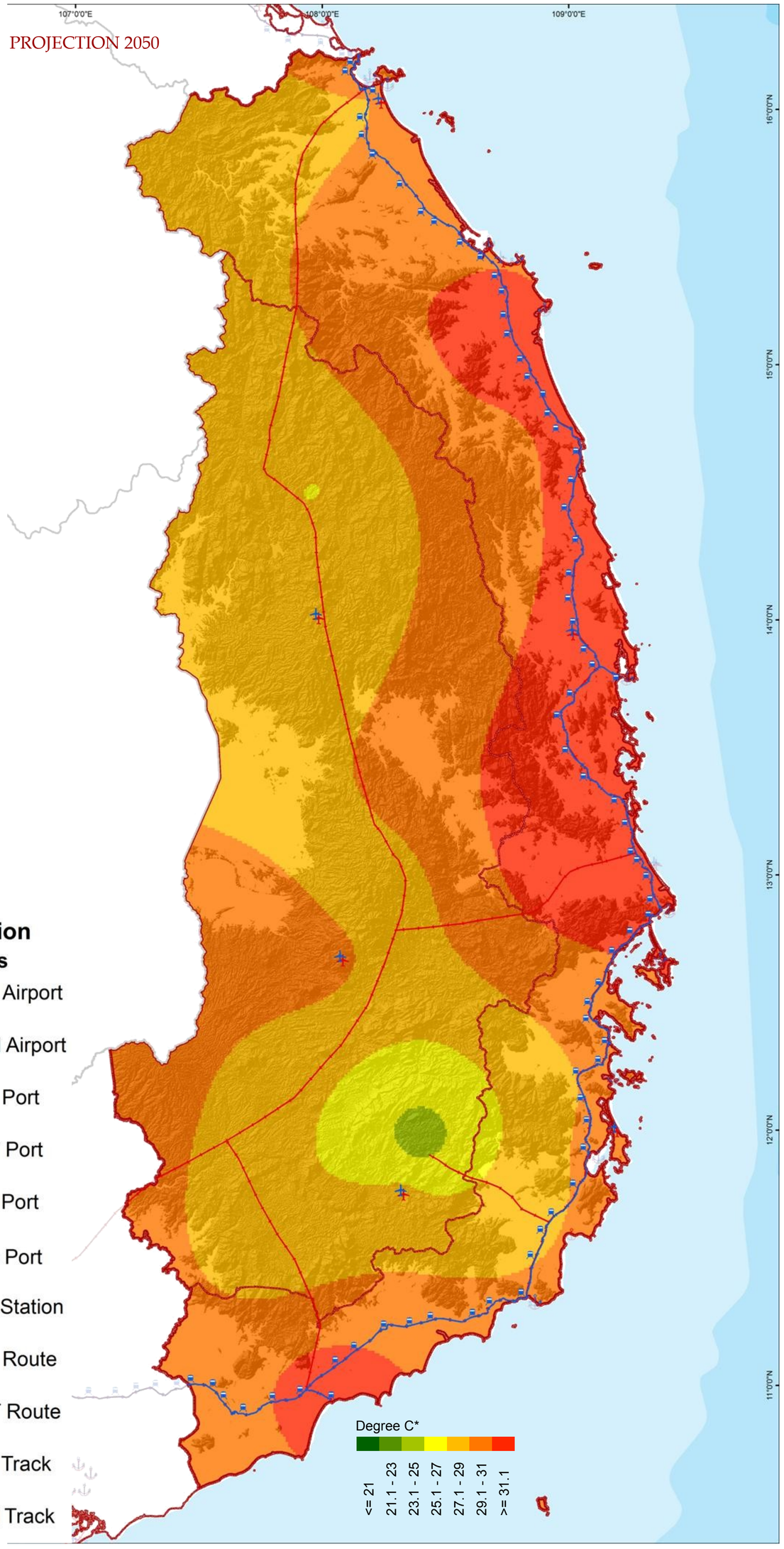


REGION 3 - OTHER TRANSPORT (AVERAGE MAXIMUM DAILY TEMPERATURE)

BASELINE



PROJECTION 2050



Transportation

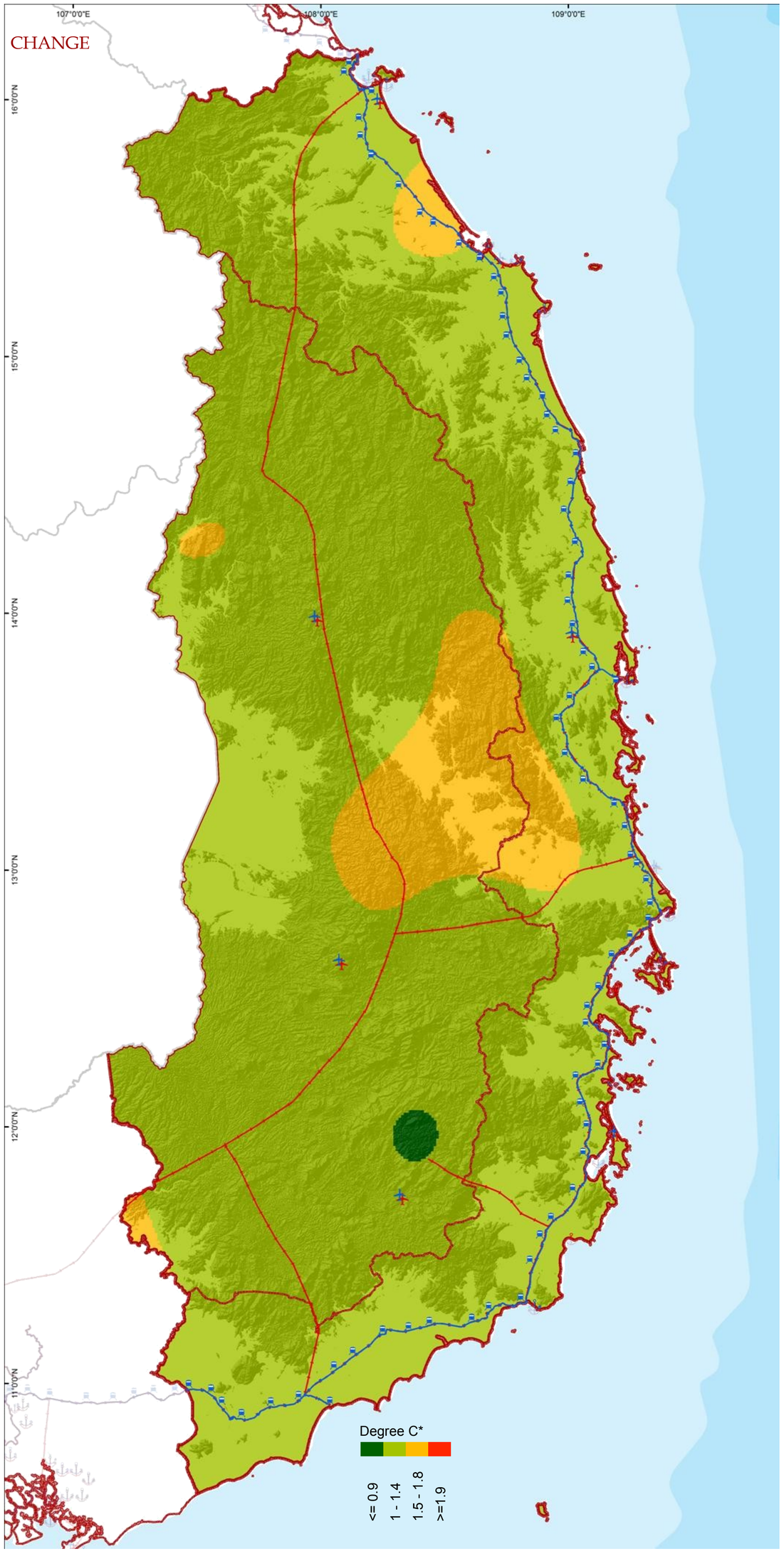
Other Assets

- Existing Civil Airport
- Planned Civil Airport
- Existing IWT Port
- Planned IWT Port
- Existing Sea Port
- Planned Sea Port
- Existing Rail Station
- Existing IWT Route
- Planned IWT Route
- Existing Rail Track
- Planned Rail Track

FUNDING AGENCIES

PARTNERS

COMPANIES



BASELINE

Baseline	Possible Affected Region	Possible Affected Assets
20 - 24 Degree Celsius	Kom Tum, Lam Dong	Rail: Da Nang-Dak Nong-Chon Thanh, Thap Cham-Da Lat.
25 - 28 Degree Celsius	Da Nang, Quang Nam, Kom Tum, Gia Lai, Dak LaK, Khanh Hoa, Lam Dong, Ninh Thuan, Binh Thuan.	Rail: Da Nang-Dak Nong-Chon Thanh, Ha Noi-Sai Gon, Tuy Hoa-Buon Ma Thuat, Dak Nong-Binh Thuan, Thap Cham-Da Lat.
29 - 34 Degree Celsius	Quang Nam, Quang Ngai, Binh Dinh, Phu Yen, Gia Lai, Dak Lak, Khanh Hoa, Ninh Thuan, Binh Thuan, Lam Dong.	Rail: Ha Noi-Sai Gon, Tuy Hoa-Buan Ma Thuat, Dak Nong-Binh Thuan, Da Nang-Dak Nong-Chon Thanh, Thap Cham-Da Lat.

2050 SCENARIO

2050	Possible Affected Region	Possible Affected Assets
20 - 24 Degree Celsius	Lam Dong	Rail: Thap Cham-Da Lat.
25 - 28 Degree Celsius	Quang Nam, Kom Tum, Gia Lai, Lam Dong, Dak Lak.	Rail: Da Nang-Dak Nong-Chon Thanh, Dak Nong-Binh Thuan, Thap Cham-Da Lat.
29 - 34 Degree Celsius	Da Nang, Quang Nam, Quang Ngai, Kom Tum, Binh Dinh, Gia Lai, Dak Lak, Phu Yen, Khanh Hoa, Ninh Thuan, Binh	Rail: Ha Noi-Sai Gon, Tuy Hoa-Buan Ma Thuat, Dak Nong-Binh Thuan, Da Nang-Dak Nong-Chon Thanh, Thap Cham-Da Lat.

SUMMARY OF PROJECTED CHANGES

Projected climate change impacts on other transport assets are not considerable. Most assets in the temperature rise are 2°C.

Region 3 includes the following provinces: Bình Định, Bình Thuận, Đà Nẵng, Đăk Lăk, Đăk Nông, Gia Lai, Khánh Hoà, Kon Tum, Lâm Đồng, Ninh Thuận, Phú Yên, Quảng Nam, Quảng Ngãi.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

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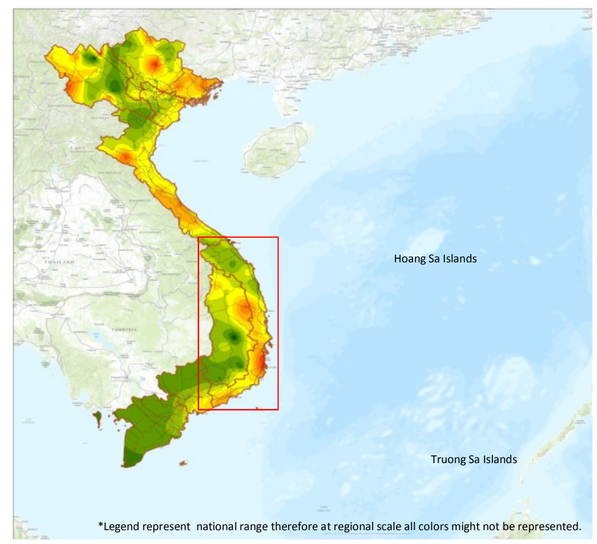
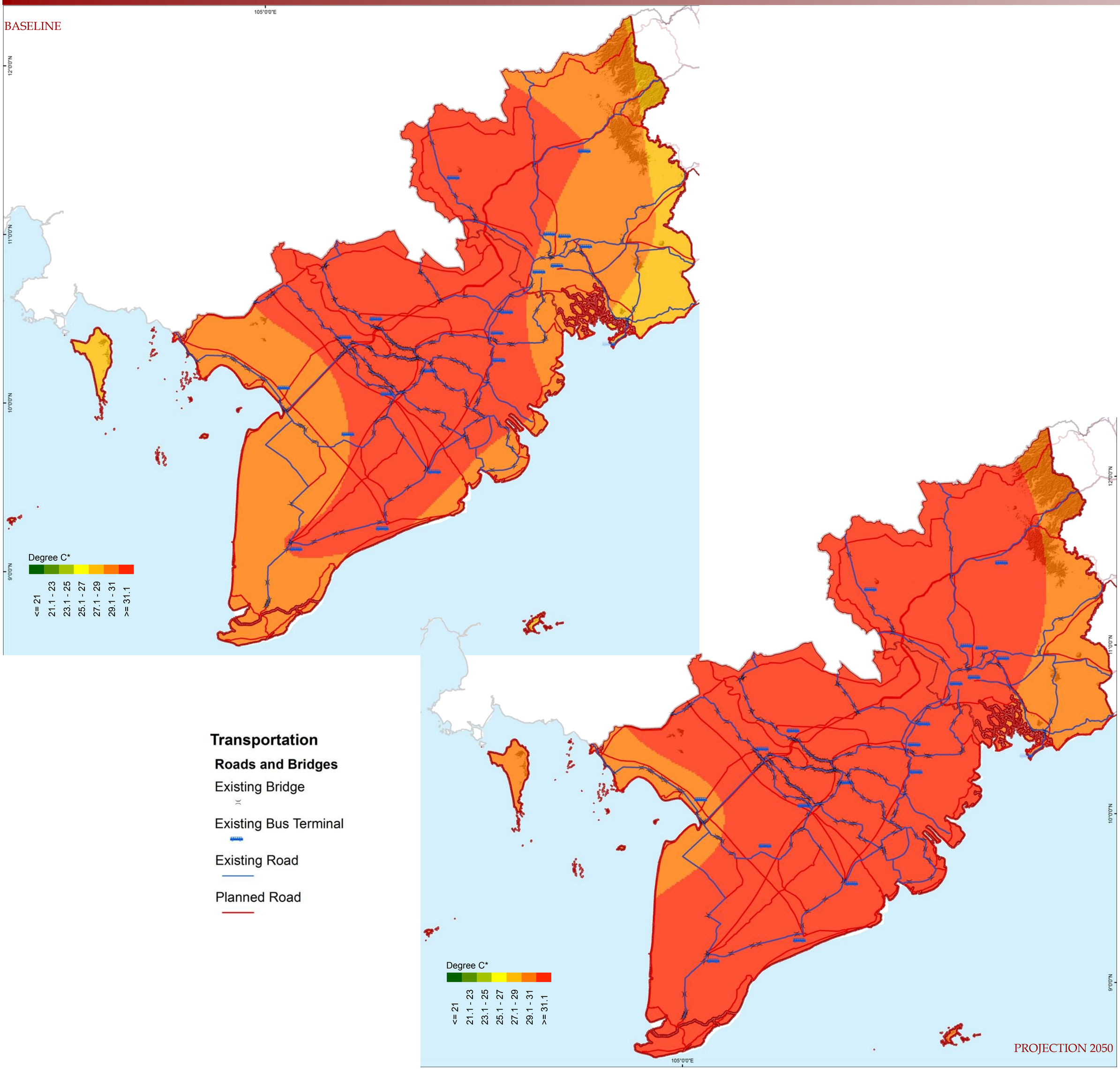
MAP SCALE - 1: 1,200,000

INDEX MAP



REGION 4 - ROADS AND BRIDGES (AVERAGE MAXIMUM DAILY TEMPERATURE)

BASELINE



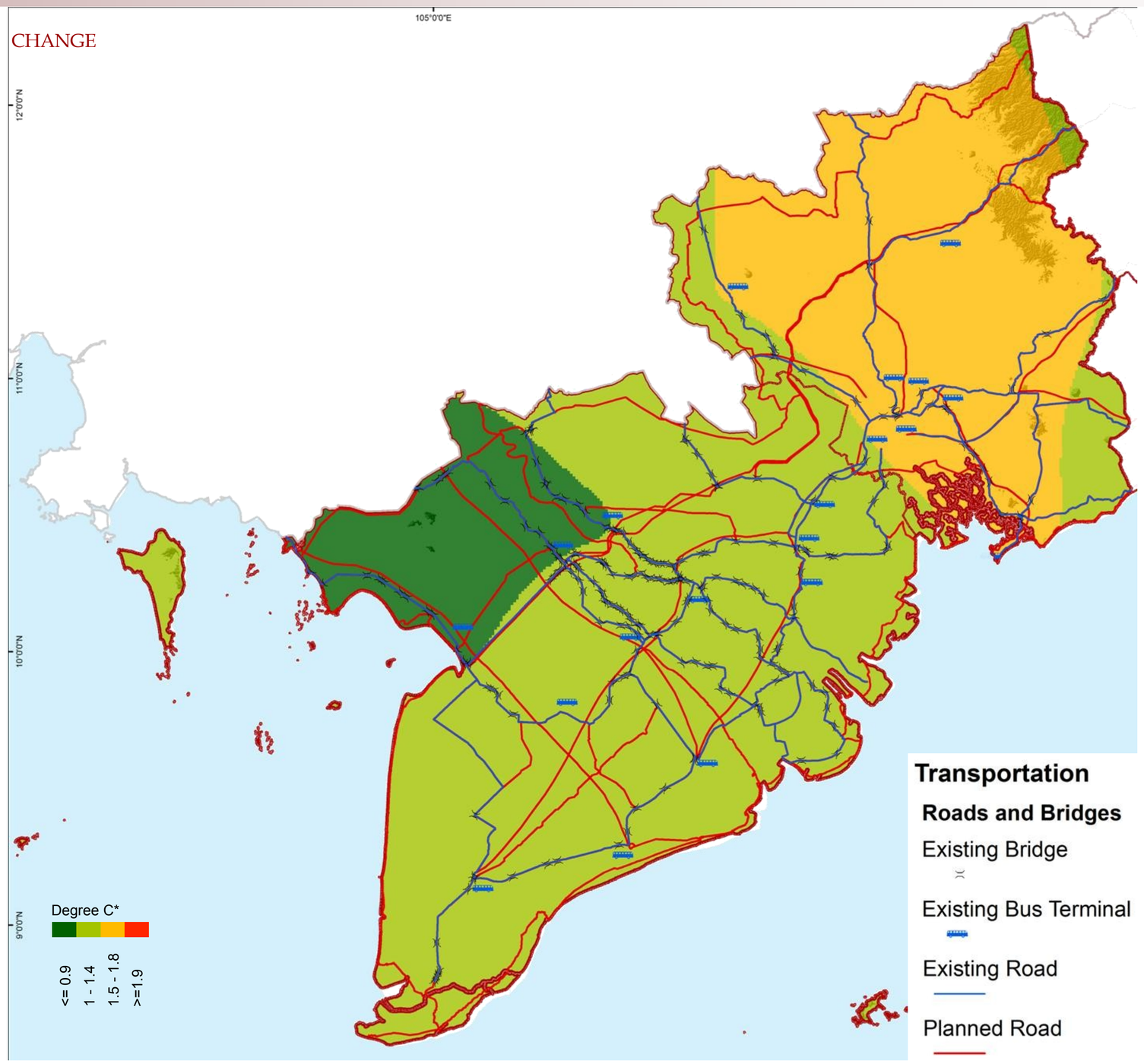
PROJECTION 2050

FUNDING AGENCIES

PARTNERS

COMPANIES

CHANGE



BASELINE		
Impact scale	**Possible Affected Region**	**Possible Affected Road**
20 - 24 Degree Celsius		
25 - 28 Degree Celsius		
29 - 34 Degree Celsius	Binh Phuoc, Dong Nai, Ba Ria Vung Tau, Binh Duong, Tay Ninh, Ho Chi Minh, Long An, Tien Giang. Ben Tre, Dong Thap, Tra Vinh, Vinh Long, An Giang, Can Tho, Soc Trang, Kien Giang, Bac Lieu, Ca Mau.	13, 14, 20, 1, 55, 56, 51, 50, 62, 60, 57, 30, 80, 53, 54, 91, 63.

2050 SCENARIO		
Impact scale	**Possible Affected Region**	**Possible Affected Road**
20 - 24 Degree Celsius		
25 - 28 Degree Celsius	Dong Nai, Ba Ria Vung Tau	20, 55
29 - 34 Degree Celsius	Binh Phuoc, Dong Nai, Ba Ria Vung Tau, Binh Duong, Tay Ninh, Ho Chi Minh, Long An, Tien Giang. Ben Tre, Dong Thap, Tra Vinh, Vinh Long, An Giang, Can Tho, Soc Trang, Kien Giang, Bac Lieu, Ca Mau.	13, 14, 20, 1, 55, 56, 51, 50, 62, 60, 57, 30, 80, 53, 54, 91, 63.

SUMMARY OF PROJECTED CHANGES

Hotpots in Climate change impacting on road assets are projected in main areas: Binh Phuoc, Dong Nai, Tay Ninh, Binh Duong, Ba Ria Vung Tau, HCM, Vinh Long, Tien Giang, Ben Tre, Long An, Dong Thap, Can Tho, Hau Giang, Soc Trang, Bac Lieu, Ca Mau, Tra Vinh. These provinces have an average maximum temperature increase from 1.01 to 1.2°C. Possible affected highways are in these areas. Kien Giang, An Ging, Dong Thap are the low affected area.

Region 4 includes the following provinces: An Giang, Bà Rịa Vũng Tàu, Bạc Liêu, Bến Tre, Bình Dương, Bình Phước, Cà Mau, Đồng Nai, Đồng Tháp, Hậu Giang, Kiên Giang, Long An, Sóc Trăng, Tây Ninh, Tiền Giang, TP Cần Thơ, TP Hồ Chí Minh, Trà Vinh, Vinh Long.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

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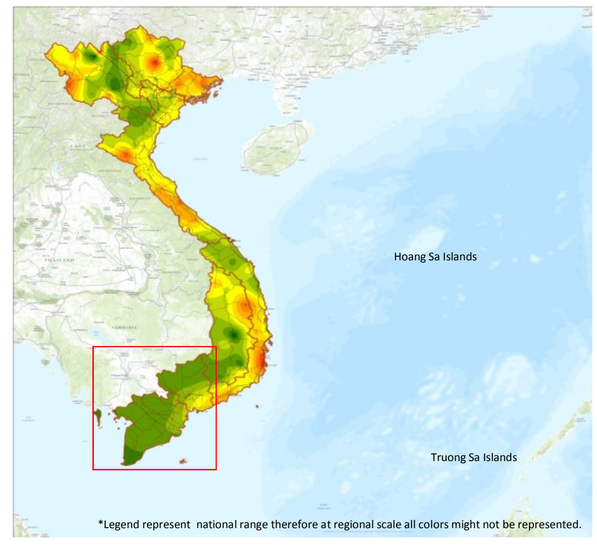
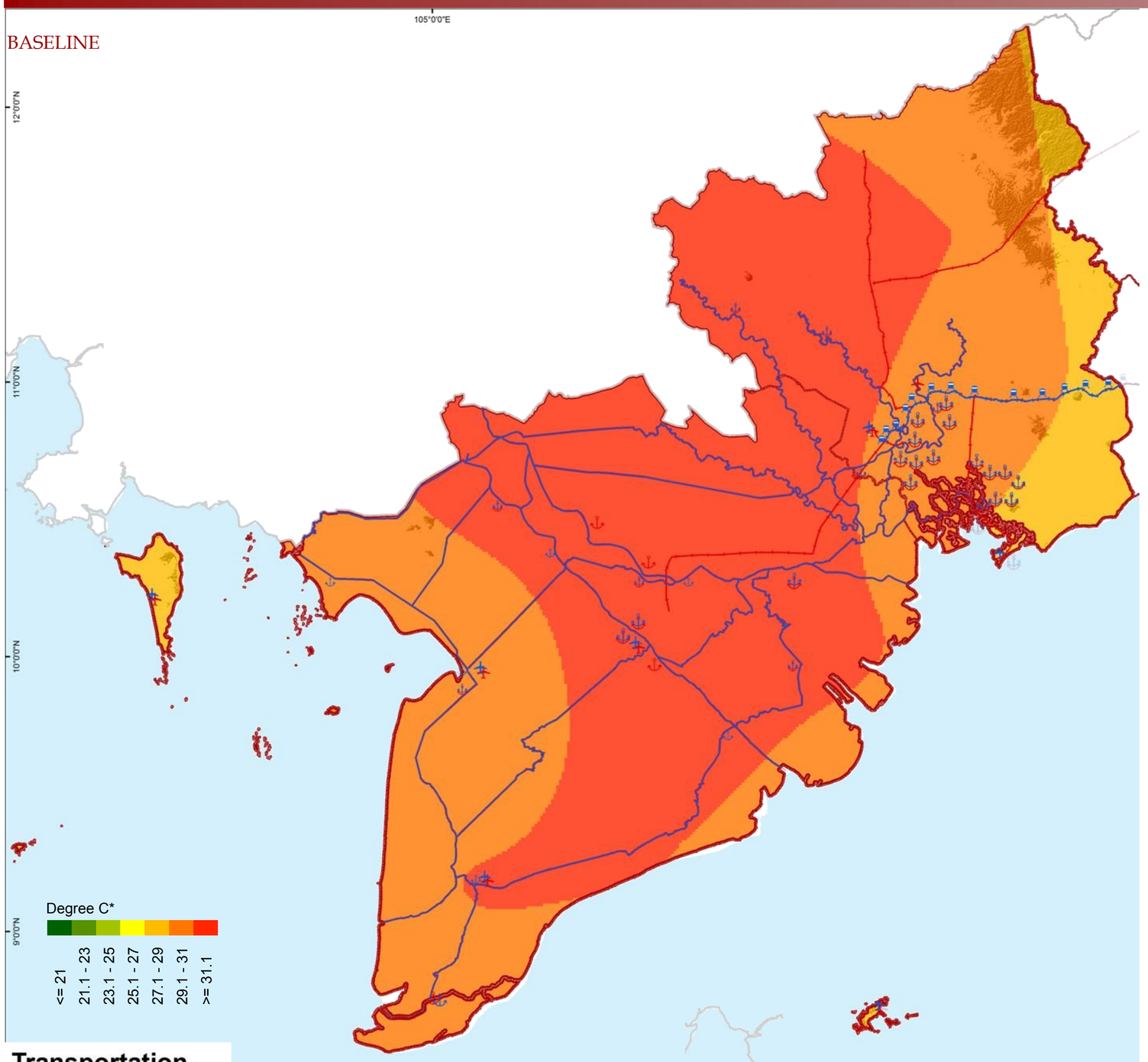
MAP SCALE - 1: 1,200,000

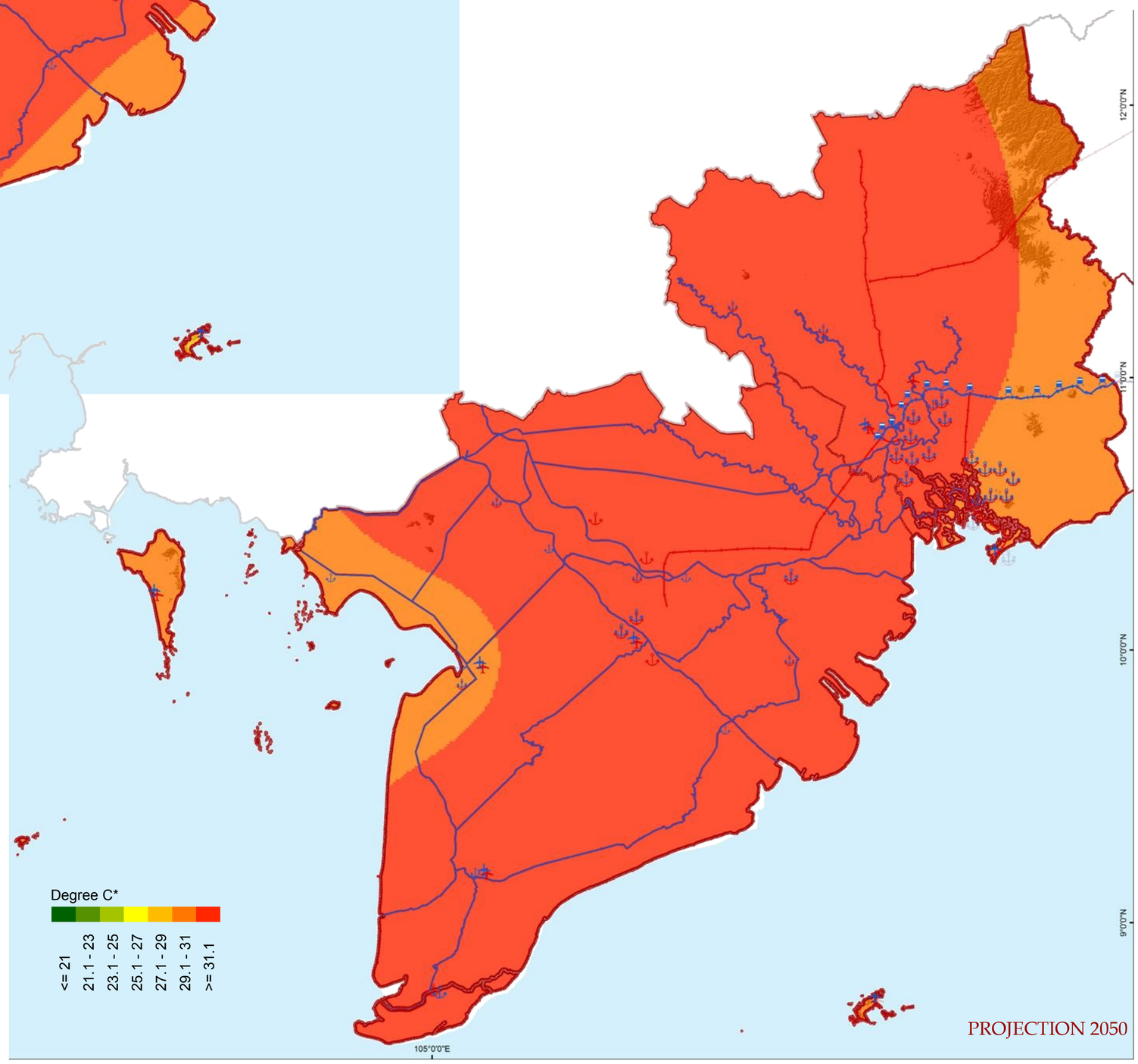
INDEX MAP



REGION 4 - OTHER TRANSPORT (AVERAGE MAXIMUM DAILY TEMPERATURE)

BASELINE





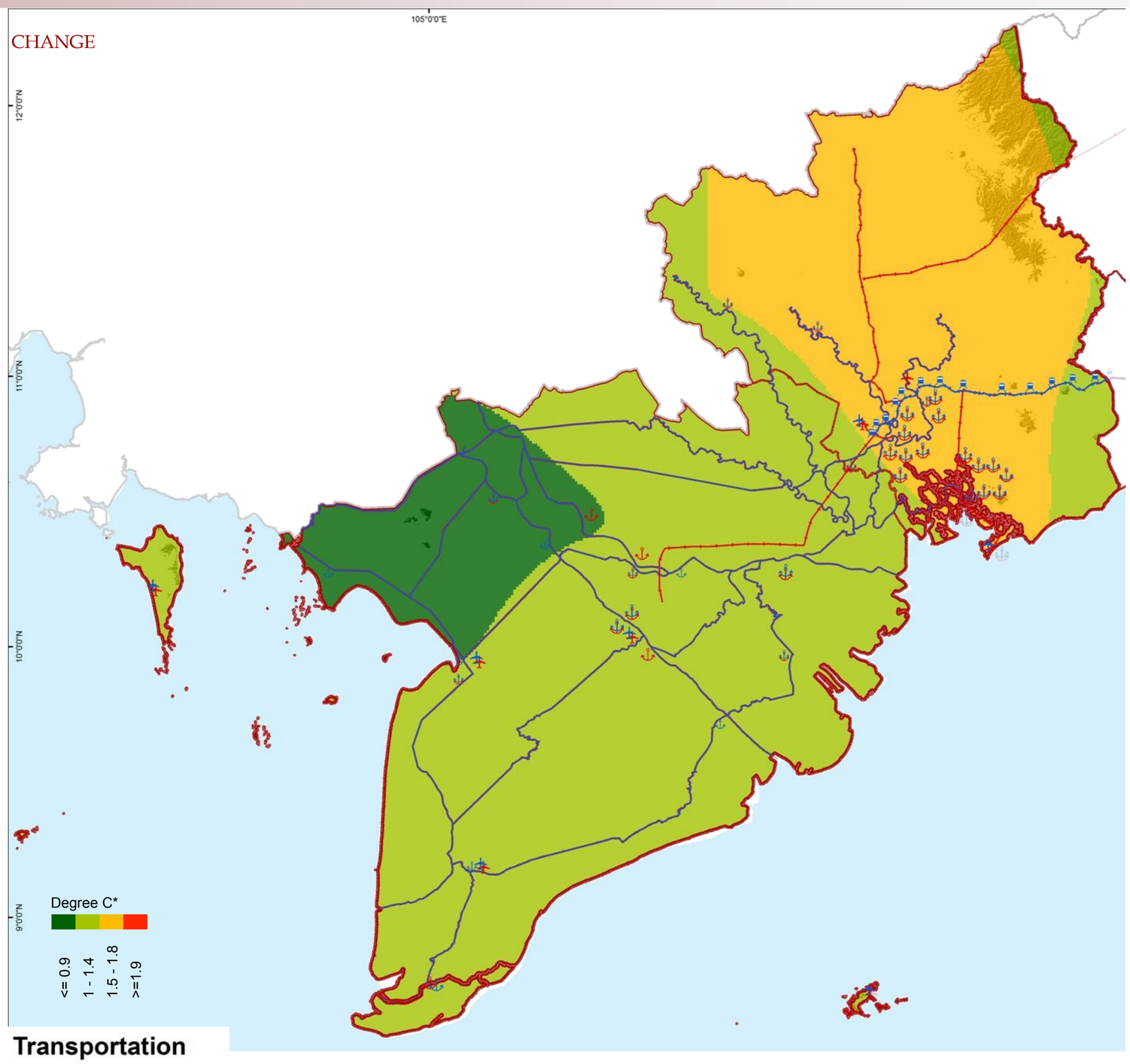
Transportation

Other Assets

- Existing Civil Airport
- Planned Civil Airport
- Existing IWT Port
- Planned IWT Port
- Existing Sea Port
- Planned Sea Port
- Existing Rail Station
- Existing IWT Route
- Planned IWT Route
- Existing Rail Track
- Planned Rail Track

PROJECTION 2050

CHANGE



Transportation

Other Assets

- Existing Civil Airport
- Planned Civil Airport
- Existing IWT Port
- Planned IWT Port
- Existing Sea Port
- Planned Sea Port
- Existing Rail Station
- Existing IWT Route
- Planned IWT Route
- Existing Rail Track
- Planned Rail Track

SUMMARY OF PROJECTED CHANGES

Hotpots in Climate change impacting on road assets are projected in main areas: Binh Phuoc, Dong Nai, Tay Ninh, Binh Duong, Ba Ria Vung Tau, HCM, Vinh Long, Tien Giang, Ben Tre, Long An, Dong Thap, Can Tho, Hau Giang, Soc Trang, Bac Lieu, Ca Mau, Tra Vinh. These provinces have an average maximum temperature increase from 1.01 to 1.2°C. Possible affected high-ways are in these areas. Kien Giang, An Ging, Dong Thap are the low af-fected area. Possible affected assets are railway, airport, seaport and IWT port.

Region 4 includes the following provinces: An Giang, Bà Rịa Vũng Tàu, Bạc Liêu, Bến Tre, Bình Dương, Bình Phước, Cà Mau, Đồng Nai, Đồng Tháp, Hậu Giang, Kiên Giang, Long An, Sóc Trăng, Tây Ninh, Tiền Giang, TP Cần Thơ, TP Hồ Chí Minh, Trà Vinh, Vinh Long.

BASELINE

Impact scale	Possible Affected Region	Possible Affected Assets
20 - 24 Degree Celsius		
25 - 28 Degree Celsius	Dong Nai, Ba Ria Vung Tau	
29 - 34 Degree Celsius	Binh Phuoc, Dong Nai, Ba Ria Vung Tau, Binh Duong, Tay Ninh, Ho Chi Minh, Long An, Tien Giang. Ben Tre, Dong Thap, Tra Vinh, Vinh Long, An Giang, Can Tho, Soc Trang, Kien Giang, Bac Lieu, Ca Mau.	Rail: Ha Noi-Sai Gon, Da Nang-Dak Nong-Chon Thanh, Ho Chi Minh-Loc Ninh, Tram Bom-Vung Tau, Ho Chi Minh-My Tho-Can Tho. IWT: Sai Gon-Hieu Liem, Sai Gon-Ben Suc, Sai Gon-Ben Keo, Sai Gon-Ca Mau, Sai Gon-Moc Hoa, Me-kong-Thi Vai, Cua Tieu-Hong Ngu, Sai Gon-Kien Luong, Moc Hoa-Ha Tien, Dinh An-Tan Chau, Rach Gia-Ca Mau.

2050 SCENARIO

Impact scale	Possible Affected Region	Possible Affected Assets
20 - 24 Degree Celsius		
25 - 28 Degree Celsius	Dong Nai, Ba Ria Vung Tau	
29 - 34 Degree Celsius	Binh Phuoc, Dong Nai, Ba Ria Vung Tau, Binh Duong, Tay Ninh, Ho Chi Minh, Long An, Tien Giang. Ben Tre, Dong Thap, Tra Vinh, Vinh Long, An Giang, Can Tho, Soc Trang, Kien Giang, Bac Lieu, Ca Mau.	Rail: Ha Noi-Sai Gon, Da Nang-Dak Nong-Chon Thanh, Ho Chi Minh-Loc Ninh, Tram Bom-Vung Tau, Ho Chi Minh-My Tho-Can Tho. IWT: Sai Gon-Hieu Liem, Sai Gon-Ben Suc, Sai Gon-Ca Mau, Sai Gon-Moc Hoa, Mekong-Thi Vai, Cua Tieu-Hong Ngu, Sai Gon-Kien Luong, Moc Hoa-Ha Tien, Dinh An-Tan Chau, Rach Gia-Ca Mau.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

IE - ENERGY INFRASTRUCTURE

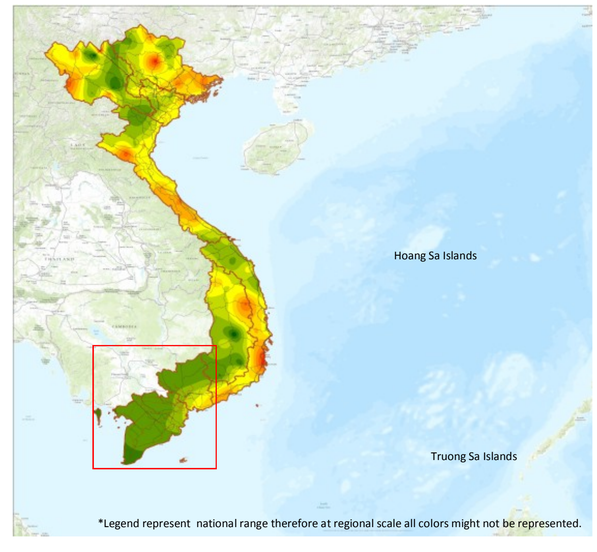
GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

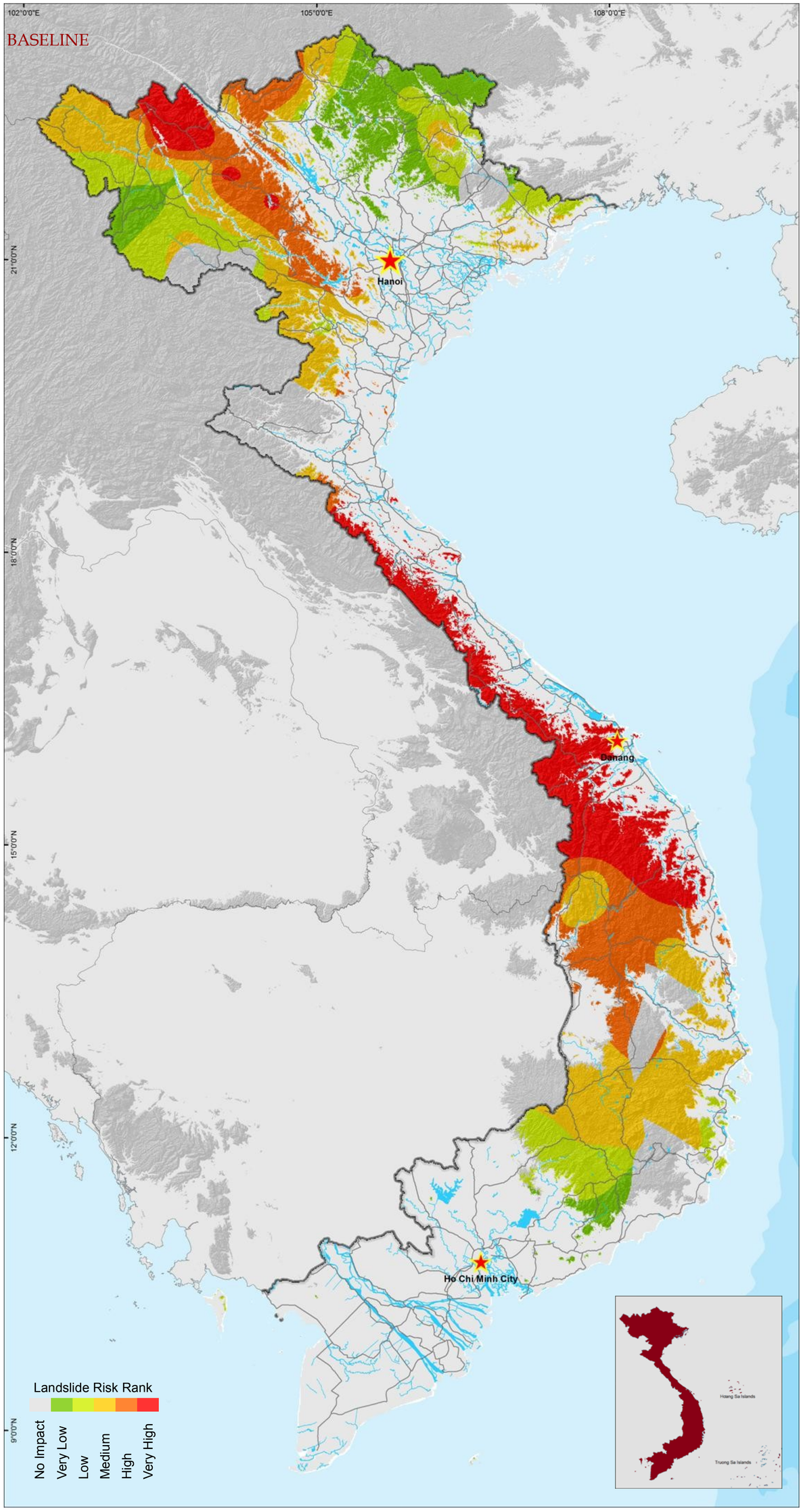
N W E S

MAP SCALE - 1: 1,200,000

INDEX MAP



RAINFALL ASSOCIATED LANDSLIDES



BASELINE

ROADS

Approximately 20% of the total length of roads in Vietnam is potentially exposed to landslides, with 3.7% being at very high risk, and 4.2% at high risk. These areas are in the Northern and Central Highlands, which are both mountainous regions. The largest lengths at risk are on National Roads 32, 4D, and 14. Sections of these roads could potentially be at risk of catastrophic failure, leading to significant reconstruction costs that will also potentially involve utilization of funds earmarked for construction of new roads, and disruptions to traffic flow.

RAILWAYS

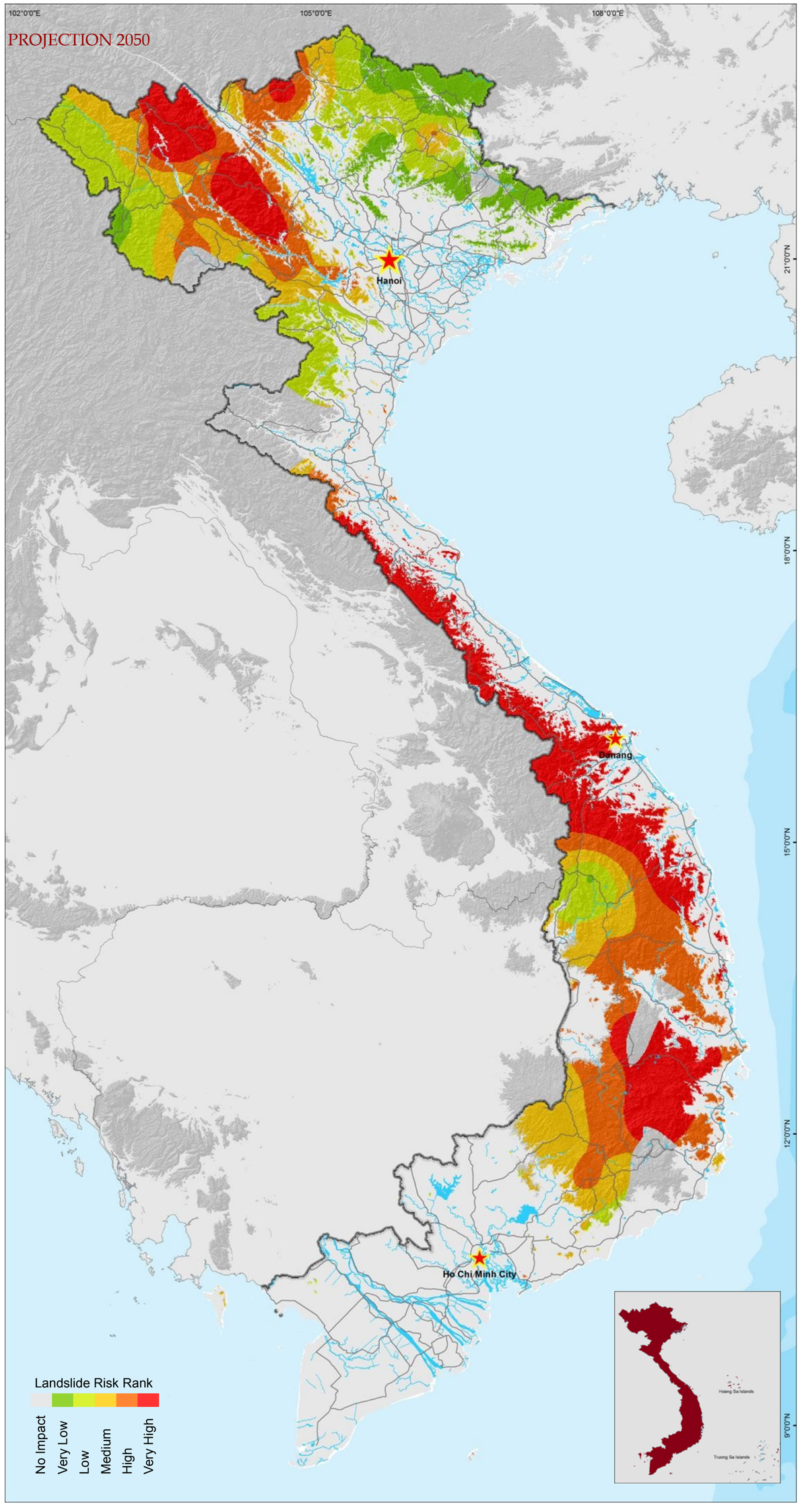
The entire length of the existing rail network is not exposed to landslides. This is because the landslide threat parameter was developed to assess infrastructure located above 300m in elevation. There is however, past experience of landslides impacting on railway lines in Vietnam. This demonstrates a potential deficiency in the filter criteria, which assumes that landslides are not as likely to occur below 300m elevation. In reality, the slope and other conditions such groundwater and soil conditions will have a much greater influence on landslide risk. This work, however, aims to set broad strategic priorities for response across all sub-sectors making the 300m elevation criterion a useful broad-level first cut at the major risk priority areas.

The planned Da Nang – Dak Nong – Chon Thanh railway line is exposed to landslides, with 100km at very high risk in the Baseline scenario.

INLAND WATERWAYS

Inland waterways are not impacted by landslides as they are all in lower elevation areas (below 300m). There is however evidence of landslides occurring in waterways in these areas that occur due to rivers undercutting the banks. This could either be classified as landslides or riverbank erosion, depending on the nature and severity of the event. For example, flooding in 2008 in Nghe An province that led to landslides which blocked many kilometers of waterways and canals. Major inland waterways in Delta's are not expected to have significant exposure to landslides.

These results however look to focus on the most critical landslides, which occur in areas of higher elevation, where hills have less vegetation and steeper slopes that are conducive to large landslide events.



2050 SCENARIO

ROADS

Large portions of National Road 14 (HCM Highway) at increased risk in 2050, along with those that link Da Lat and Nha Trang to HCMC (NR20), Da Lat to Buon Ma Thuot (NR27) and Quy Nhon on the coast up to the mountains (NR19). Many planned roads, such as the North-South (West) road will be under very high risk in the future, and should be designed to mitigate this. There is a decrease in risk between the Baseline and 2050 results towards the northern part of the Central Highlands in the Sesan Basin, due to modelling results showing projected decreases in peak daily rainfall.

A number of roads in the Northern mountainous provinces of Vietnam are at very high risk. For example, the length of National Road 4D exposed to landslides doubles between baseline and 2050. This road traverses the border of Vietnam and China and services the important tourist areas of Lao Cai and Sapa. Close to 200km of National Road 32, which provides connection between Ha Noi and Lao Cai, is also projected to be at very high risk in 2050. Damage and/or failure of these roads will impact tourism traffic and revenue.

RAILWAYS

In 2050, the only segment of railway exposed to landslides remains the planned Da Nang – Dak Nong – Chon Thanh line. There is an increase in the length at very high risk to 180km.

These lines link HCMC with Da Nang through the mountains and provide critical connectivity to the mountainous provinces. The lines traverse regions that are known for landslides and therefore it is critical for the design to be landslide and climate resilient. If this project is to proceed, detailed geotechnical studies are recommended to ensure that the terrain is suitable for construction, and climate and hydrological modeling should be undertaken to determine more detailed risk of landslides.

SUMMARY OF PROJECTED CHANGES

ROADS

The 2050 results show a shift in existing and planned roads of approximately 3-4% from medium to high risk. These roads and bridges, which were historically not impacted by landslides, will now have greater exposure due to climate change.

The proposed GMS Southern Economic Corridor passes through the lower Central Highlands – an area in which road assets are shown to be shifting from medium to high risk. A detailed climate change vulnerability study should be undertaken so that locating and designing of new infrastructure or retrofits to existing infrastructure will account for this projected increase.

Large sections of National Road 14 and 14C will have increased risk, as will roads such as National Road 28, which runs from the coast up to the mountains and connects minor cities in the area. This will require a change in monitoring and maintenance requirements.

RAILWAYS

The railway line going from Da Nang – Dak Nong – Chon Thanh is rated at very high risk. There has been a significant shift in climate between baseline and 2050 across this railway line, as:

- A 20km section has increased from low to very high,
- A 40km section has increased from medium to very high, and
- A 60km section has increased from high to very high risk.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

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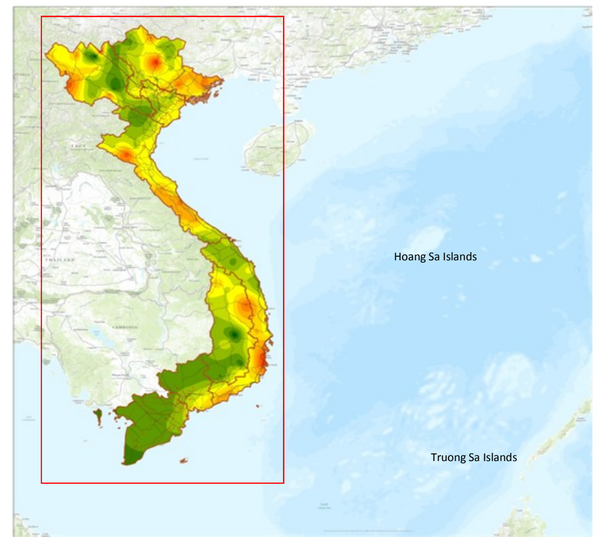
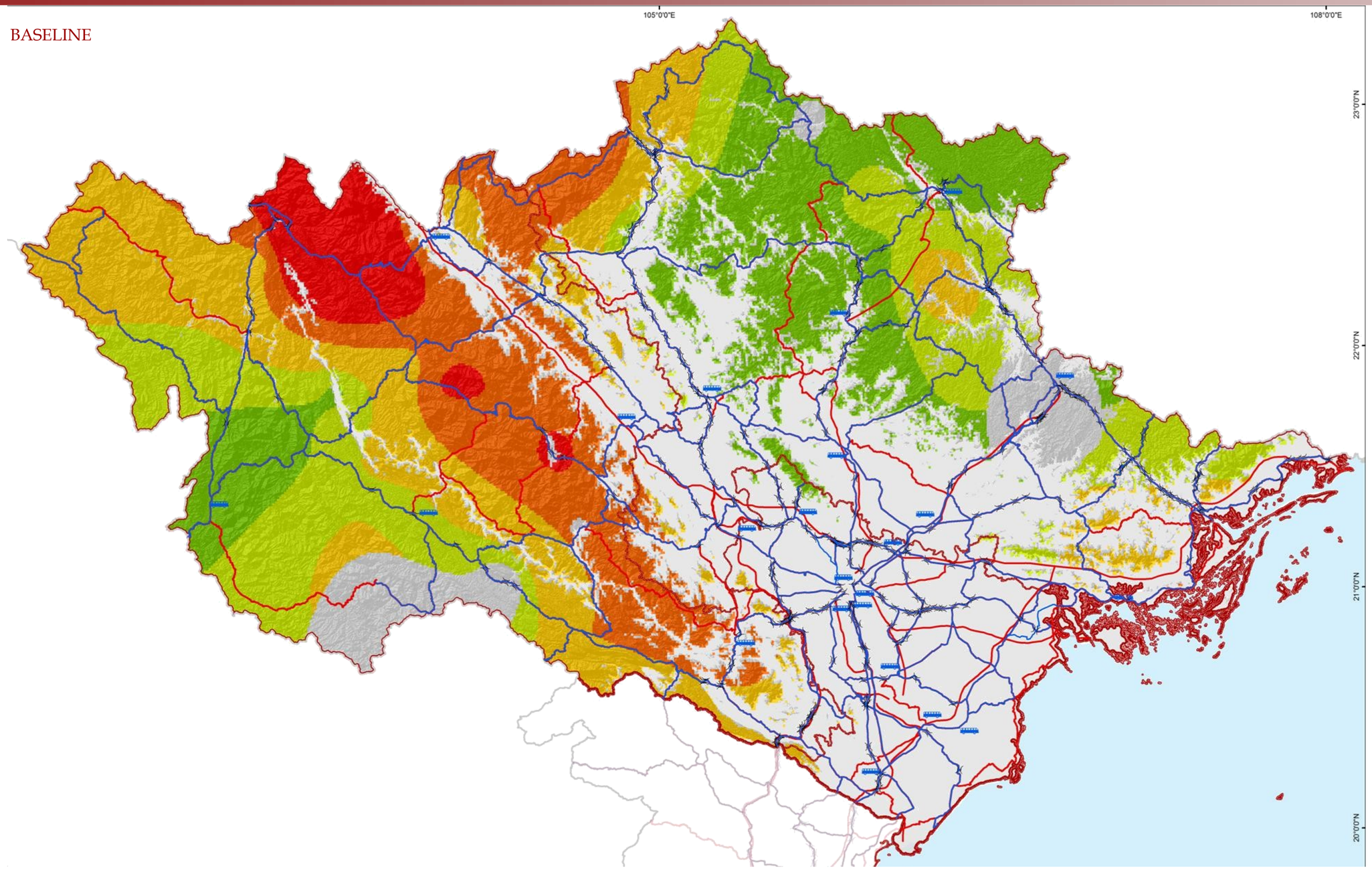
MAP SCALE - 1: 3,000,000

INDEX MAP



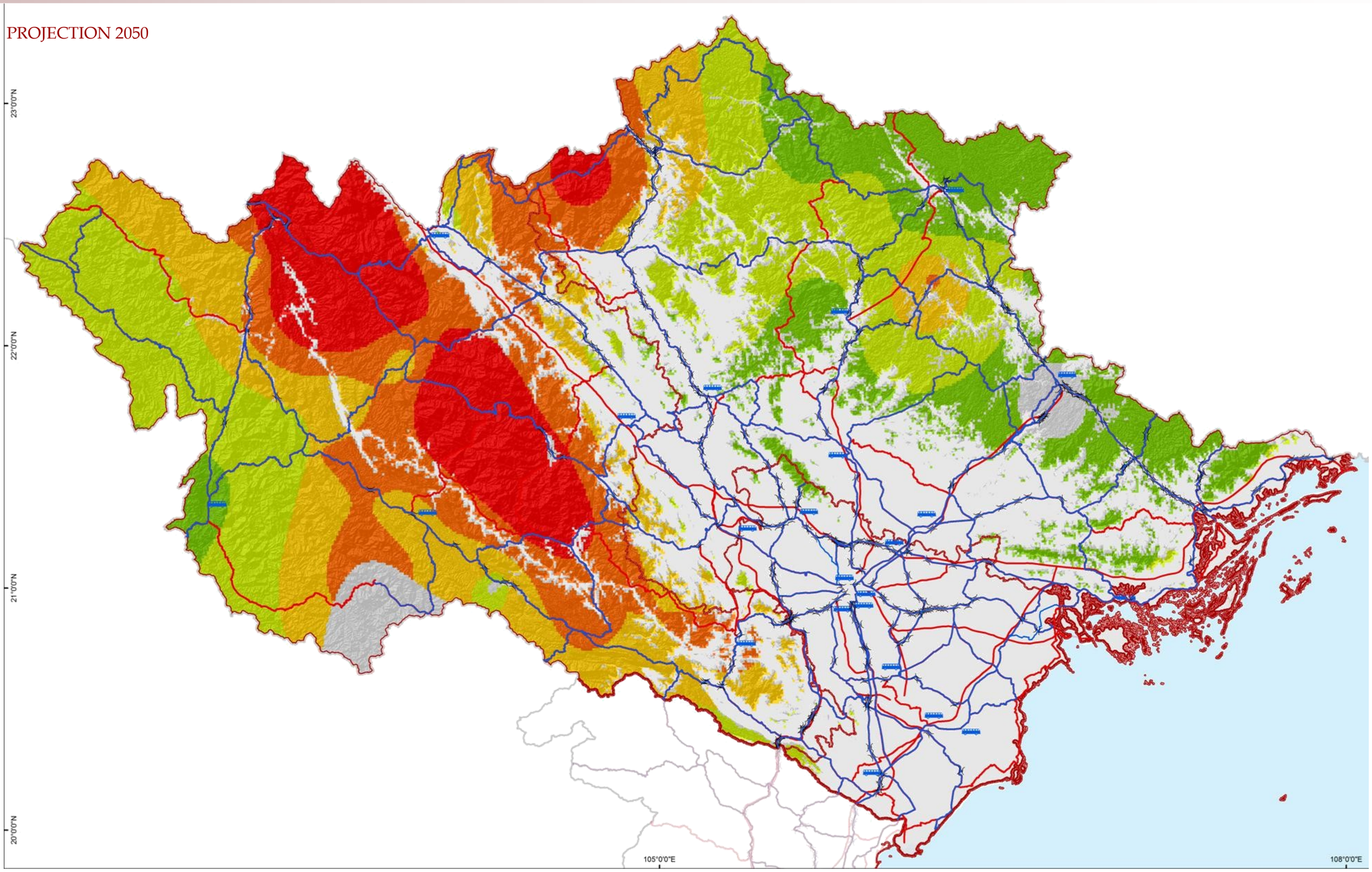
REGION 1 - ROADS AND BRIDGES (RAINFALL ASSOCIATED LANDSLIDES)

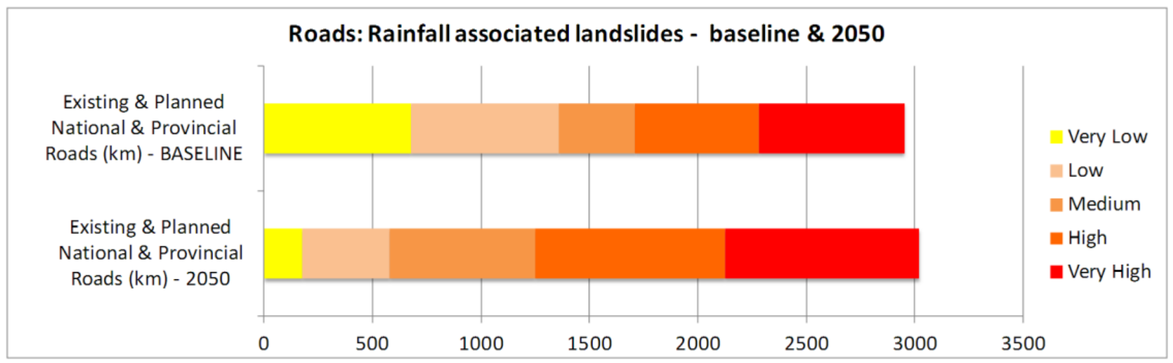
BASELINE



BASELINE		
Impact scale	**Possible Affected Region**	**Possible Affected Road**
No impact or Very low	Lai Chau, Son La, Lao Cai, Yen Bai, Ha Giang, Tuyen Quang, Cao Bang, Thai Nguyen, Bac Can, Lang Son, Quang Ninh, Hai Phong, Hai Duong, Thai Binh, Nam Dinh, Ha Nam, Hoa Binh, Ha Tay, Ha Noi, Bac Ninh, Vinh Phuc, Thai Nguyen, Phu Tho.	12, 279, 6, 4, 70, 2, 34, 3, 37. 32. 5, 10, 38, 39, 21, 1, 18, HCM
Low or Medium	Lai Chau, Son La, Hoa Binh, Lao Cai, Ha Giang, Cao Bang, Bac Can, Lang Son, Quang Ninh.	4, 12, 6, 37, 34, 2, 3. 18, 31.
High or Very high	Lai Chau, Lao Cai, Yen Bai, Son La, Hoa Binh, Ha Giang.	4, 100, 32, 279, 37, 43, 34.

PROJECTION 2050





2050 SCENARIO

Impact scale	Possible Affected Region	Possible Affected Road
No impact or Very low	Lai Chau, Son La, Lao Cai, Yen Bai, Ha Giang, Tuyen Quang, Cao Bang, Thai Nguyen, Bac Can, Lang Son, Quang Ninh, Hai Phong, Hai Duong, Thai Binh, Nam Dinh, Ha Nam, Hoa Binh, Ha Tay, Ha Noi, Bac Ninh, Vinh Phuc, Thai Nguyen, Phu Tho.	12, 279, 6, 4, 70, 2, 34, 3, 37. 32. 5, 10, 38, 39, 21, 1, 18, HCM
Low or Medium	Lai Chau, Son La, Hoa Binh, Lao Cai, Ha Giang, Cao Bang, Bac Can, Lang Son.	4, 12, 6, 37, 34, 2, 3.
High or Very high	Lai Chau. Lao Cai, Yen Bai, Son La, Hoa Binh, Ha Giang.	4, 100, 32, 279, 37, 43, 34.

Region 1 includes the following provinces: Bắc Cạn, Bắc Giang, Bắc Ninh, Cao Bằng, Điện Biên, Hà Giang, Hà Nam, Hà Nội, Hải Dương, Hải Phòng, Hoà Bình, Hưng Yên, Lai Châu, Lạng Sơn, Lào Cai, Nam Định, Ninh Bình, Phú Thọ, Quảng Ninh, Sơn La, Thái Bình, Thái Nguyên, Tuyên Quang, Vĩnh Phúc, Yên Bái.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

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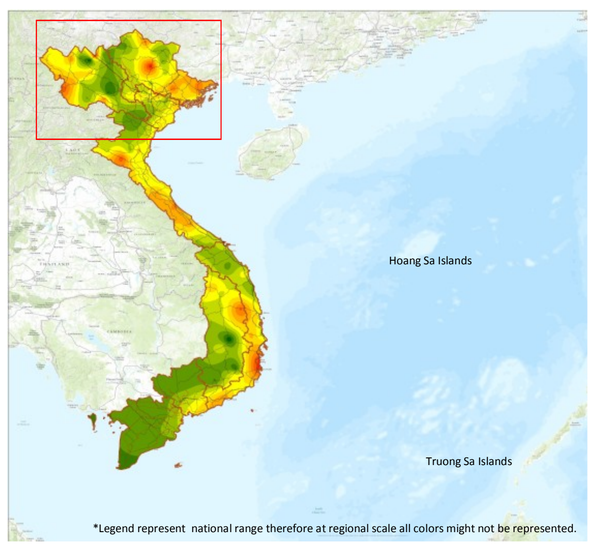
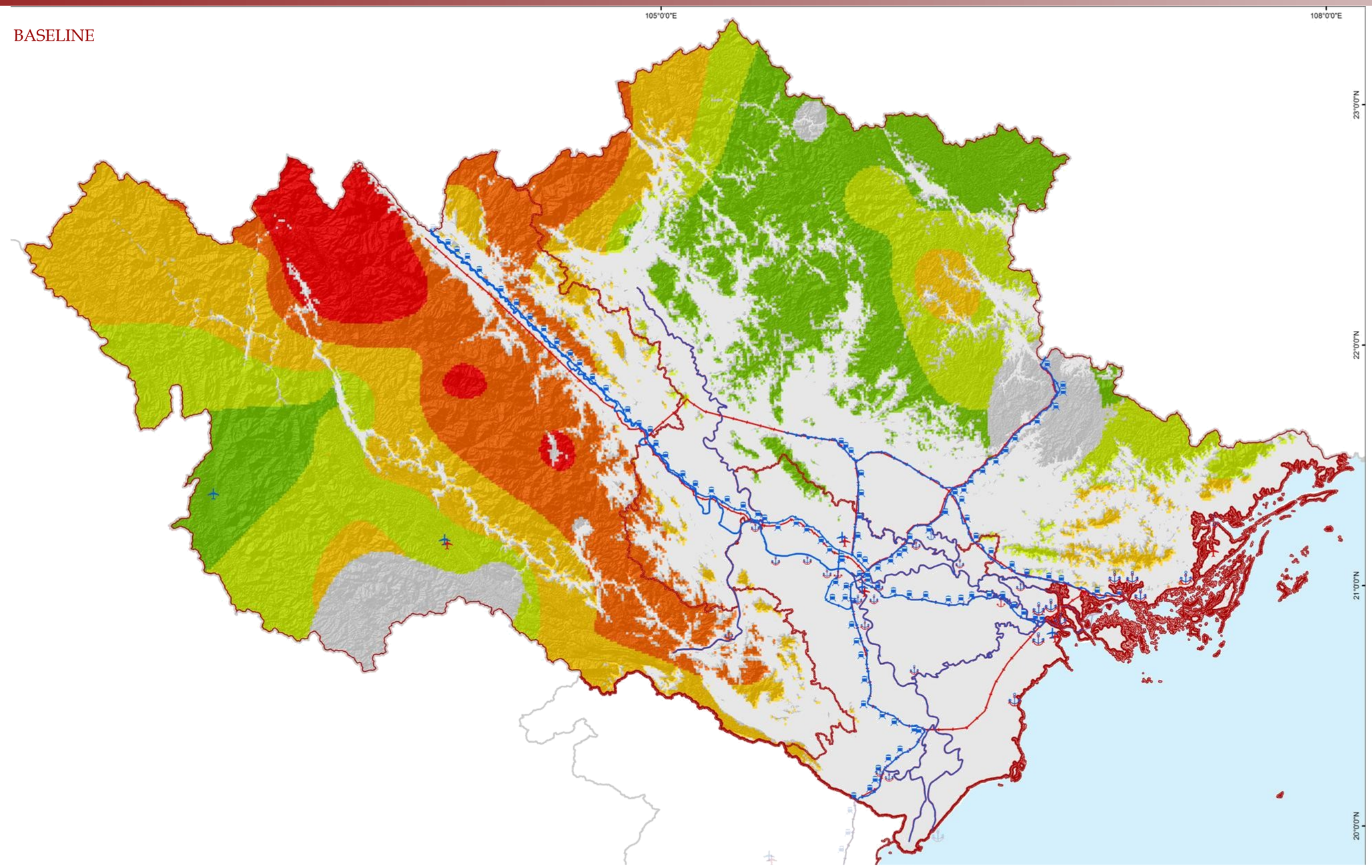
MAP SCALE - 1: 1,200,000

INDEX MAP



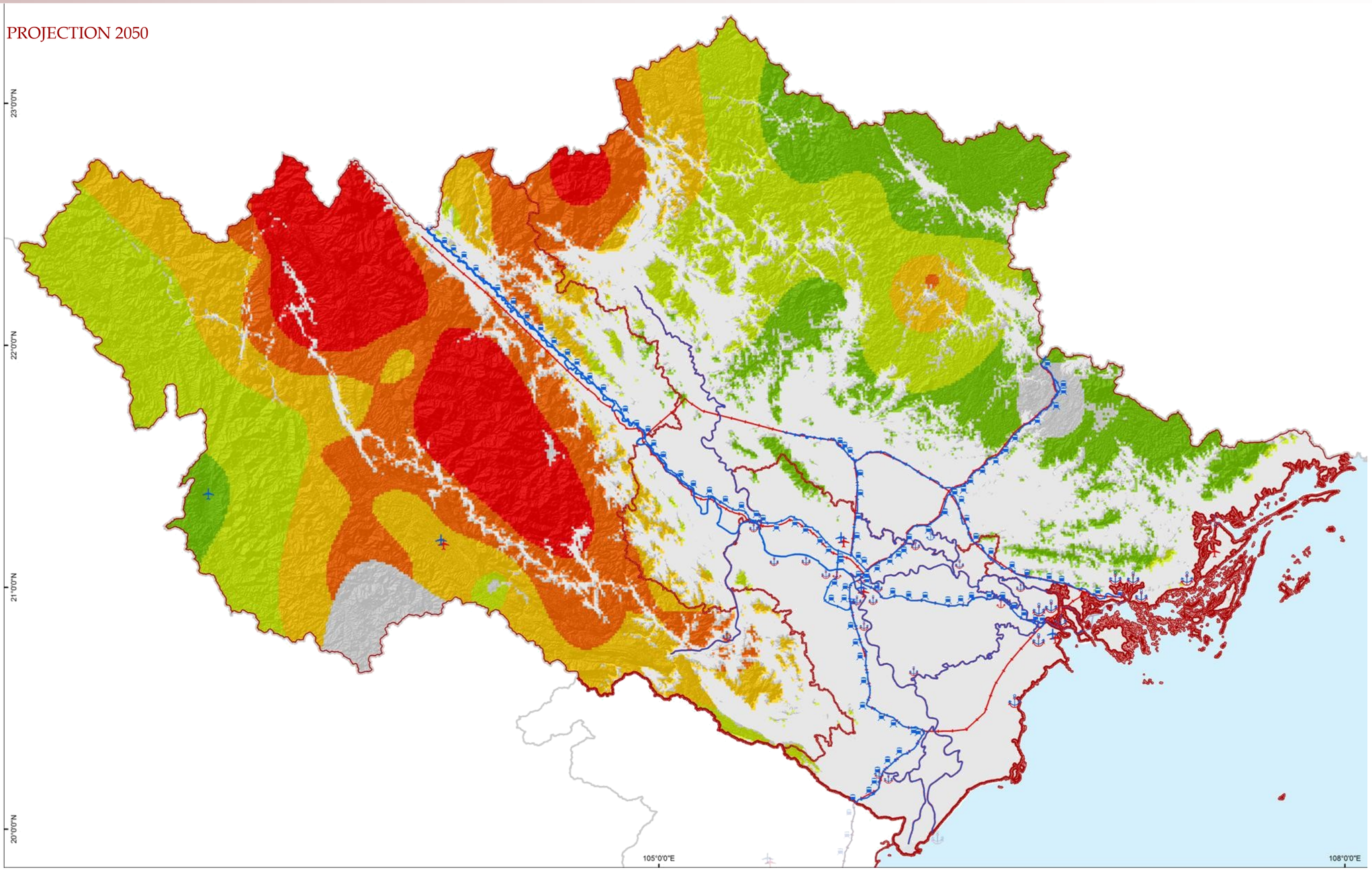
REGION 1 - OTHER TRANSPORT (RAINFALL ASSOCIATED LANDSLIDES)

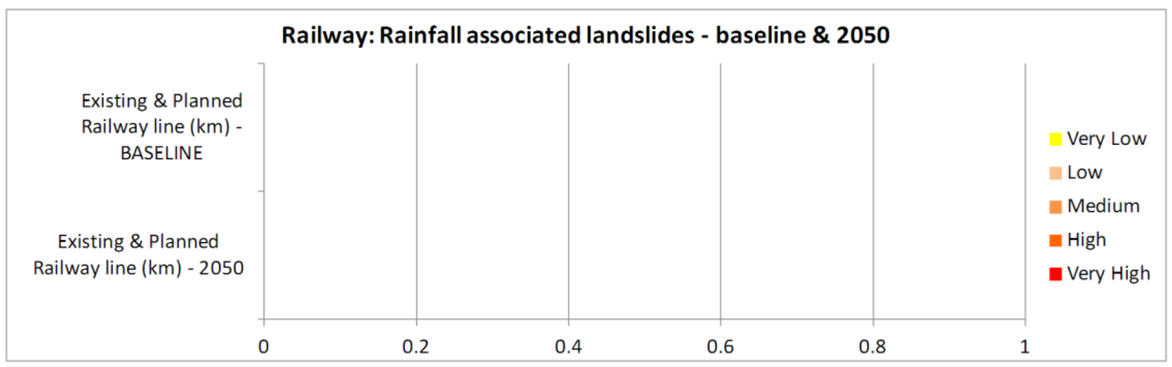
BASELINE



BASELINE		
Impact scale	**Possible Affected Region**	**Possible Affected Assets**
No impact or Very low	Lai Chau, Son La, Lao Cai, Yen Bai, Ha Giang, Tuyen Quang, Cao Bang, Thai Nguyen, Bac Can, Lang Son, Quang Ninh, Hai Phong, Hai Duong, Thai Binh, Nam Dinh, Ha Nam, Hoa Binh, Ha Tay, Ha Noi, Bac Ninh, Vinh Phuc, Thai Nguyen, Phu Tho.	Rail: Ha Noi-Lao Cai, Dong Anh-Quan Trieu, Kep-Ha Long, Ha Noi-Dong Dang, Ha Noi-Hai Phong, Hai Phong -Thai Binh, Ha Noi-Sai Gon. IWT: Ha Noi-Lao Cai, Viet Tri-Tuyen Quang, Hong Da-Hoa Binh, Pha Lai-Da Phuc, Pha Lai-A lu, Ha Noi-Hai Phong, Quang Ninh-Pha Lai, Quang Ninh-Ninh Binh, Lach Giang-Ha Noi, Cua Day-Ninh Binh.
Low or Medium	Lai Chau, Son La, Hoa Binh, Lao Cai, Ha Giang, Cao Bang, Bac Can, Lang Son, Quang Ninh.	IWT: Hong Da-Hoa Binh
High or Very high	Lai Chau, Lao Cai, Yen Bai, Son La, Hoa Binh, Ha Giang.	

PROJECTION 2050





2050 SCENARIO

Impact scale	Possible Affected Region	Possible Affected Assets
No impact or Very low	Lai Chau, Son La, Lao Cai, Yen Bai, Ha Giang, Tuyen Quang, Cao Bang, Thai Nguyen, Bac Can, Lang Son, Quang Ninh, Hai Phong, Hai Duong, Thai Binh, Nam Dinh, Ha Nam, Hoa Binh, Ha Tay, Ha Noi, Bac Ninh, Vinh Phuc, Thai Nguyen, Phu Tho.	Rail: Ha Noi-Lao Cai, Dong Anh-Quan Trieu, Kep-Ha Long, Ha Noi-Dong Dang, Ha Noi-Hai Phong, Hai Phong-Thai Binh, Ha Noi-Sai Gon. IWT: Ha Noi-Lao Cai, Viet Tri-Tuyen Quang, Hong Da-Hoa Binh, Pha Lai-Da Phuc, Pha Lai-A lu, Ha Noi-Hai Phong, Quang Ninh-Pha Lai, Quang Ninh-Ninh Binh, Lach Giang-Ha Noi, Cua Day-Ninh Binh.
Low or Medium	Lai Chau, Son La, Hoa Binh, Lao Cai, Ha Giang, Cao Bang, Bac Can, Lang Son.	IWT: Hong Da-Hoa Binh
High or Very high	Lai Chau. Lao Cai, Yen Bai, Son La, Hoa Binh, Ha Giang.	

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

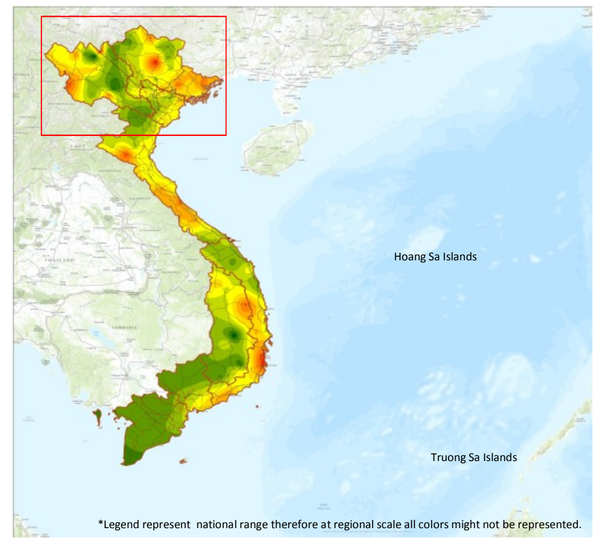
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

MAP SCALE - 1: 1,200,000

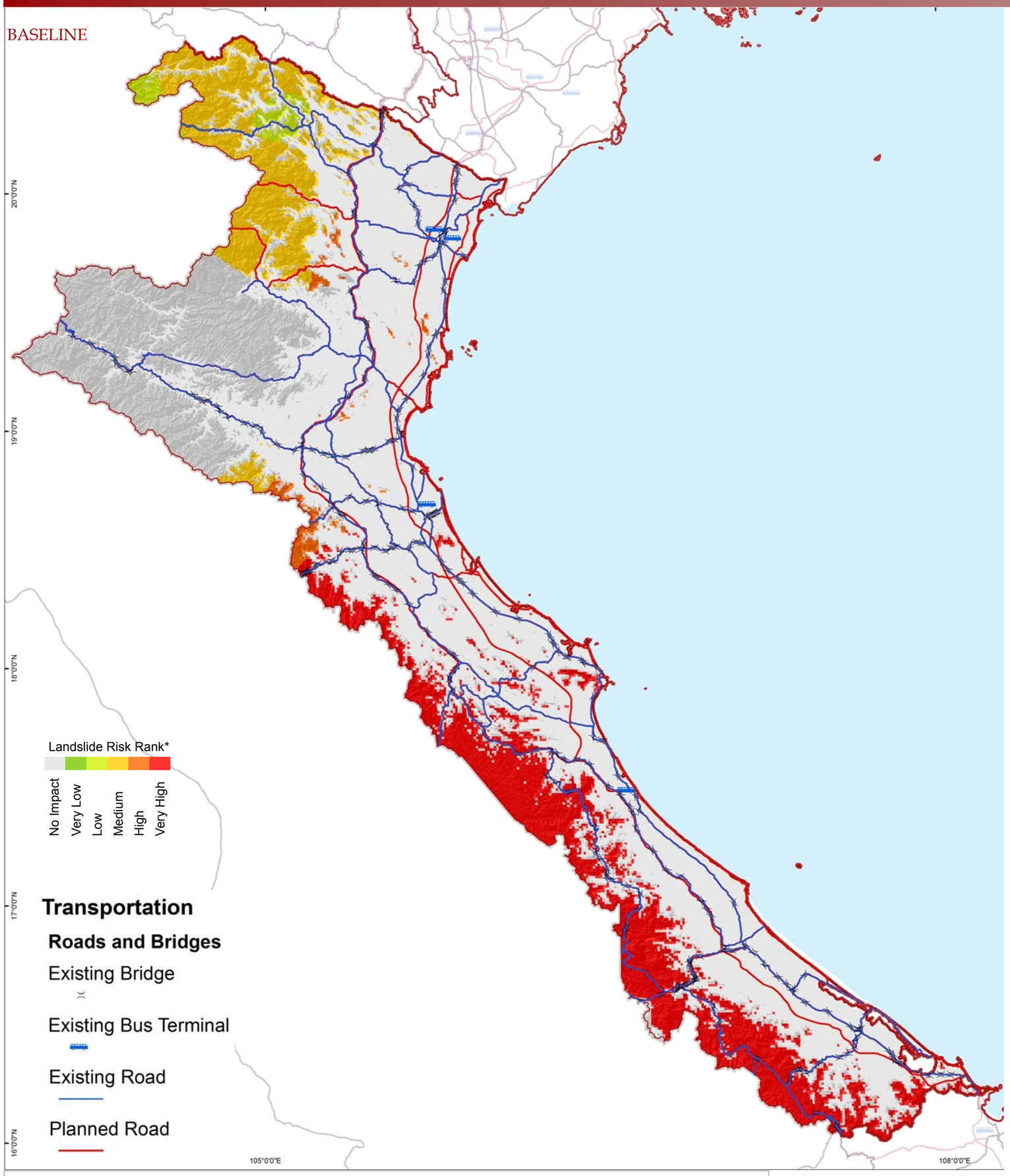
INDEX MAP

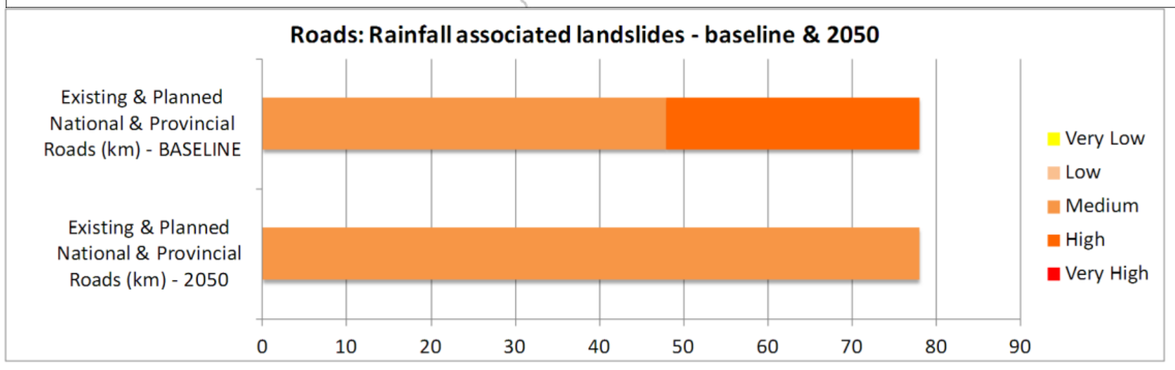


Region 1 includes the following provinces: Bắc Cạn, Bắc Giang, Bắc Ninh, Cao Bằng, Điện Biên, Hà Giang, Hà Nam, Hà Nội, Hải Dương, Hải Phòng, Hoà Bình, Hưng Yên, Lai Châu, Lạng Sơn, Lào Cai, Nam Định, Ninh Bình, Phú Thọ, Quảng Ninh, Sơn La, Thái Bình, Thái Nguyên, Tuyên Quang, Vĩnh Phúc, Yên Bái.

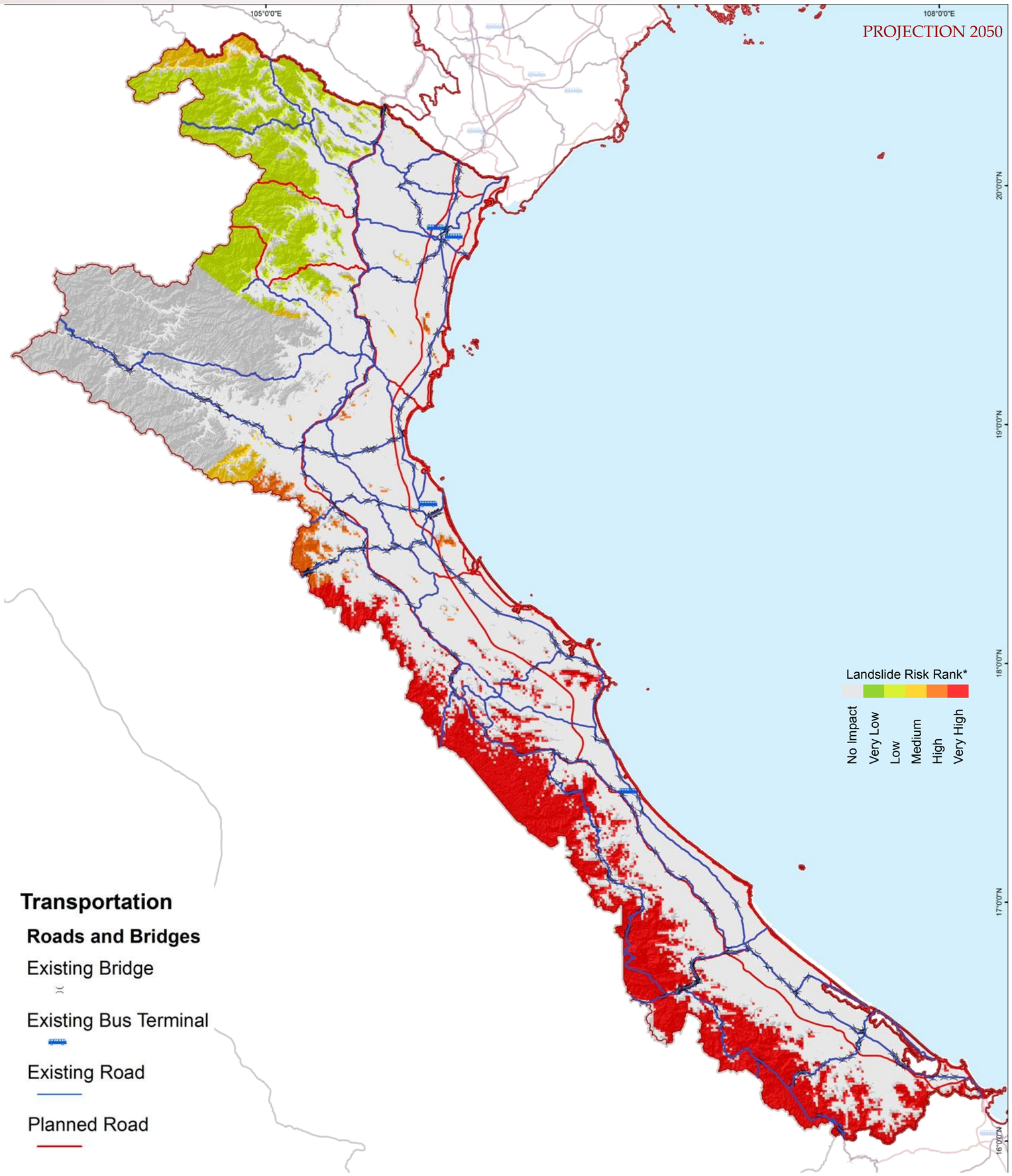
REGION 2 - ROADS AND BRIDGES (RAINFALL ASSOCIATED LANDSLIDES)

BASELINE





BASELINE		
Impact scale	**Possible Affected Region**	**Possible Affected Road**
No impact or Very low	Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Tri, Thua Thien Hue.	217, HCM, 45, 1, 10, 15, 47, 7, 48, 8, 46, 12, 9, 49.
Low or Medium	Thanh Hoa, Nghe An.	217, 15.
High or Very high	Nghe An, Ha Tinh, Quang Binh, Quang Tri, Thua Thien Hue.	8, 12, HCM, 9, 49.



2050 SCENARIO		
Impact scale	**Possible Affected Region**	**Possible Affected Road**
No impact or Very low	Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Tri, Thua Thien Hue.	217, HCM, 45, 1, 10, 15, 47, 7, 48, 8, 46, 12, 9, 49.
Low or Medium	Thanh Hoa, Nghe An.	217, 15.
High or Very high	Nghe An, Ha Tinh, Quang Binh, Quang Tri, Thua Thien Hue.	8, 12, HCM, 9, 49.

Region 2 includes the following provinces: Hà Tĩnh, Nghệ An, Quảng Bình, Quảng Trị, Thanh Hoá, Thừa Thiên Huế.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

IE - ENERGY INFRASTRUCTURE

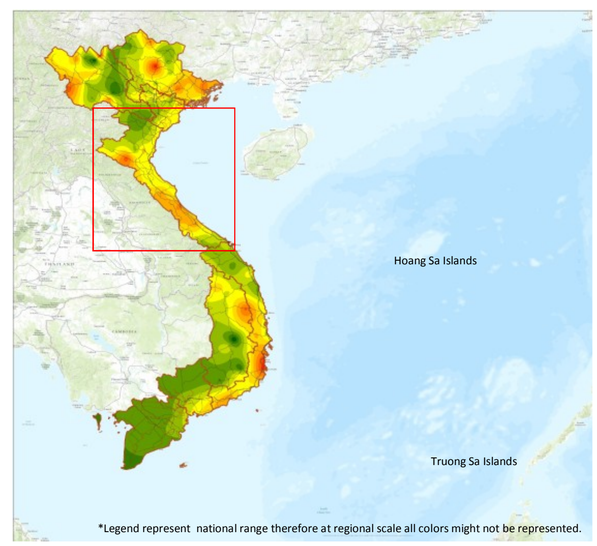
GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

N
W
E
S

MAP SCALE - 1: 1,200,000

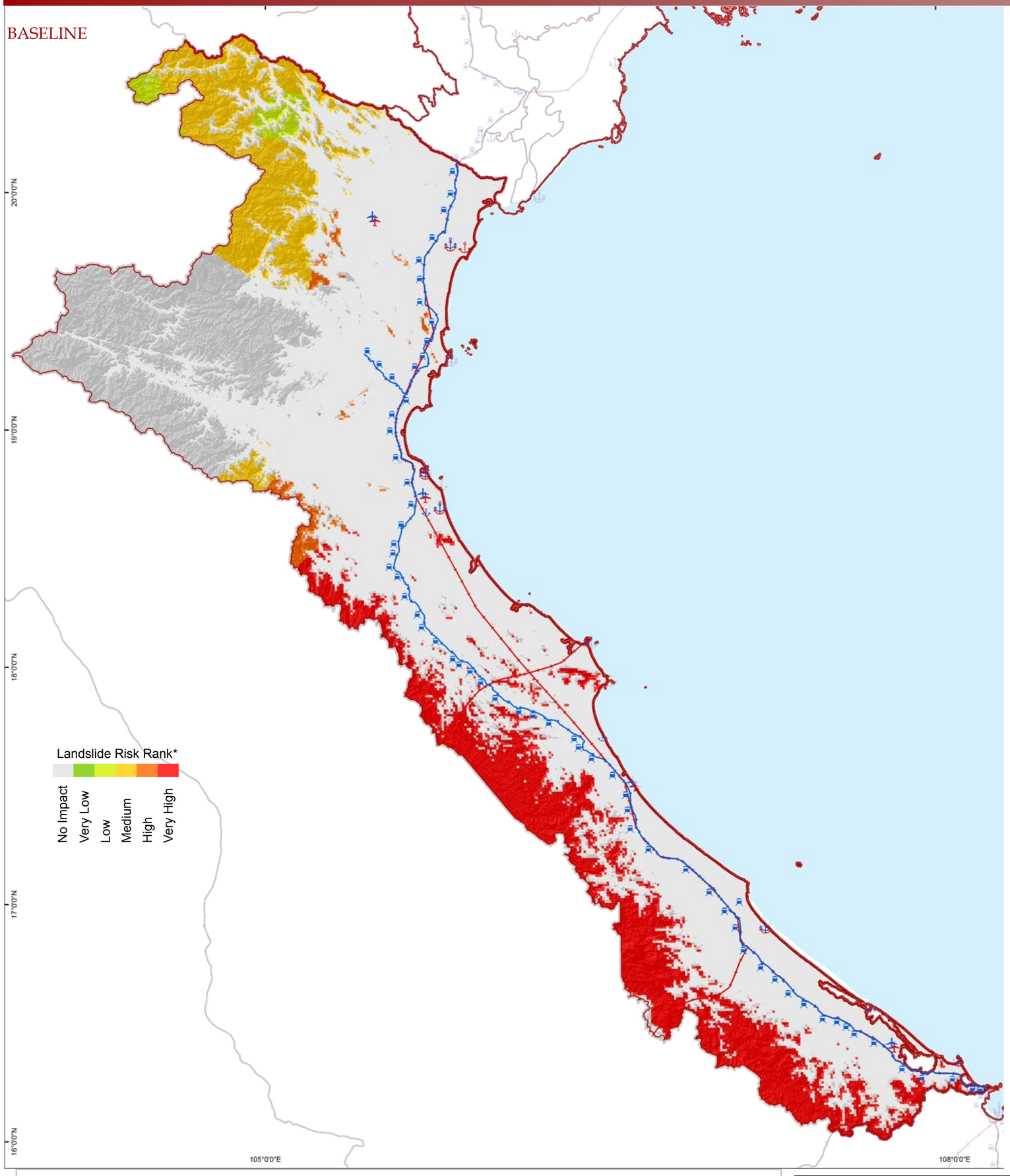
INDEX MAP



*Legend represent national range therefore at regional scale all colors might not be represented.

REGION 2 - OTHER TRANSPORT (RAINFALL ASSOCIATED LANDSLIDES)

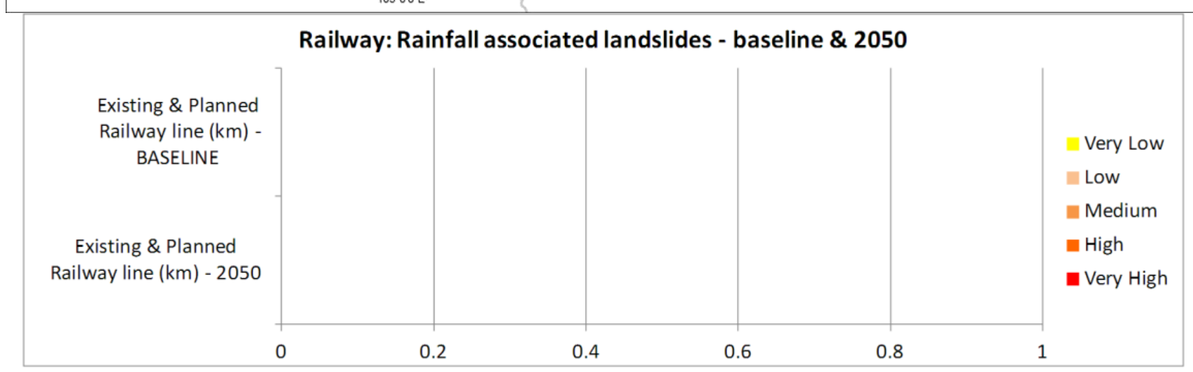
BASELINE



Transportation

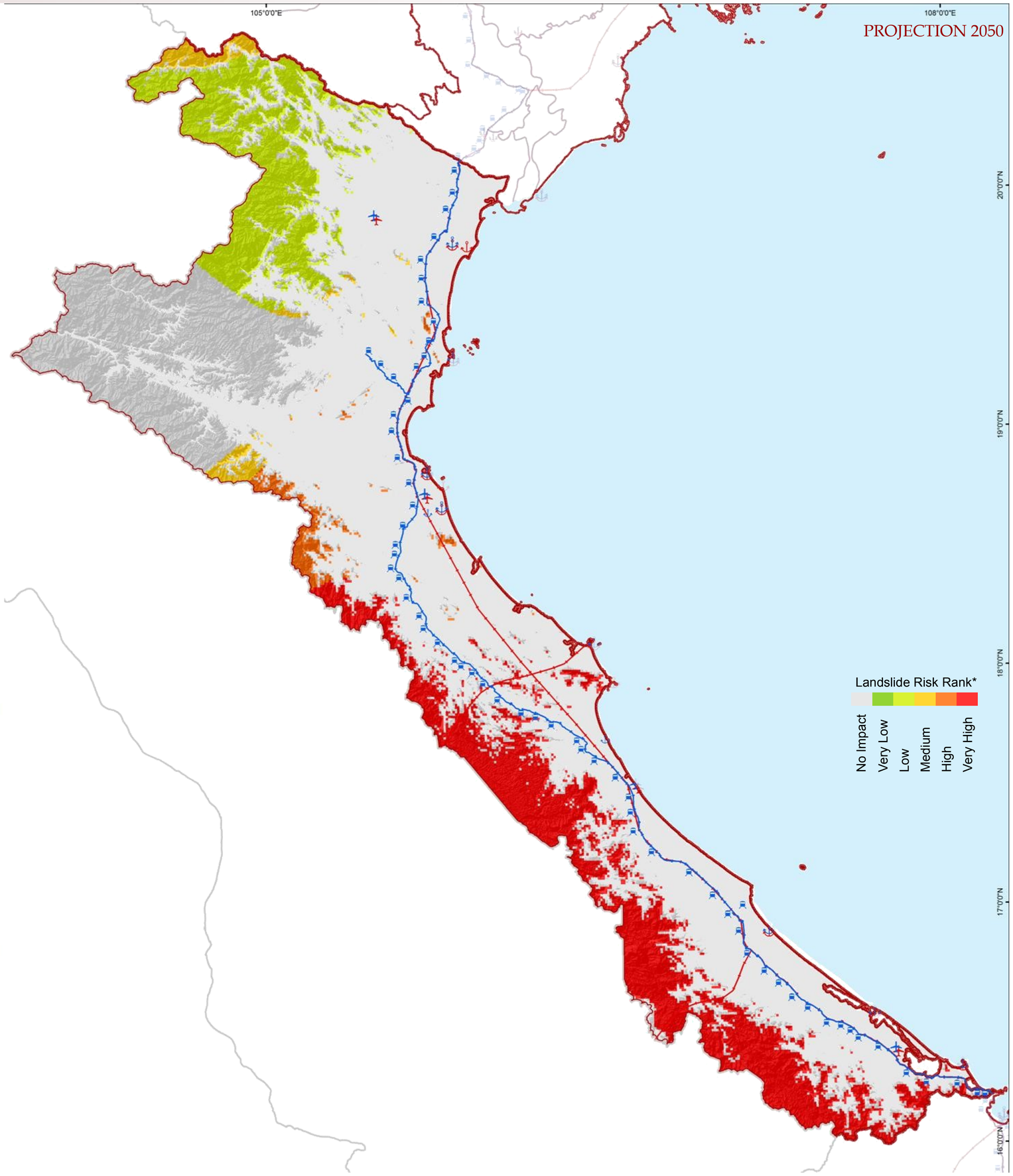
Other Assets

- Existing Civil Airport
- Planned Civil Airport
- Existing IWT Port
- Planned IWT Port
- Existing Sea Port
- Planned Sea Port
- Existing Rail Station
- Existing IWT Route
- Planned IWT Route
- Existing Rail Track
- Planned Rail Track



BASELINE		
Impact scale	**Possible Affected Region**	**Possible Affected Assets**
No impact or Very low	Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Tri, Thua Thien Hue.	Rail: Ha Noi-SaiGon, Vung Ang-Mu Gia, Dong Ha-Lao Bao.
Low or Medium	Thanh Hoa, Nghe An.	
High or Very high	Nghe An, Ha Tinh, Quang Binh, Quang Tri, Thua Thien Hue.	Rail: Vung Ang-Mu Gia, Dong ha-Lao Bao.

PROJECTION 2050



Transportation

Other Assets

Existing Civil Airport

Planned Civil Airport

Existing IWT Port

Planned IWT Port

Existing Sea Port

Planned Sea Port

Existing Rail Station

Existing IWT Route

Planned IWT Route

Existing Rail Track

Planned Rail Track

2050 SCENARIO		
Impact scale	**Possible Affected Region**	**Possible Affected Assets**
No impact or Very low	Thanh Hoa, Nghe An, Ha Tinh, Quang Binh, Quang Tri, Thua Thien Hue.	Rail: Ha Noi-Saigon, Vung Ang-Mu Gia, Dong Ha-Lao Bao.
Low or Medium	Thanh Hoa, Nghe An.	
High or Very high	Nghe An, Ha Tinh, Quang Binh, Quang Tri, Thua Thien Hue.	Rail: Vung Ang-Mu Gia, Dong ha-Lao Bao.

Region 2 includes the following provinces: Hà Tĩnh, Nghệ An, Quảng Bình, Quảng Trị, Thanh Hoá, Thừa Thiên Huế.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

IE - ENERGY INFRASTRUCTURE

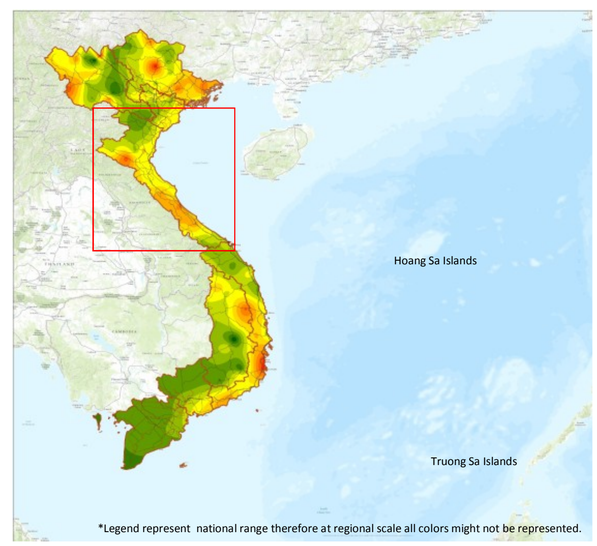
GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

N
W
E
S

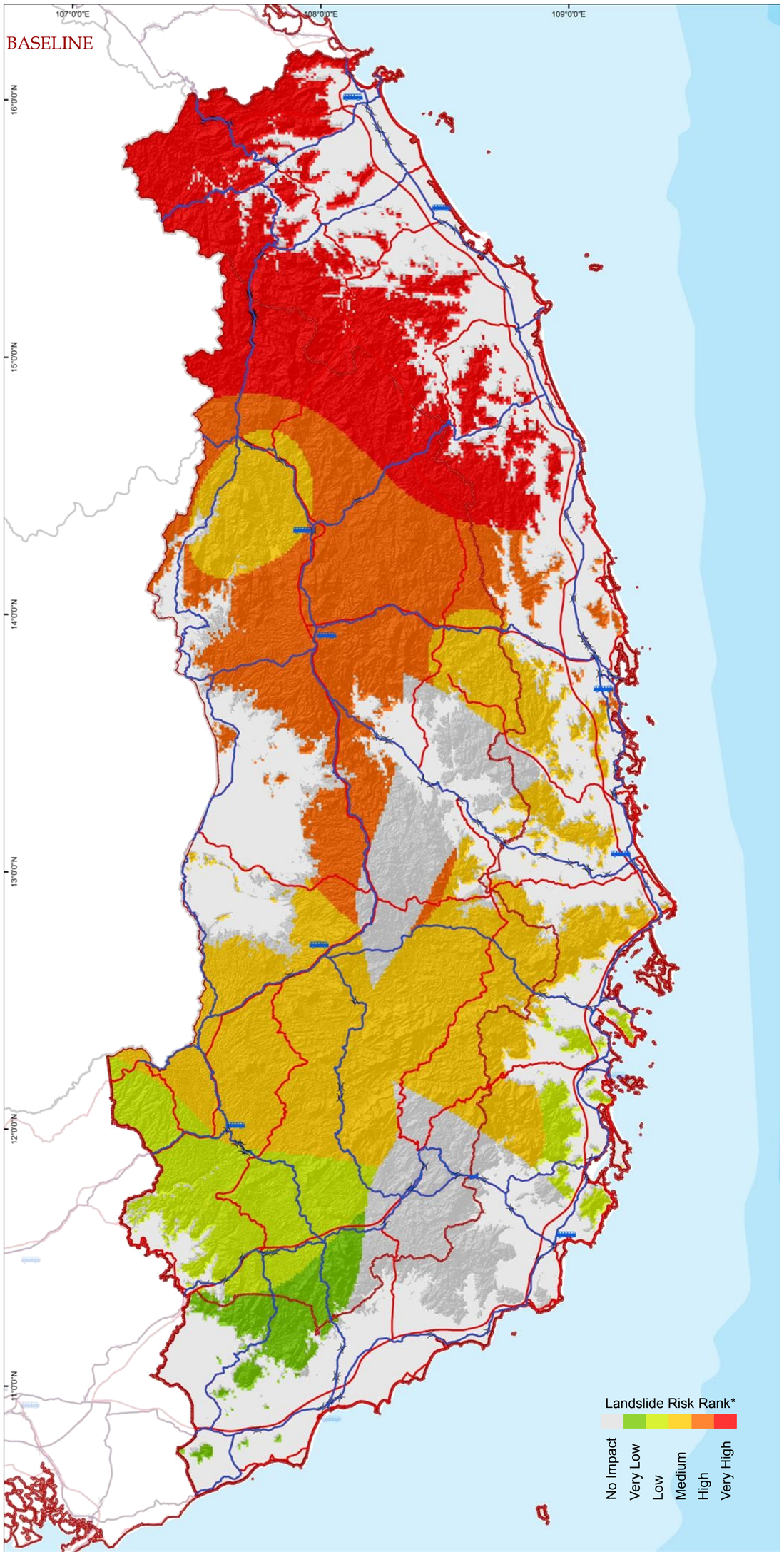
MAP SCALE - 1: 1,200,000

INDEX MAP



*Legend represent national range therefore at regional scale all colors might not be represented.

REGION 3 - ROADS AND BRIDGES (RAINFALL ASSOCIATED LANDSLIDES)



BASELINE		
Impact scale	**Possible Affected Region**	**Possible Affected Road**
No impact or Very low	Da Nang, Quang Nam, Quang Ngai, Binh Dinh, Phu Yen, Gia Lai, Khanh Hoa, Ninh Thuan, Lam Dong, Binh Thuan, Dak Lak.	1, 14, 24, 19, 25, 20, 26, 27, 28, 55,
Low or Medium	Kom Tum, Dak Lak, Lam Dong, Khanh Hoa, Ninh Thuan.	14, HCM, 16, 26, 27, 28, 20, 55.
High or Very high	Da Nang, Quang Nam, Kom Tum, Quang Ngai, Binh Dinh, Gia Lai, Dak Lak.	HCM, 14, 24, 19, 25.

Transportation

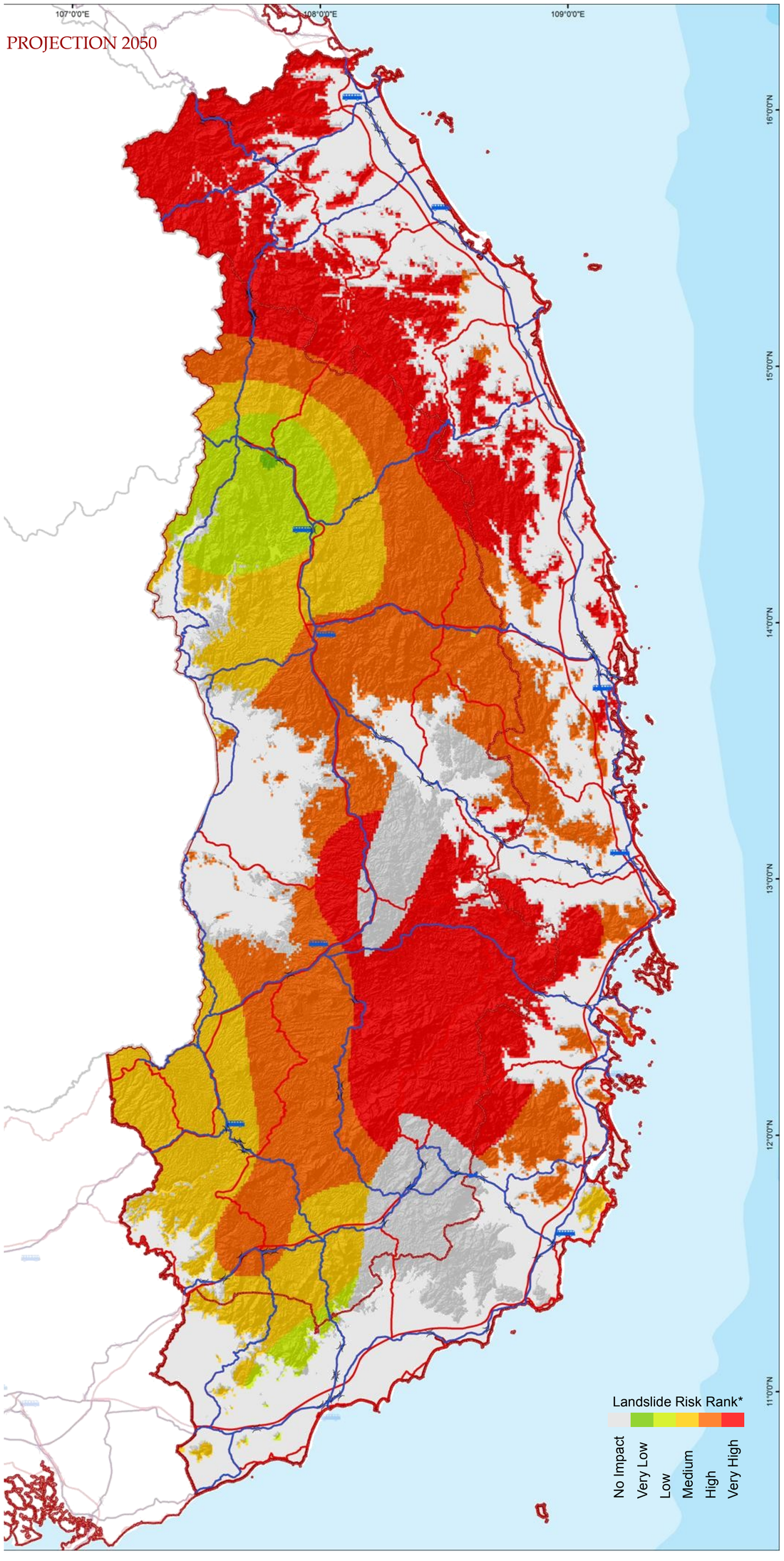
Roads and Bridges

Existing Bridge

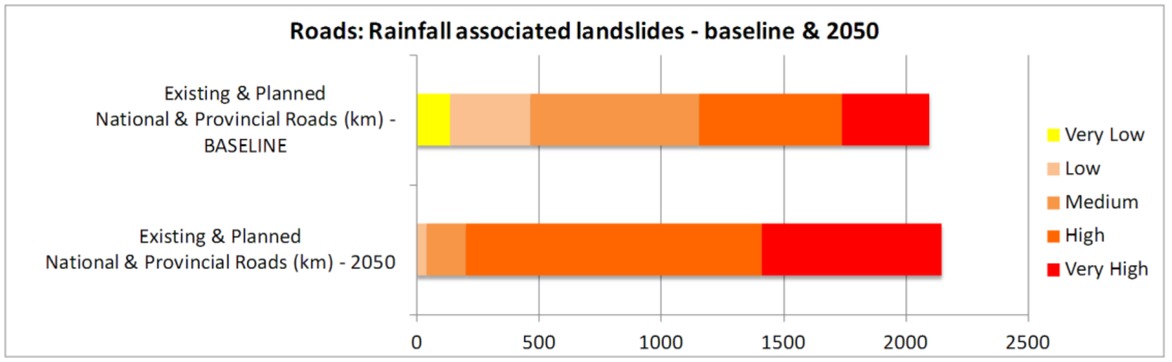
Existing Bus Terminal

Existing Road

Planned Road



2050 SCENARIO		
Impact scale	**Possible Affected Region**	**Possible Affected Road**
No impact or Very low	Da Nang, Quang Nam, Quang Ngai, Binh Dinh, Gia Lai, Dak Lak, Lam Dong, Khanh Hoa, Phu Yen, Gia Lai, Khanh Hoa, Dak Lak, Ninh Thuan, Lam Dong, Binh Thuan.	14, 1, 24, 19, 26, 27, 28, 20, 55.
Low or Medium	Dak Lak, Lam Dong, Kom Tum, Gia Lai	14, HCM, 19, 24, 28, 20, 55.
High or Very high	Da Nang, Quang Nam, Quang Ngai, Kom Tum, Binh Dinh, Gia Lai, Dak Lak, Lam Dong, Khanh Hoa, Phu Yen.	14, HCM, 19, 24, 25, 26, 27, 28, 55, 20.



Transportation

Roads and Bridges

Existing Bridge

Existing Bus Terminal

Existing Road

Planned Road

Region 3 includes the following provinces: Bình Định, Bình Thuận, Đà Nẵng, Đắk Lăk, Đắk Nông, Gia Lai, Khánh Hoà, Kon Tum, Lâm Đồng, Ninh Thuận, Phú Yên, Quảng Nam, Quảng Ngãi.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

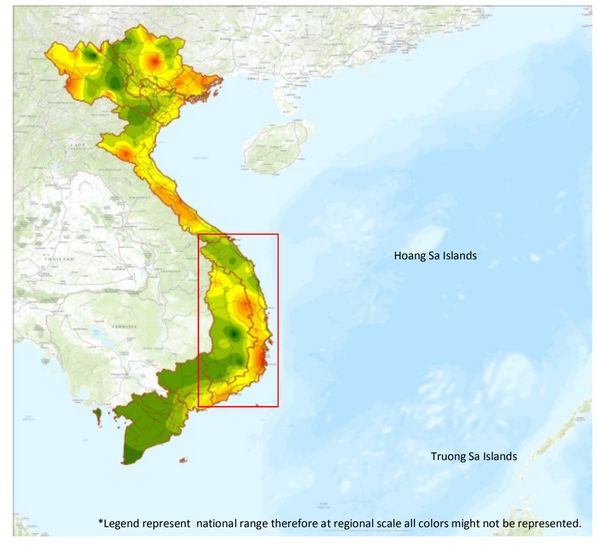
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

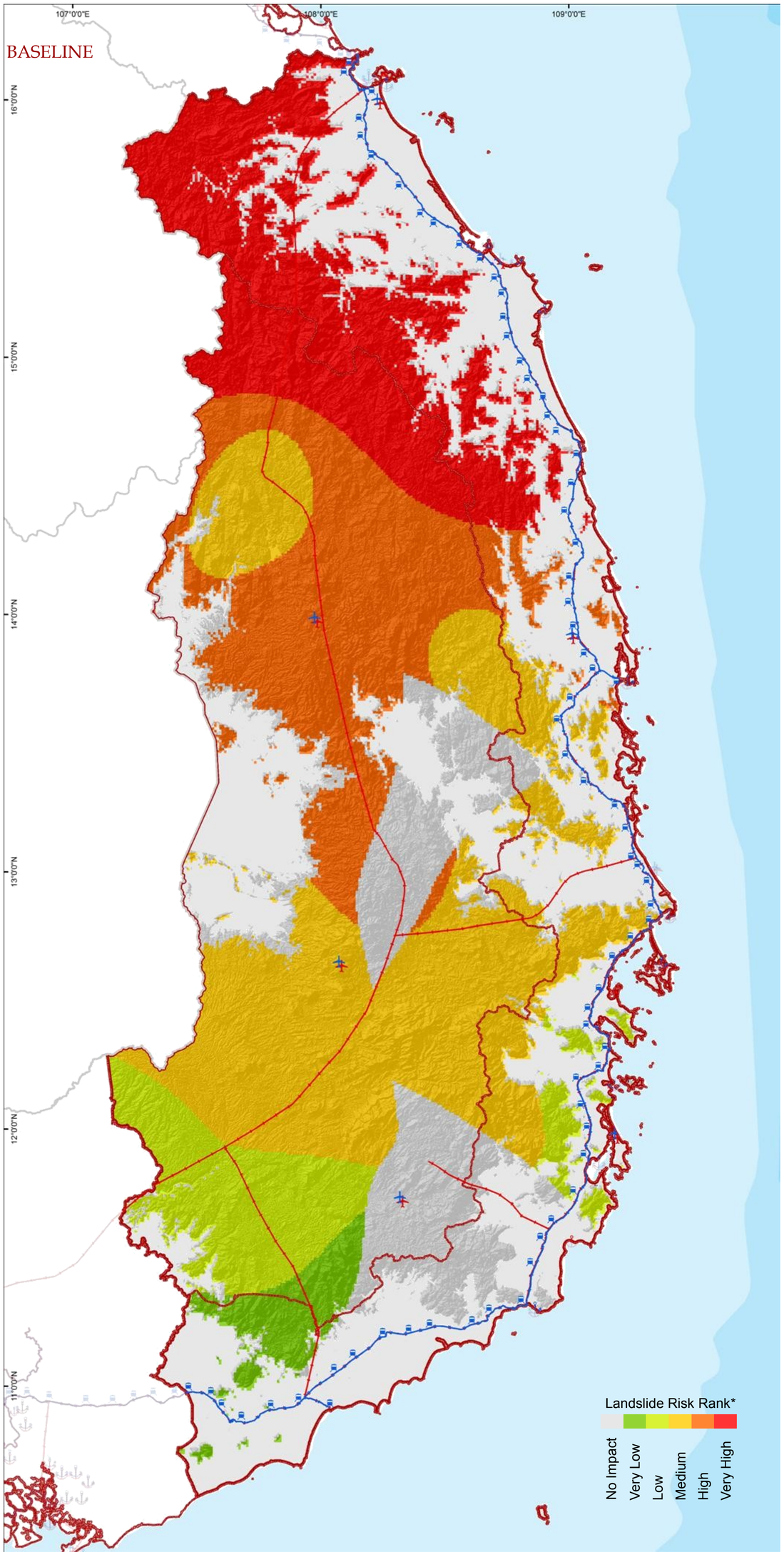
GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

MAP SCALE - 1: 1,200,000

INDEX MAP



REGION 3 - OTHER TRANSPORT (RAINFALL ASSOCIATED LANDSLIDES)

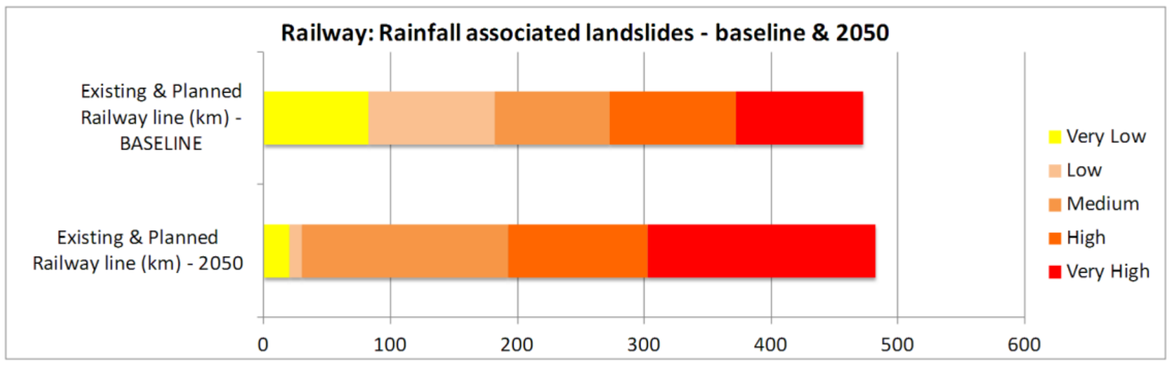


BASELINE		
Impact scale	**Possible Affected Region**	**Possible Affected Assets**
No impact or Very low	Da Nang, Quang Nam, Quang Ngai, Binh Dinh, Phu Yen, Gia Lai, Khanh Hoa, Ninh Thuan, Lam Dong, Binh Thuan, Dak Lak.	Rail: Ha Noi-Sai Gon, Tuy Hoa-Buon Ma Thuat, Dak Nong-Binh Thuan, Thap Cham-Da Lat.
Low or Medium	Kom Tum, Dak Lak, Lam Dong, Khanh Hoa, Ninh Thuan.	Rail: Da Nang-Dak Nong-Chon Thanh, Tuy Hoa-Buon Ma Thuat, Dak Nong-Binh Thuan.
High or Very high	Da Nang, Quang Nam, Kom Tum, Quang Ngai, Binh Dinh, Gia Lai, Dak Lak.	Rail: Da Nang-Dak Nong-Chon Thanh.

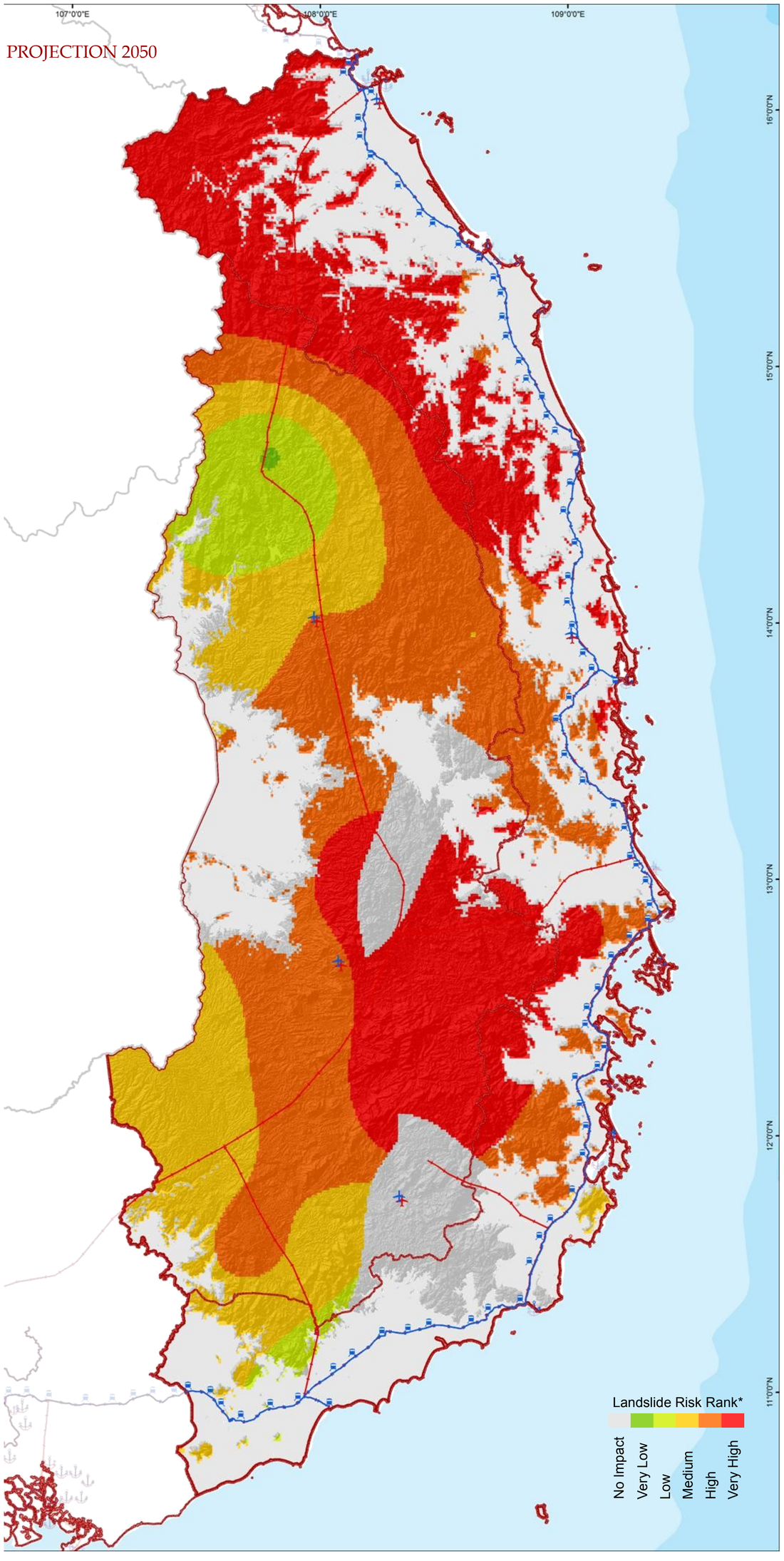
Transportation

Other Assets

- Existing Civil Airport
- Planned Civil Airport
- Existing IWT Port
- Planned IWT Port
- Existing Sea Port
- Planned Sea Port
- Existing Rail Station
- Existing IWT Route
- Planned IWT Route
- Existing Rail Track
- Planned Rail Track



PROJECTION 2050



2050 SCENARIO		
Impact scale	**Possible Affected Region**	**Possible Affected Assets**
No impact or Very low	Da Nang, Quang Nam, Quang Ngai, Binh Dinh, Gia Lai, Dak Lak, Lam Dong, Khanh Hoa, Phu Yen, Gia Lai, Khanh Hoa, Dak Lak, Ninh Thuan, Lam Dong, Binh Thuan.	Rail: Ha Noi-Sai Gon, Tuy Hoa-Buon Ma Thuat, Thap Cham-Da Lat,
Low or Medium	Dak Lak, Lam Dong, Kom Tum, Gia Lai	Rail: Da Nang-Dak Nong-Chon Thanh, Dak Nong-Binh Thuan.
High or Very high	Da Nang, Quang Nam, Quang Ngai, Kom Tum, Binh Dinh, Gia Lai, Dak Lak, Lam Dong, Khanh Hoa, Phu Yen.	Rail: Da Nang-Dak Nong-Chon Thanh, Tuy Hoa-Buon Ma Thuat, Dak Nong-Binh Thuan.

Transportation

Other Assets

Existing Civil Airport

Planned Civil Airport

Existing IWT Port

Planned IWT Port

Existing Sea Port

Planned Sea Port

Existing Rail Station

Existing IWT Route

Planned IWT Route

Existing Rail Track

Planned Rail Track

Region 3 includes the following provinces: Bình Định, Bình Thuận, Đà Nẵng, Đăk Lăk, Đăk Nông, Gia Lai, Khánh Hoà, Kon Tum, Lâm Đồng, Ninh Thuận, Phú Yên, Quảng Nam, Quảng Ngãi.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

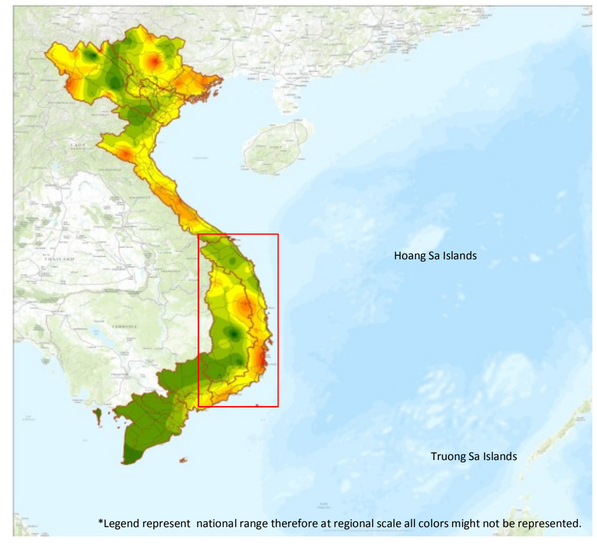
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

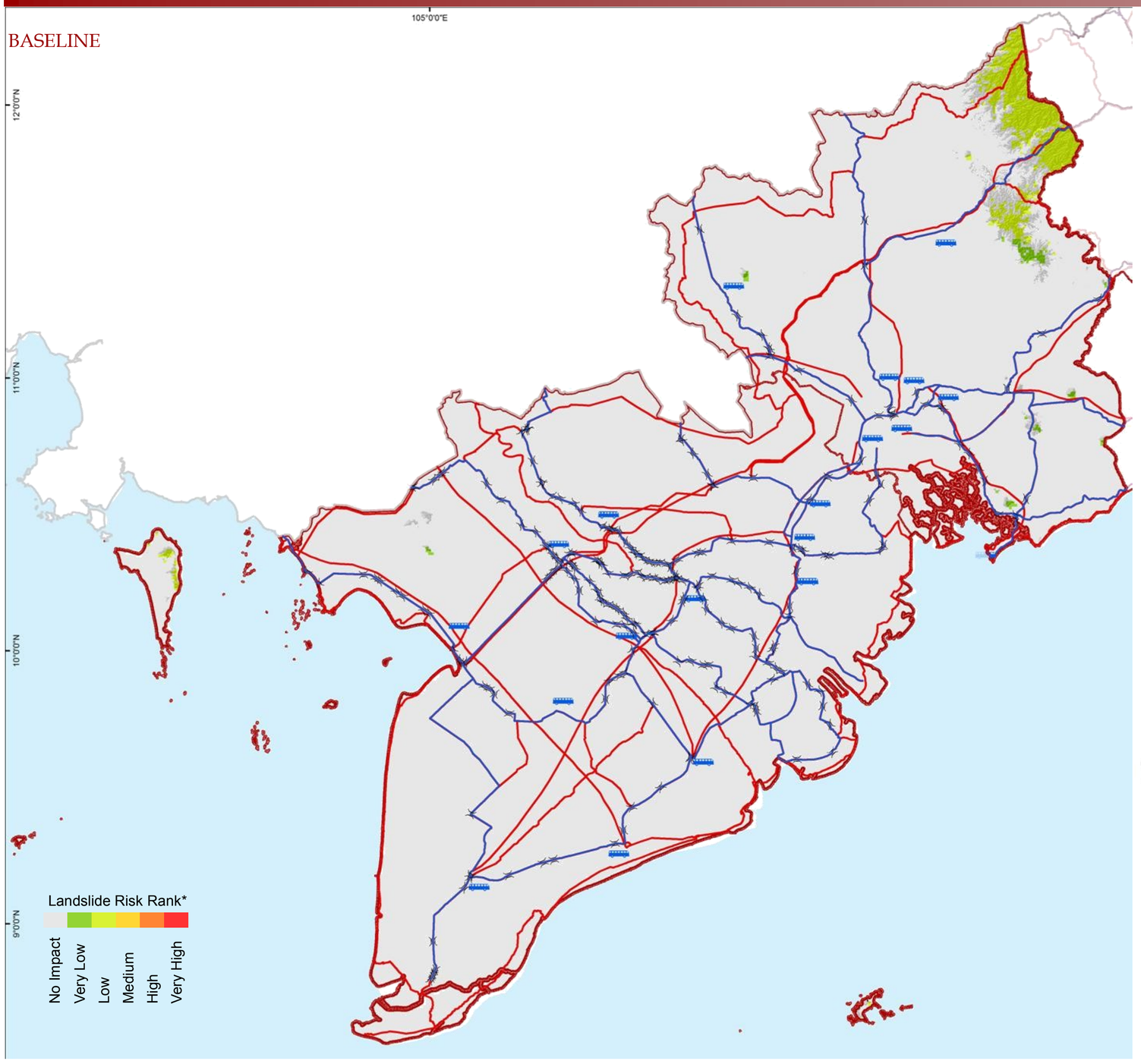
MAP SCALE - 1: 1,200,000

INDEX MAP



REGION 4 - ROADS AND BRIDGES (RAINFALL ASSOCIATED LANDSLIDES)

BASELINE



Transportation

Roads and Bridges

Existing Bridge

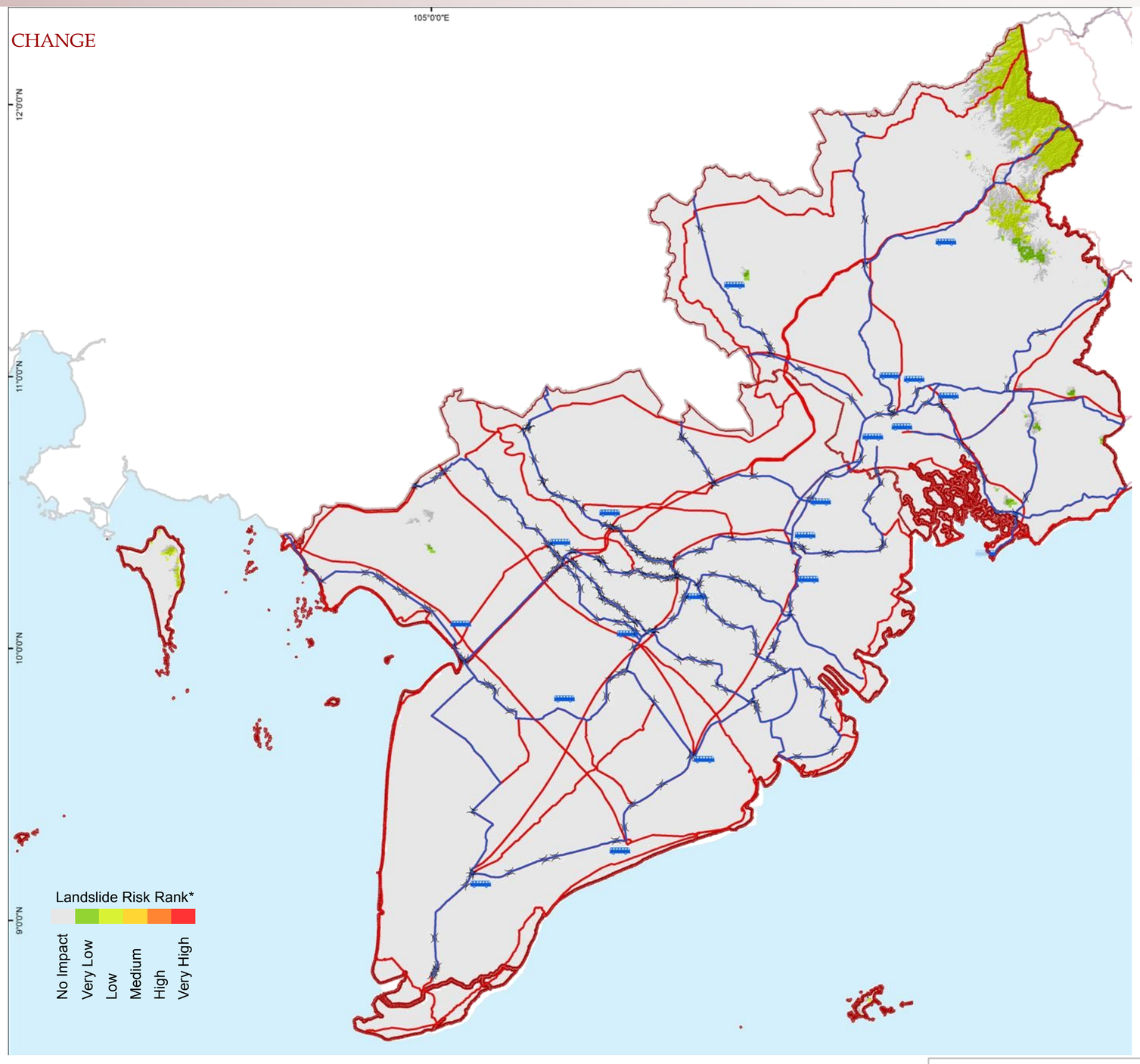
Existing Bus Terminal

Existing Road

Planned Road

BASELINE		
Impact scale	**Possible Affected Region**	**Possible Affected Road**
No impact or Very low	Binh Phuoc, Dong Nai, Ba Ria Vung Tau, Binh Duong, Tay Ninh, Ho Chi Minh, Long An, Tien Giang. Ben Tre, Dong Thap, Tra Vinh, Vinh Long, An Giang, Can Tho, Soc Trang, Kien Giang, Bac Lieu, Ca Mau.	13, 14, 20, 1, 55, 56, 51, 50, 62, 60, 57, 30, 80, 53, 54, 91, 63.
Low or Medium		
High or Very high		

CHANGE



Transportation

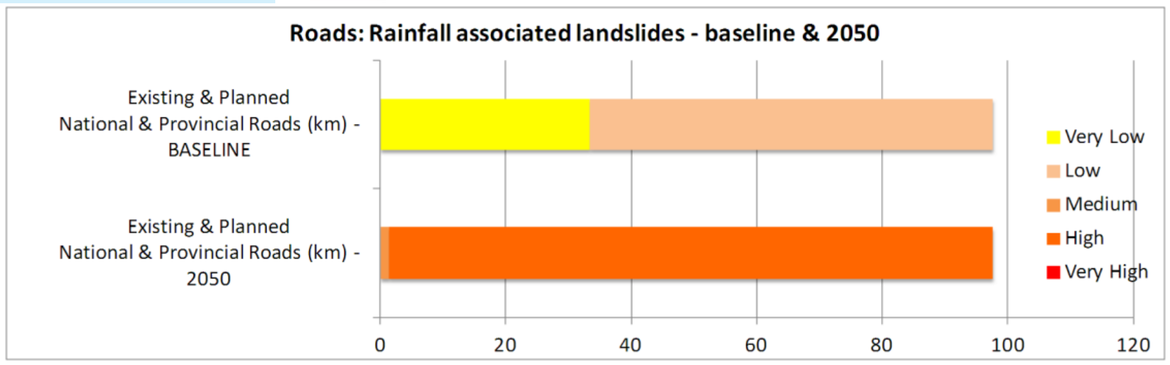
Roads and Bridges

Existing Bridge

Existing Bus Terminal

Existing Road

Planned Road



2050 SCENARIO		
Impact scale	**Possible Affected Region**	**Possible Affected Road**
No impact or Very low	Binh Phuoc, Dong Nai, Ba Ria Vung Tau, Binh Duong, Tay Ninh, Ho Chi Minh, Long An, Tien Giang. Ben Tre, Dong Thap, Tra Vinh, Vinh Long, An Giang, Can Tho, Soc Trang, Kien Giang, Bac Lieu, Ca Mau.	13, 14, 20, 1, 55, 56, 51, 50, 62, 60, 57, 30, 80, 53, 54, 91, 63.
Low or Medium	Binh Phuoc	14
High or Very high		

Region 4 includes the following provinces: An Giang, Bà Rịa Vũng Tàu, Bạc Liêu, Bến Tre, Bình Dương, Bình Phước, Cà Mau, Đồng Nai, Đồng Tháp, Hậu Giang, Kiên Giang, Long An, Sóc Trăng, Tây Ninh, Tiền Giang, TP Cần Thơ, TP Hồ Chí Minh, Trà Vinh, Vinh Long.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

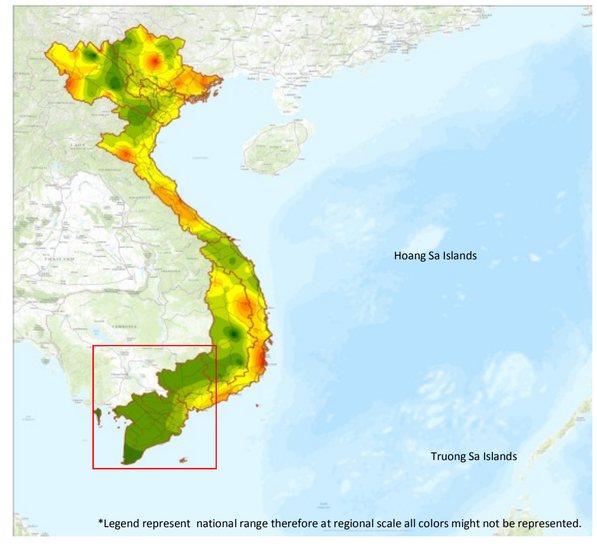
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

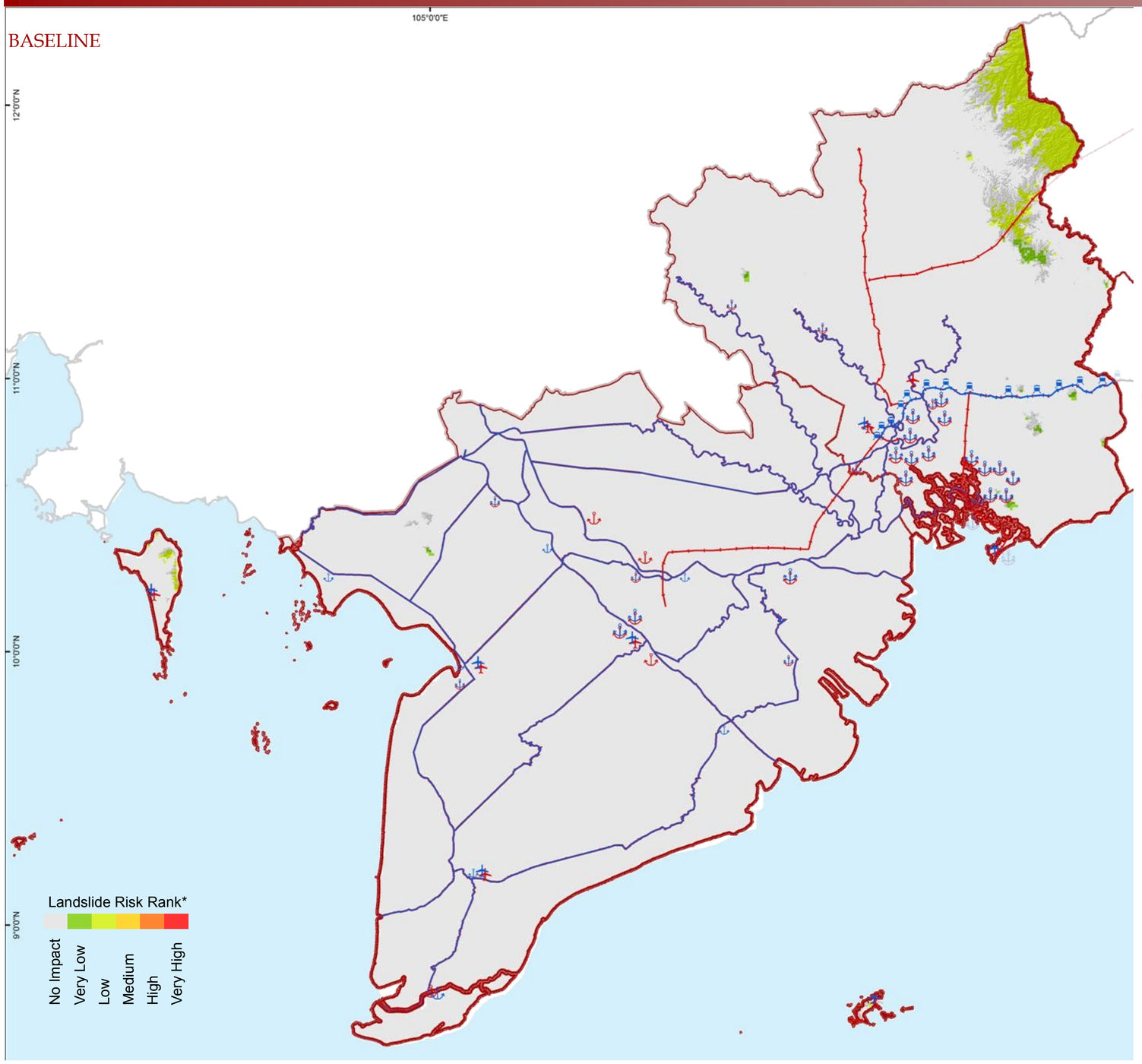
MAP SCALE - 1: 1,200,000

INDEX MAP

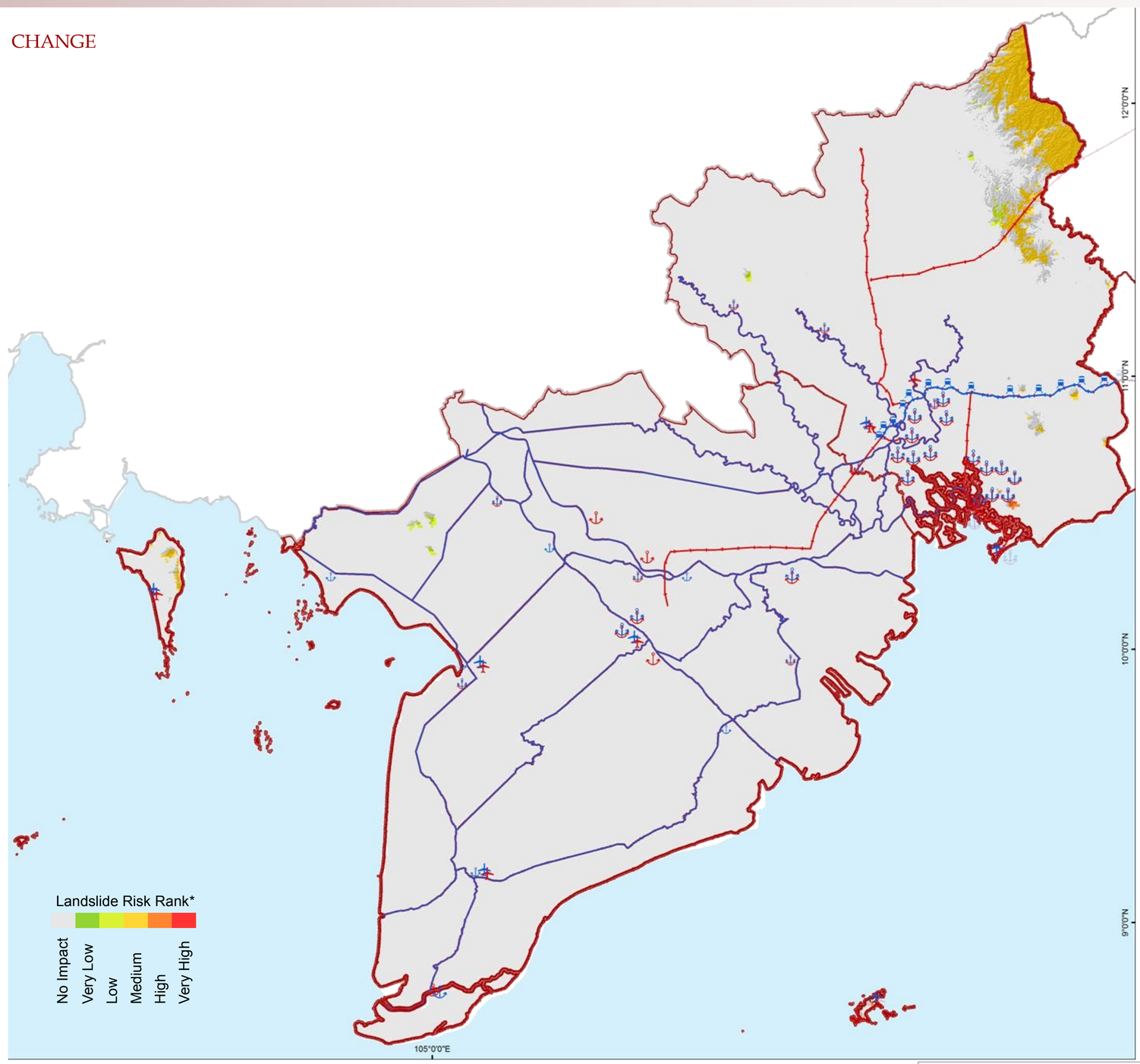


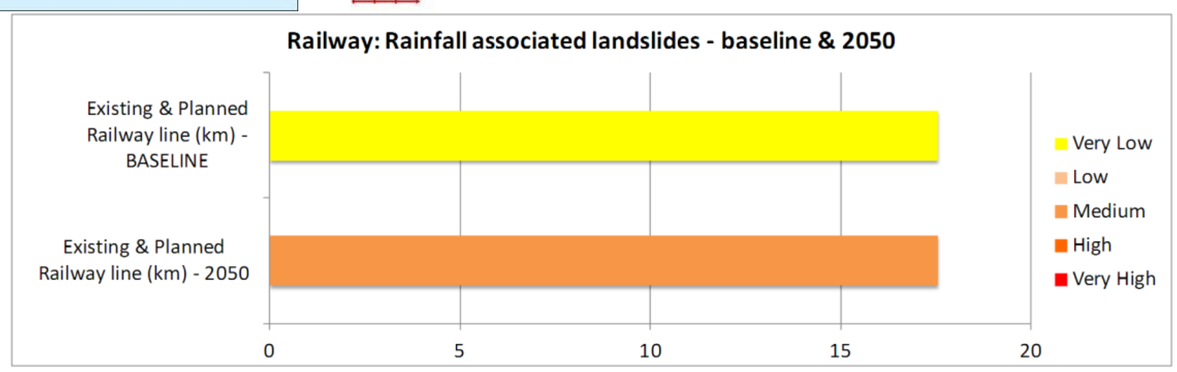
REGION 4 - OTHER TRANSPORT (RAINFALL ASSOCIATED LANDSLIDES)

BASELINE



BASELINE		
Impact scale	**Possible Affected Region**	**Possible Affected Assets**
No impact or Very low	Binh Phuoc, Dong Nai, Ba Ria Vung Tau, Binh Duong, Tay Ninh, Ho Chi Minh, Long An, Tien Giang. Ben Tre, Dong Thap, Tra Vinh, Vinh Long, An Giang, Can Tho, Soc Trang, Kien Giang, Bac Lieu, Ca Mau.	Rail: Ha Noi-Sai Gon, Da Nang-Dak Nong-Chon Thanh, Ho Chi Minh-Loc Ninh, Tram Bom-Vung Tau, Ho Chi Minh-My Tho-Can Tho. IWT: Sai Gon-Hieu Liem, Sai Gon-Ben Suc, Sai Gon-Ben Keo, Sai Gon-Ca Mau, Sai Gon-Moc Hoa, Mekong -Thi Vai, Cua Tieu-Hong Ngu, Sai Gon-Kien Luong, Moc Hoa-Ha Tien, Dinh An-Tan Chau, Rach Gia-Ca Mau.
Low or Medium		
High or Very high		





2050 SCENARIO

Impact scale	Possible Affected Region	Possible Affected Assets
No impact or Very low	Binh Phuoc, Dong Nai, Ba Ria Vung Tau, Binh Duong, Tay Ninh, Ho Chi Minh, Long An, Tien Giang. Ben Tre, Dong Thap, Tra Vinh, Vinh Long, An Giang, Can Tho, Soc Trang, Kien Giang, Bac Lieu, Ca Mau.	Rail: Ha Noi-Sai Gon, Da Nang-Dak Nong-Chon Thanh, Ho Chi Minh-Loc Ninh, Tram Bom-Vung Tau, Ho Chi Minh-My Tho-Can Tho. IWT: Sai Gon-Hieu Liem, Sai Gon-Ben Suc, Sai Gon-Ben Keo, Sai Gon-Ca Mau, Sai Gon-Moc Hoa, Mekong -Thi Vai, Cua Tieu-Hong Ngu, Sai Gon-Kien Luong, Moc Hoa-Ha Tien, Dinh An-Tan Chau, Rach Gia-Ca Mau.
Low or Medium	Binh Phuoc.	Rail: Da Nang-Dak Nong-Chon Thanh.
High or Very high		

Region 4 includes the following provinces: An Giang, Bà Rịa Vũng Tàu, Bạc Liêu, Bến Tre, Bình Dương, Bình Phước, Cà Mau, Đồng Nai, Đồng Tháp, Hậu Giang, Kiên Giang, Long An, Sóc Trăng, Tây Ninh, Tiền Giang, TP Cần Thơ, TP Hồ Chí Minh, Trà Vinh, Vinh Long.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

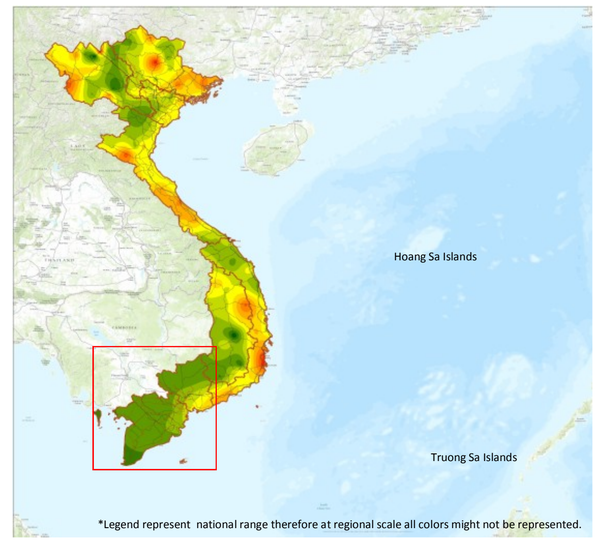
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

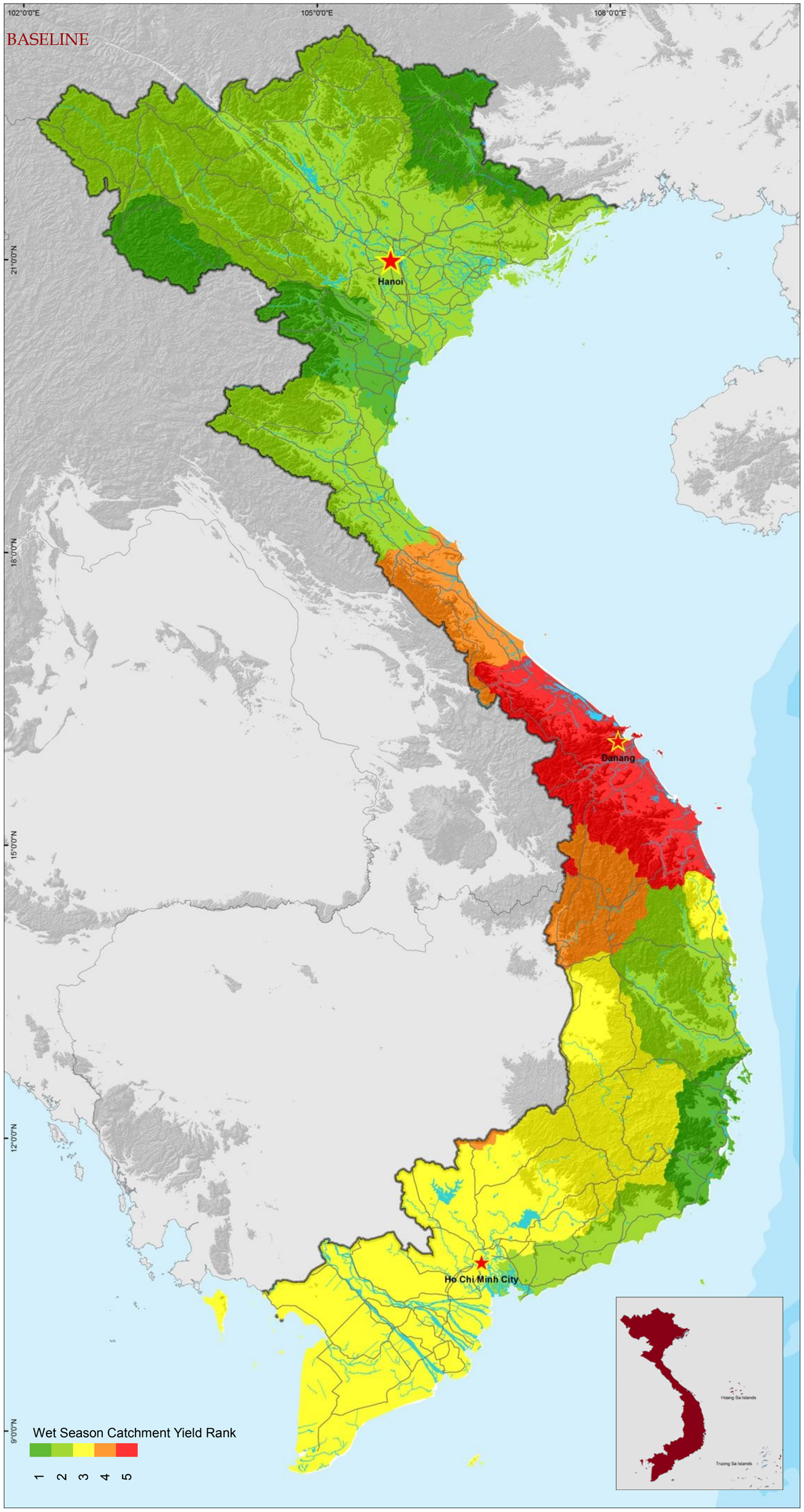
GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

MAP SCALE - 1: 1,200,000

INDEX MAP



WET SEASON CATCHMENT YIELD



BASELINE

ROADS

Approximately 7.8% of the total length of existing and planned roads in Vietnam is at very high risk of flooding, followed by 6.4% at high risk. The Central Vietnam KEZ is mostly within the high and very high rated areas, and includes the major hub of Da Nang City and it's strategically significant deep water Tien Sa Seaport. The proposed East West Economic Corridor from Da Nang to Myanmar is also in this area. Effectively functioning transportation networks are critical for boosting development of the key sectors in the KEZ, including oil and gas, shipbuilding, logistics, tourism and hi-tech industries. These routes are being used for freight transport to ports for export and vice-versa, and therefore need to be made climate resilient to flooding.

There are many long lengths of major roads that are exposed to a very high level of risk from this climate indicator. This includes sections of National Road 1 and 14 that carry traffic between Northern (Hanoi), Central (Da Nang) and Southern (HCMC) Vietnam, as well as many east-west roads that provide a critical link between the coast and highland areas for local people. National Roads 14B and 14D for example, connect Da Nang to the Cambodia border gate, and are at risk along their entire length as they are located in the Vu Gia Thu Bon basin which regularly floods. National Road 14E is at high risk. This road (along with NR14G) connects National Road 14 to National Road 1 and links traffic between HCMC and Da Nang and therefore is an important transport artery.

It is important to note that these assets may be elevated on, or protected by, dykes and therefore may not be inundated in a flood event.

RAILWAYS

Approximately 7.8% of the total length of existing and planned roads in Vietnam is at very high risk of flooding, followed by 6.4% at high risk. The Central Vietnam KEZ is mostly within the high and very high rated areas, and includes the major hub of Da Nang City and it's strategically significant deep water Tien Sa Seaport. The proposed East West Economic Corridor from Da Nang to Myanmar is also in this area. Effectively functioning transportation networks are critical for boosting development of the key sectors in the KEZ, including oil and gas, shipbuilding, logistics, tourism and hi-tech industries. These routes are being used for freight transport to ports for export and vice-versa, and therefore need to be made climate resilient to flooding.

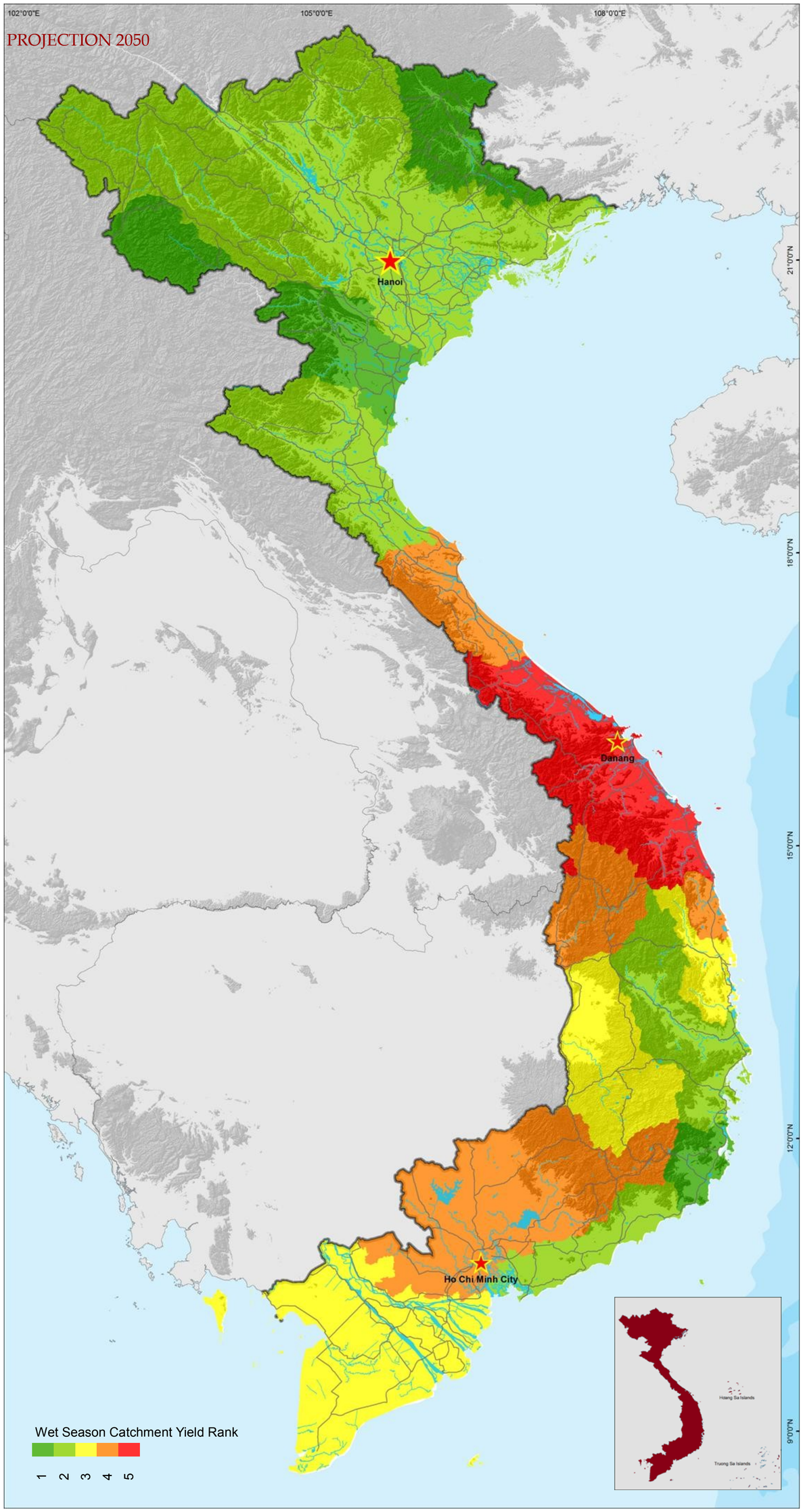
There are many long lengths of major roads that are exposed to a very high level of risk from this climate indicator. This includes sections of National Road 1 and 14 that carry traffic between Northern (Hanoi), Central (Da Nang) and Southern (HCMC) Vietnam, as well as many east-west roads that provide a critical link between the coast and highland areas for local people. National Roads 14B and 14D for example, connect Da Nang to the Cambodia border gate, and are at risk along their entire length as they are located in the Vu Gia Thu Bon basin which regularly floods. National Road 14E is at high risk. This road (along with NR14G) connects National Road 14 to National Road 1 and links traffic between HCMC and Da Nang and therefore is an important transport artery.

It is important to note that these assets may be elevated on, or protected by, dykes and therefore may not be inundated in a flood event.

INLAND WATER WAYS

There are no inland waterway routes or ports that are rated as very high risk. This is because these assets are primarily located in the Mekong and Red River Deltas and therefore are mostly low to medium risk as the catchments are very large relative to the rainfall volume they receive.

The medium risk inland waterway route and port assets are located in the Mekong delta area where analysis of past extreme events has shown major annual floods that can affect clearance and navigability in the channels from high water levels and sediment.



2050 SCENARIO

ROADS

National Road 20 links Dalat to HCMC and is also exposed along its entire length, as are its bridges. Existing and planned roads and bridges in the Dong Nai Basin link HCMC to the mountainous areas and eventually Da Nang, and will also be placed at risk. This will have an impact on North-South traffic between Ha Noi and HCMC. The Southern Economic Corridor planned between Quy Nhon and Bangkok (via National Road 19) intersects only medium risk areas.

RAILWAYS

Entire lengths of planned tracks from Da Nang to Dak Nonh (providing crucial connections to the mountainous provinces, and Dong Ha to Lao Bao (which would provide a link to Lao PDR and enhance economic growth) are at risk in 2050 and therefore should be designed with flood resilience in mind.

INLAND WATERWAYS

Approximately 21.2% of the total length of inland waterways will be at high risk of flooding in 2050. These inland waterway routes are located in Dong Nai river basin and are rated as high risk due to the increase in rainfall. All planned ports assessed are in the Red River Basin and have the same medium risk ranking from baseline to 2050.

SUMMARY OF PROJECTED CHANGES

ROADS

There is a 13% shift in length of road at risk from medium to high, resulting in close to 25% of the entire road network rated as high or very high exposure to flowing. This means that the overall flood risk to the transport sector is increasing significantly, as for example, the total length of National Roads at High Risk, which is more than double the Baseline amount in 2050. Significant sections of major roads (e.g. National Road 1 and 14 and many East-West roads) in the central coastal provinces will be shifting in risk of floods.

RAILWAYS

The climate threat risk ranking from baseline and 2050 time slices shows that for the existing and planned railway lines, there is a shift of over 15% of the total length of railway from a Medium risk to a High risk, which is a significant change. The railway line with the largest shift in risk is the existing Hanoi – HCMC line that crosses through the coastal area of all basins identified as high risk of flooding. This track will however be elevated above ground and therefore only specific portions where flood waters exceed the embankment height will be at risk. Significant lengths of planned rail links such as the Da Nang – Dak Nong – Chon Thanh, which runs northwards in the mountainous areas, are also at increased risk.

INLAND WATERWAYS

All inland waterway routes and ports located in the Dong Nai Basin have shifted from medium to high risk, as there is increased rainfall in the basin in the 2050 scenario. This may result in more channel erosion and dredging to ensure navigability.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

IE - ENERGY INFRASTRUCTURE

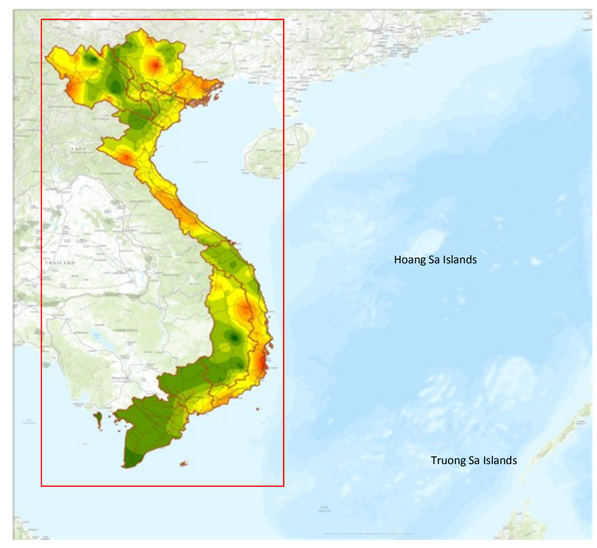
GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

N
W
E
S

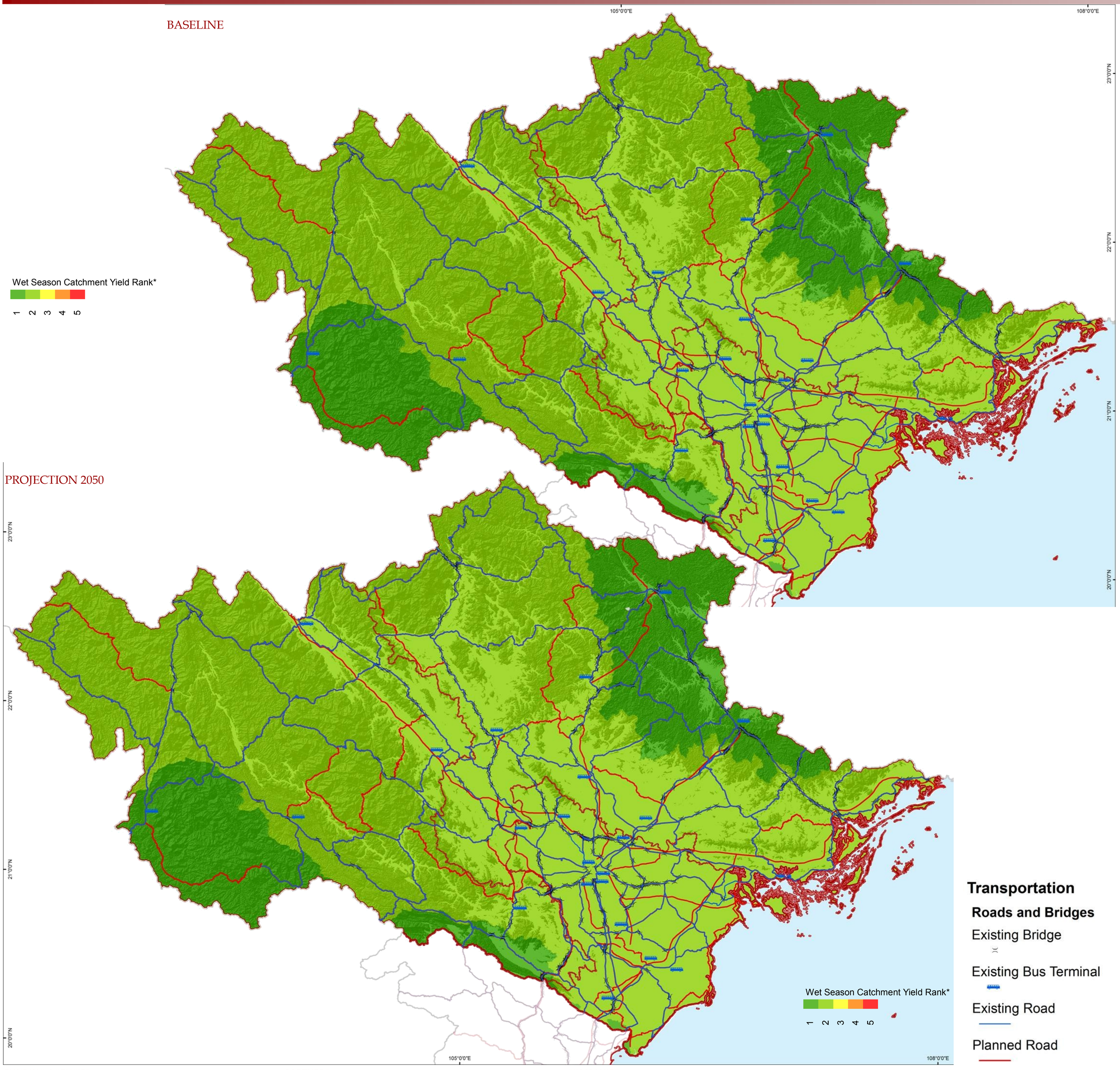
MAP SCALE - 1: 3,000,000

INDEX MAP



REGION 1 - ROADS AND BRIDGES (WET SEASON CATCHMENT YIELD)

BASELINE

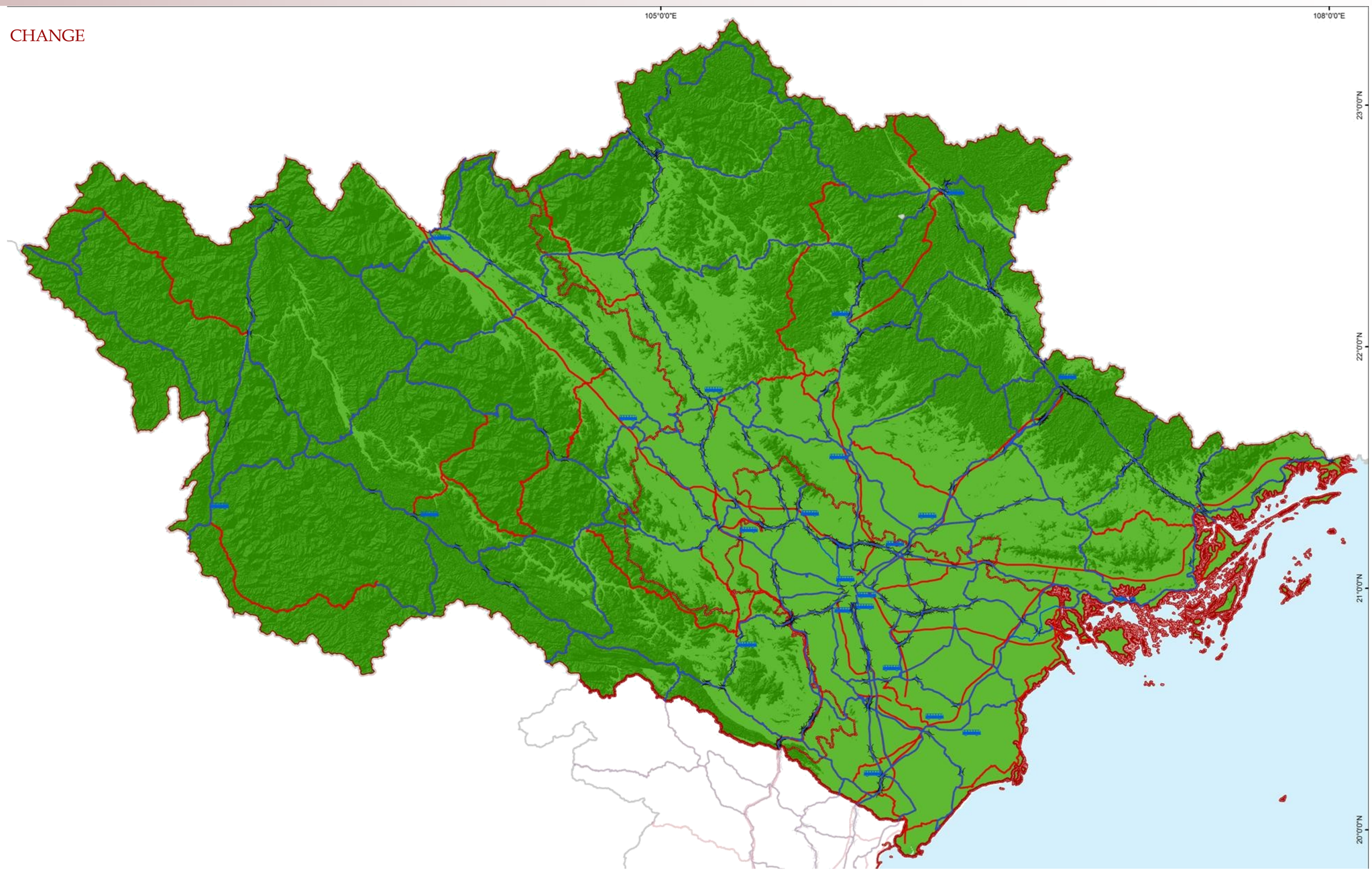


PROJECTION 2050

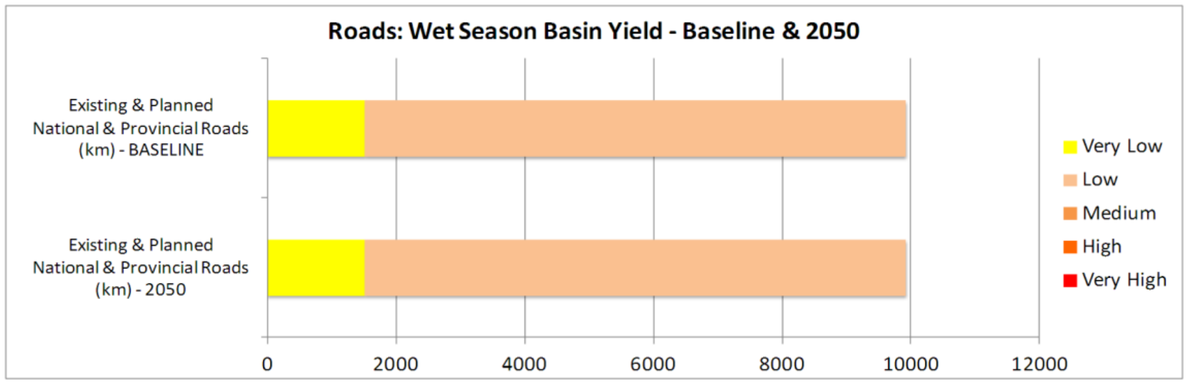
FUNDING AGENCIES

PARTNERS

COMPANIES



BASELINE		
Impact scale	**Possible Affected Region**	**Possible Affected Road**
No impact or Very low	Ha Giang, Lai Chau, Lao Cai, Cao Bang, Lang Son, Bac Can, Tuyen Quang, Yen Bai, Son La, Phu Tho, Thai Nguyen, Quang Ninh, Bac Giang, Vinh Phuc, Ha Noi, Son La, Hoa Binh, Ha Tay, Bac Ninh, Hai Duong, Hai Phong, Hung Yen, Ha Nam, Thai Binh, Nam Dinh, Ninh Binh.	1, 2, 3, 4, 5, 6, 10, 12, 15, 18, 23, 31, 32, 34, 37, 38, 39, 43, , 70, 100, 279, HCM, LHL, PV-CG.
Low or Medium		
High or Very high		



2050 SCENARIO		
Impact scale	**Possible Affected Region**	**Possible Affected Road**
No impact or Very low	Ha Giang, Lai Chau, Lao Cai, Cao Bang, Lang Son, Bac Can, Tuyen Quang, Yen Bai, Son La, Phu Tho, Thai Nguyen, Quang Ninh, Bac Giang, Vinh Phuc, Ha Noi, Son La, Hoa Binh, Ha Tay, Bac Ninh, Hai Duong, Hai Phong, Hung Yen, Ha Nam, Thai Binh, Nam Dinh, Ninh Binh.	1, 2, 3, 4, 5, 6, 10, 12, 15, 18, 23, 31, 32, 34, 37, 38, 39, 43, , 70, 100, 279, HCM, LHL, PV-CG.
Low or Medium		
High or Very high		

Region 1 includes the following provinces: Bắc Cạn, Bắc Giang, Bắc Ninh, Cao Bằng, Điện Biên, Hà Giang, Hà Nam, Hà Nội, Hải Dương, Hải Phòng, Hoà Bình, Hưng Yên, Lai Châu, Lạng Sơn, Lào Cai, Nam Định, Ninh Bình, Phú Thọ, Quảng Ninh, Sơn La, Thái Bình, Thái Nguyên, Tuyên Quang, Vĩnh Phúc, Yên Bái.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

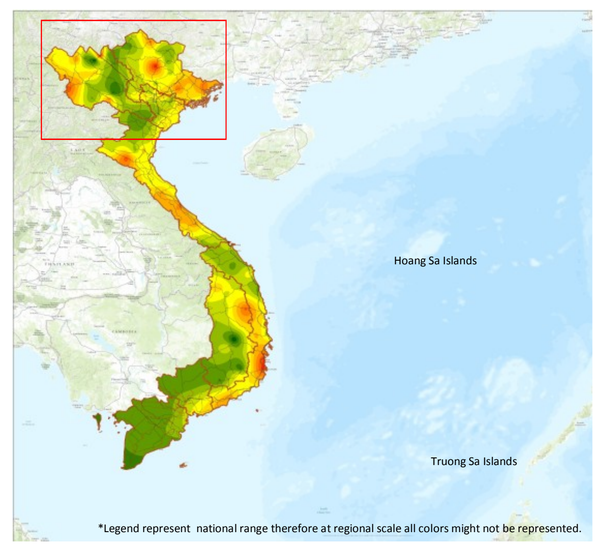
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

MAP SCALE - 1: 1,200,000

INDEX MAP



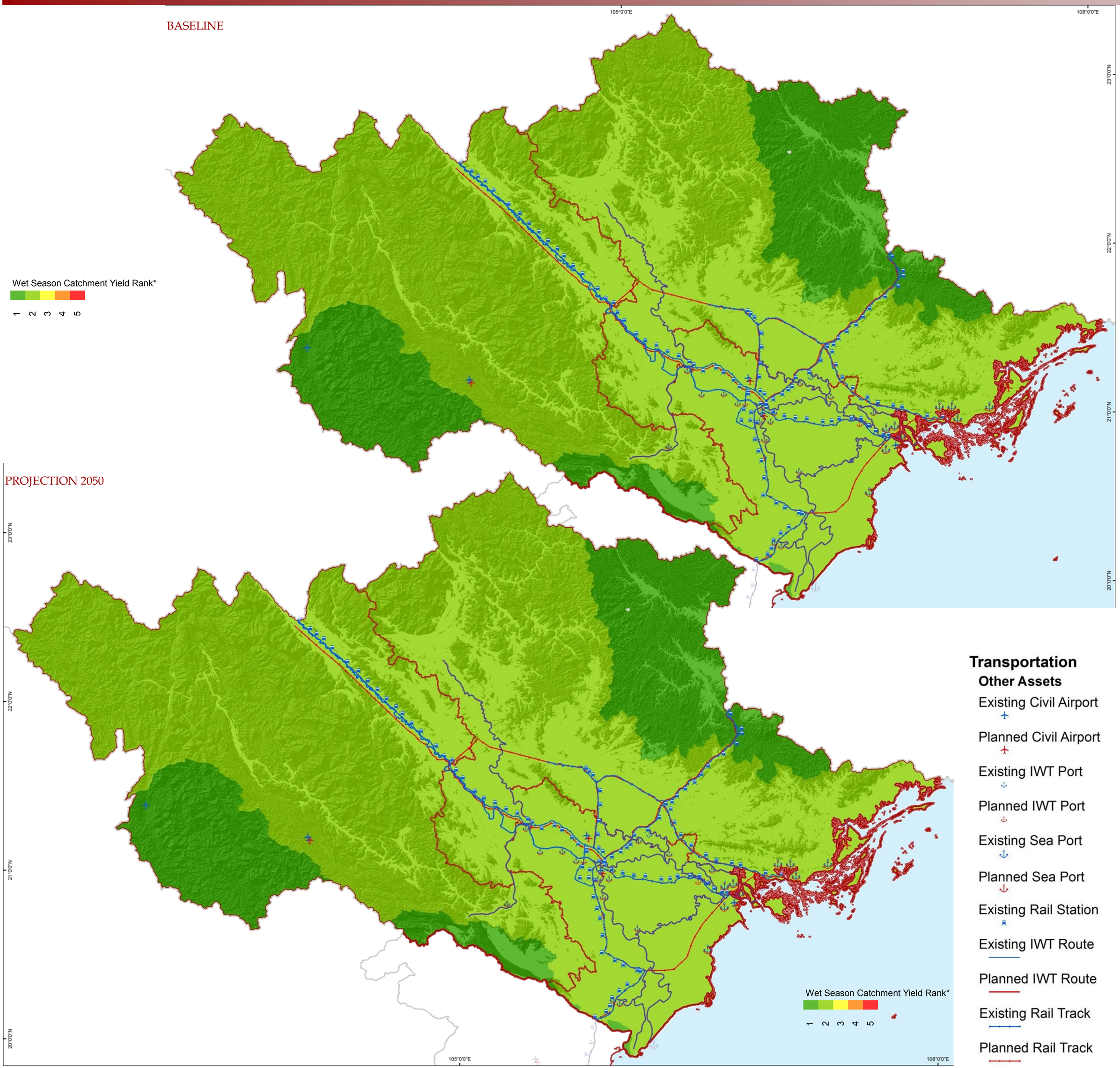
REGION 1 - OTHER TRANSPORT (WET SEASON CATCHMENT YIELD)

BASELINE

Wet Season Catchment Yield Rank*

1 2 3 4 5

PROJECTION 2050



Transportation

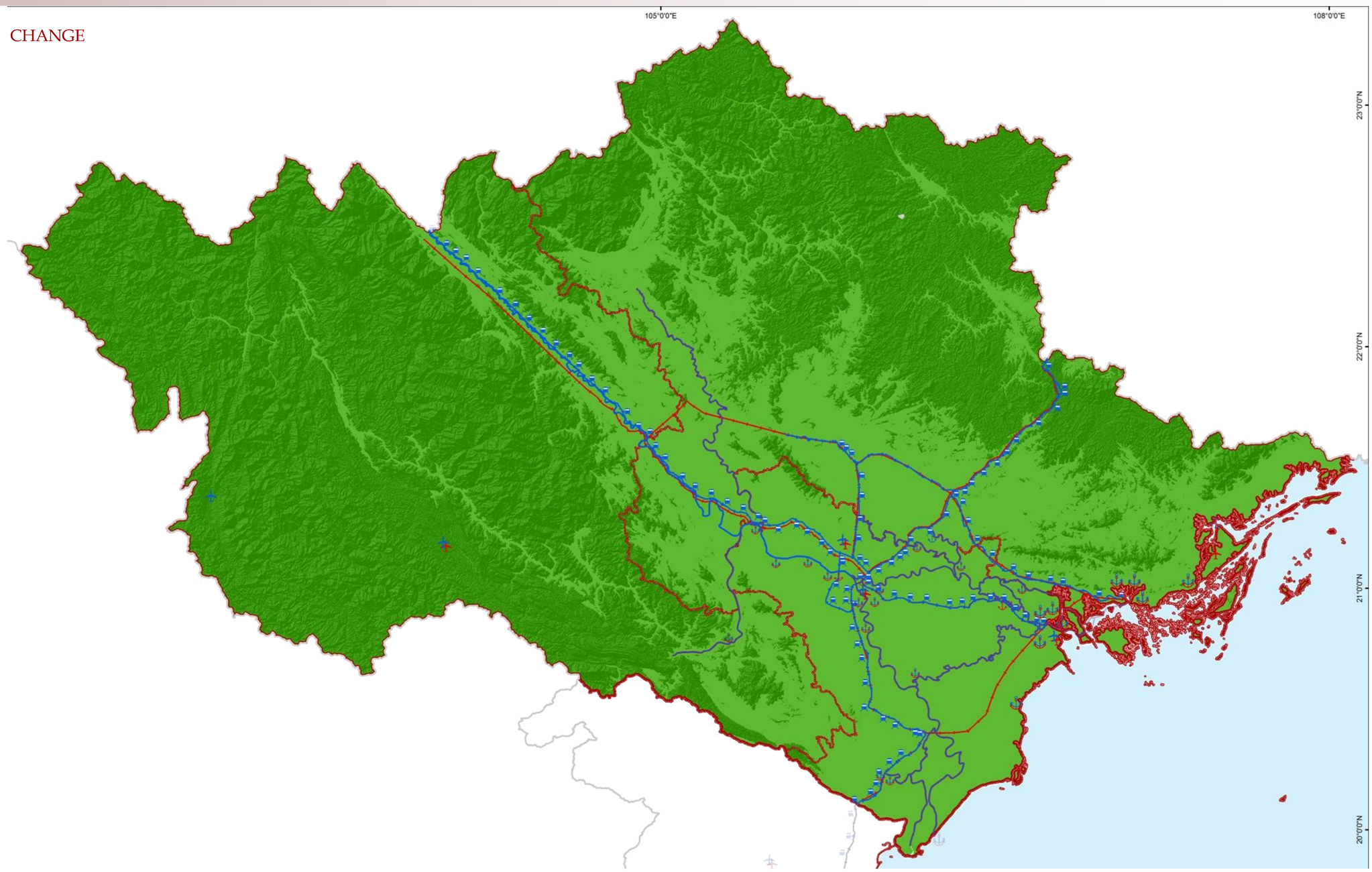
Other Assets

- Existing Civil Airport
- Planned Civil Airport
- Existing IWT Port
- Planned IWT Port
- Existing Sea Port
- Planned Sea Port
- Existing Rail Station
- Existing IWT Route
- Planned IWT Route
- Existing Rail Track
- Planned Rail Track

FUNDING AGENCIES

PARTNERS

COMPANIES



Wet Season Catchment Yield Rank*

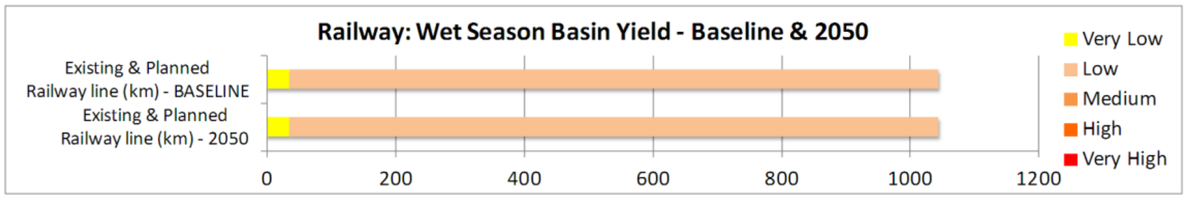
0 1

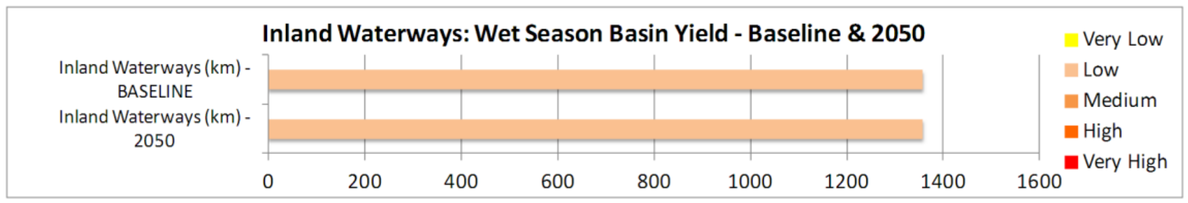
Transportation

Other Assets

- Existing Civil Airport
- Planned Civil Airport
- Existing IWT Port
- Planned IWT Port
- Existing Sea Port
- Planned Sea Port
- Existing Rail Station
- Existing IWT Route
- Planned IWT Route
- Existing Rail Track
- Planned Rail Track

BASELINE		
Impact scale	**Possible Affected Region**	**Possible Affected Assets**
No impact or Very low	Ha Giang, Lai Chau, Lao Cai, Cao Bang, Lang Son, Bac Can, Tuyen Quang, Yen Bai, Son La, Phu Tho, Thai Nguyen, Quang Ninh, Bac Giang, Vinh Phuc, Ha Noi, Son La, Hoa Binh, Ha Tay, Bac Ninh, Hai Duong, Hai Phong, Hung Yen, Ha Nam, Thai Binh, Nam Dinh, Ninh Binh.	Rail: Dong Anh-Quan Trieu, Ha Noi-Lao Cai, Ha Noi-Dong Dang, Ha Noi-Hai Phong, Kep-Ha Long, Ha Noi-Sai Gon, Hai Phong-Thai Binh-Nam Dinh. IWT: Ha Noi-Lao Cai, Viet Tri-TuyenQuang, Ha Noi-Hai Phong, Quang Ninh-PhaLai, Pha Lai-A lu, Pha Lai-Da Phuc, Lach Giang-Ha Noi, Quang Ninh-Ninh Binh, Cua Day-Ninh Binh, Hong Da-Hoa Binh.
Low or Medium		
High or Very high		





2050 SCENARIO		
Impact scale	**Possible Affected Region**	**Possible Affected Assets**
No impact or Very low	Ha Giang, Lai Chau, Lao Cai, Cao Bang, Lang Son, Bac Can, Tuyen Quang, Yen Bai, Son La, Phu Tho, Thai Nguyen, Quang Ninh, Bac Giang, Vinh Phuc, Ha Noi, Son La, Hoa Binh, Ha Tay, Bac Ninh, Hai Duong, Hai Phong, Hung Yen, Ha Nam, Thai Binh, Nam Dinh, Ninh Binh.	Rail: Dong Anh-Quan Trieu, Ha Noi-Lao Cai, Ha Noi-Dong Dang, Ha Noi-Hai Phong, Kep-Ha Long, Ha Noi-Sai Gon, Hai Phong-Thai Binh-Nam Dinh. IWT: Ha Noi-Lao Cai, Viet Tri-TuyenQuang, Ha Noi-Hai Phong, Quang Ninh-PhaLai, Pha Lai-A lu, Pha Lai-Da Phuc, Lach Giang-Ha Noi, Quang Ninh-Ninh Binh, Cua Day-Ninh Binh, Hong Da-Hoa Binh.
Low or Medium		
High or Very high		

Region 1 includes the following provinces: Bắc Cạn, Bắc Giang, Bắc Ninh, Cao Bằng, Điện Biên, Hà Giang, Hà Nam, Hà Nội, Hải Dương, Hải Phòng, Hoà Bình, Hưng Yên, Lai Châu, Lạng Sơn, Lào Cai, Nam Định, Ninh Bình, Phú Thọ, Quảng Ninh, Sơn La, Thái Bình, Thái Nguyên, Tuyên Quang, Vĩnh Phúc, Yên Bái.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

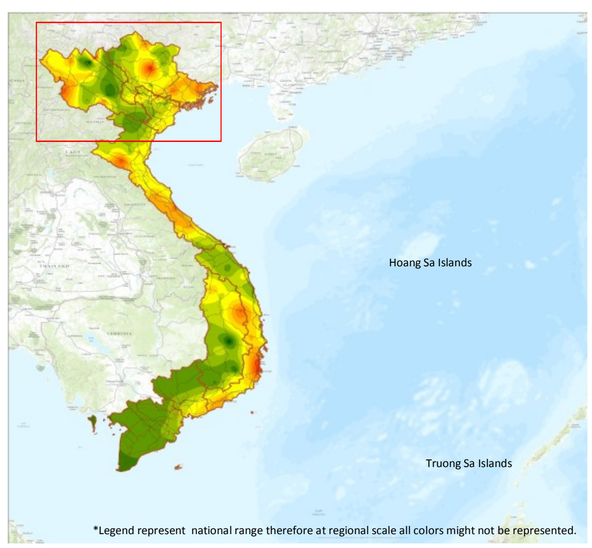
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

MAP SCALE - 1: 1,200,000

INDEX MAP



*Legend represent national range therefore at regional scale all colors might not be represented.

REGION 2 - ROADS AND BRIDGES (WET SEASON CATCHMENT YIELD)

BASELINE

PROJECTION 2050

Wet Season Catchment Yield Rank*

1 2 3 4 5

Wet Season Catchment Yield Rank*

1 2 3 4 5

105°0'0"E
108°0'0"E
20°0'0"N
19°0'0"N
18°0'0"N
17°0'0"N
16°0'0"N

Transportation

Roads and Bridges

Existing Bridge

Existing Bus Terminal

Existing Road

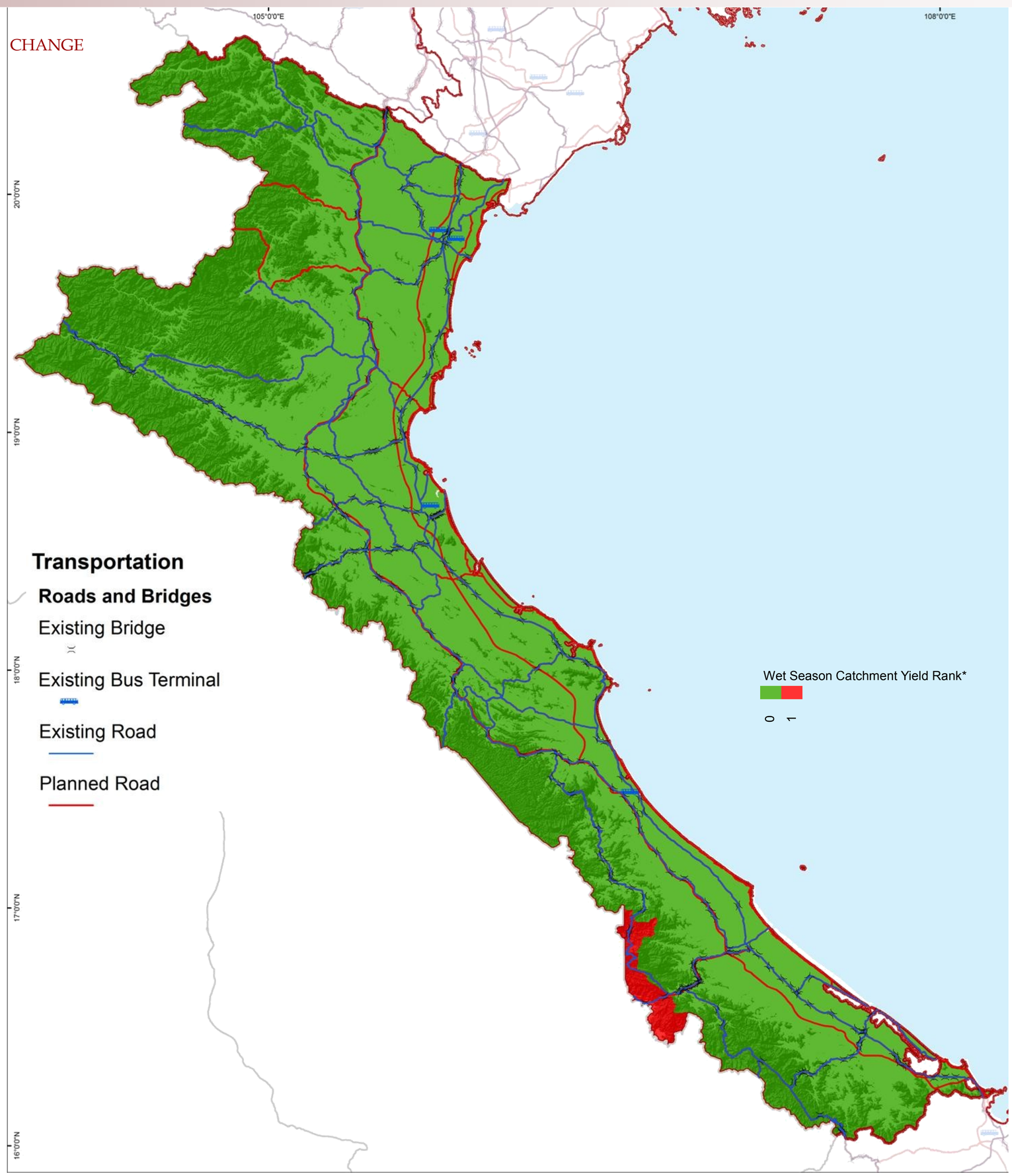
Planned Road

FUNDING AGENCIES

PARTNERS

COMPANIES

CHANGE

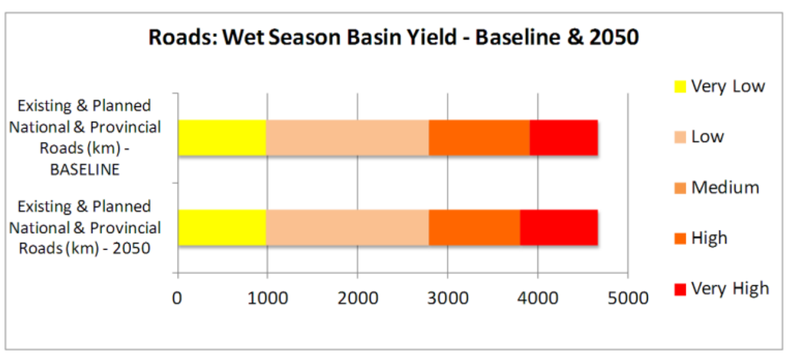


BASELINE

Impact scale	Possible Affected Region	Possible Affected Road
No impact or Very low	Thanh Hoa, Nghe An, Ha Tinh	217, 15, HCM, 1, 10, 45, 47, 48, 7, 8, 46.
Low or Medium		
High or Very high	Ha Tinh, Quang Binh, Quang Tri, Thua Thien Hue.	15, 12, HCM, 1, 9, 49.

2050 SCENARIO

Impact scale	Possible Affected Region	Possible Affected Road
No impact or Very low	Thanh Hoa, Nghe An, Ha Tinh	217, 15, HCM, 1, 10, 45, 47, 48, 7, 8, 46.
Low or Medium		
High or Very high	Ha Tinh, Quang Binh, Quang Tri, Thua Thien Hue.	15, 12, HCM, 1, 9, 49.



Region 2 includes the following provinces: Hà Tĩnh, Nghệ An, Quảng Bình, Quảng Trị, Thanh Hoá, Thừa Thiên Huế.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

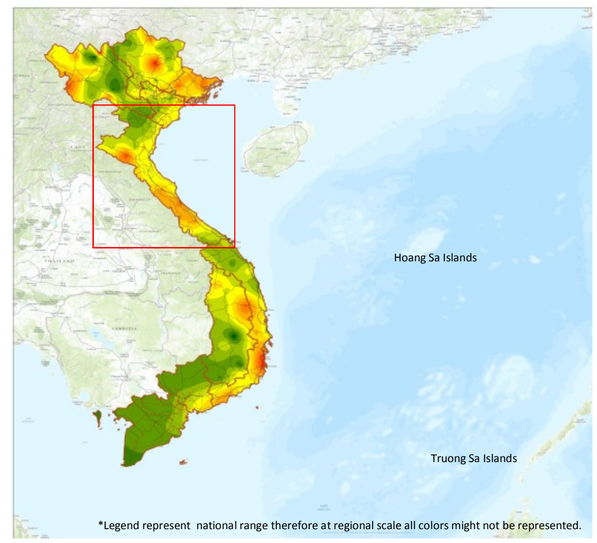
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

MAP SCALE - 1: 1,200,000

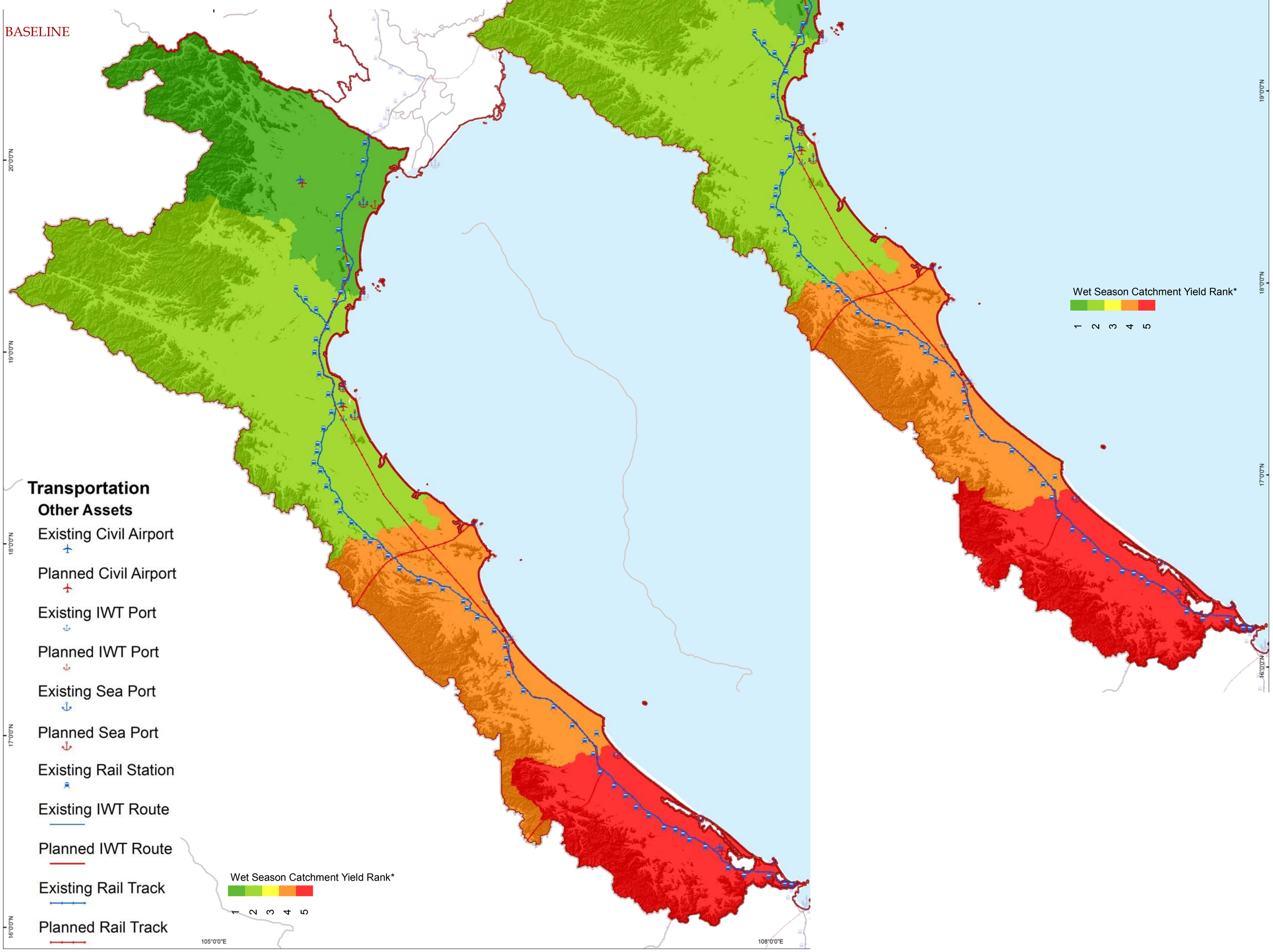
INDEX MAP



REGION 2 - OTHER TRANSPORT (WET SEASON CATCHMENT YIELD)

BASELINE

PROJECTION 2050

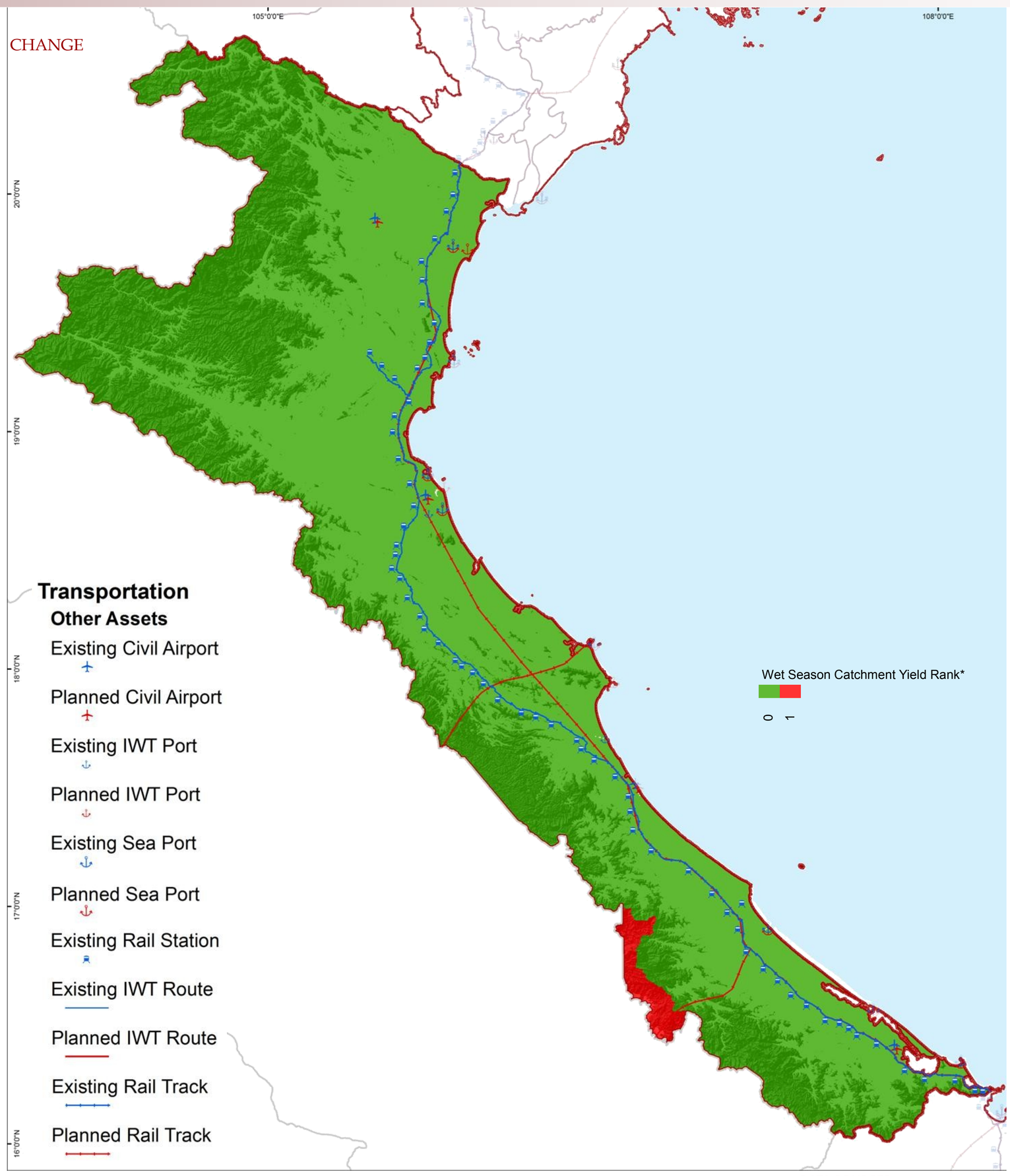


FUNDING AGENCIES

PARTNERS

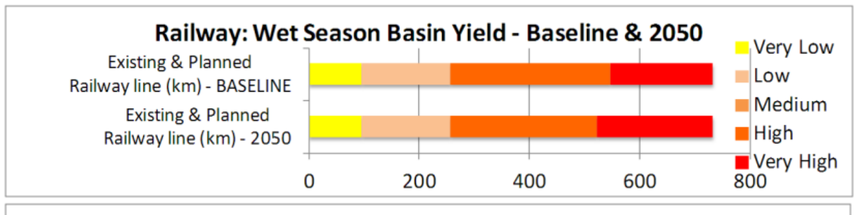
COMPANIES

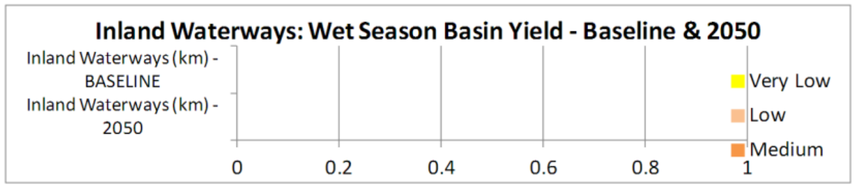
CHANGE



BASELINE		
Impact scale	**Possible Affected Region**	**Possible Affected Assets**
No impact or Very low	Thanh Hoa, Nghe An, Ha Tinh	Rail: Ha Noi-Sai Gon
Low or Medium		
High or Very high	Ha Tinh, Quang Binh, Quang Tri, Thua Thien Hue.	Rail: Ha Noi-Sai Gon, Vung Ang-Mu Gia, Dong Ha-Lao Bao.

2050 SCENARIO		
Impact scale	**Possible Affected Region**	**Possible Affected Assets**
No impact or Very low	Thanh Hoa, Nghe An, Ha Tinh	Rail: Ha Noi-Sai Gon
Low or Medium		
High or Very high	Ha Tinh, Quang Binh, Quang Tri, Thua Thien Hue.	Rail: Ha Noi-Sai Gon, Vung Ang-Mu Gia, Dong Ha-Lao Bao.





Region 2 includes the following provinces: Hà Tĩnh, Nghệ An, Quảng Bình, Quảng Trị, Thanh Hoá, Thừa Thiên Huế.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

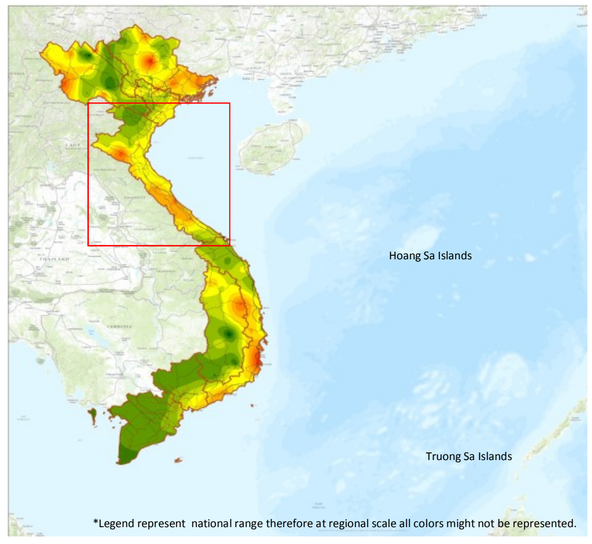
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

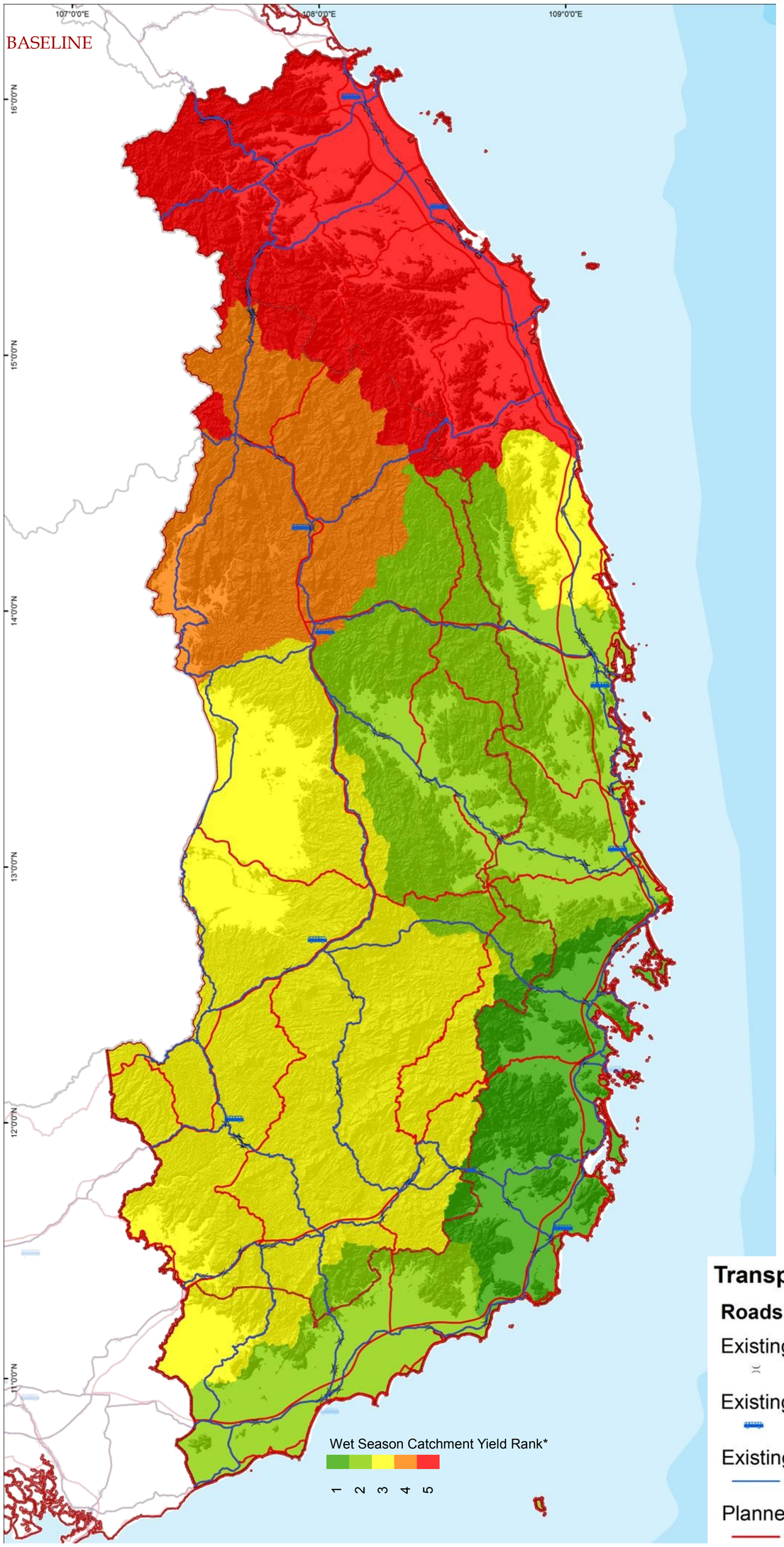
MAP SCALE - 1: 1,200,000

INDEX MAP

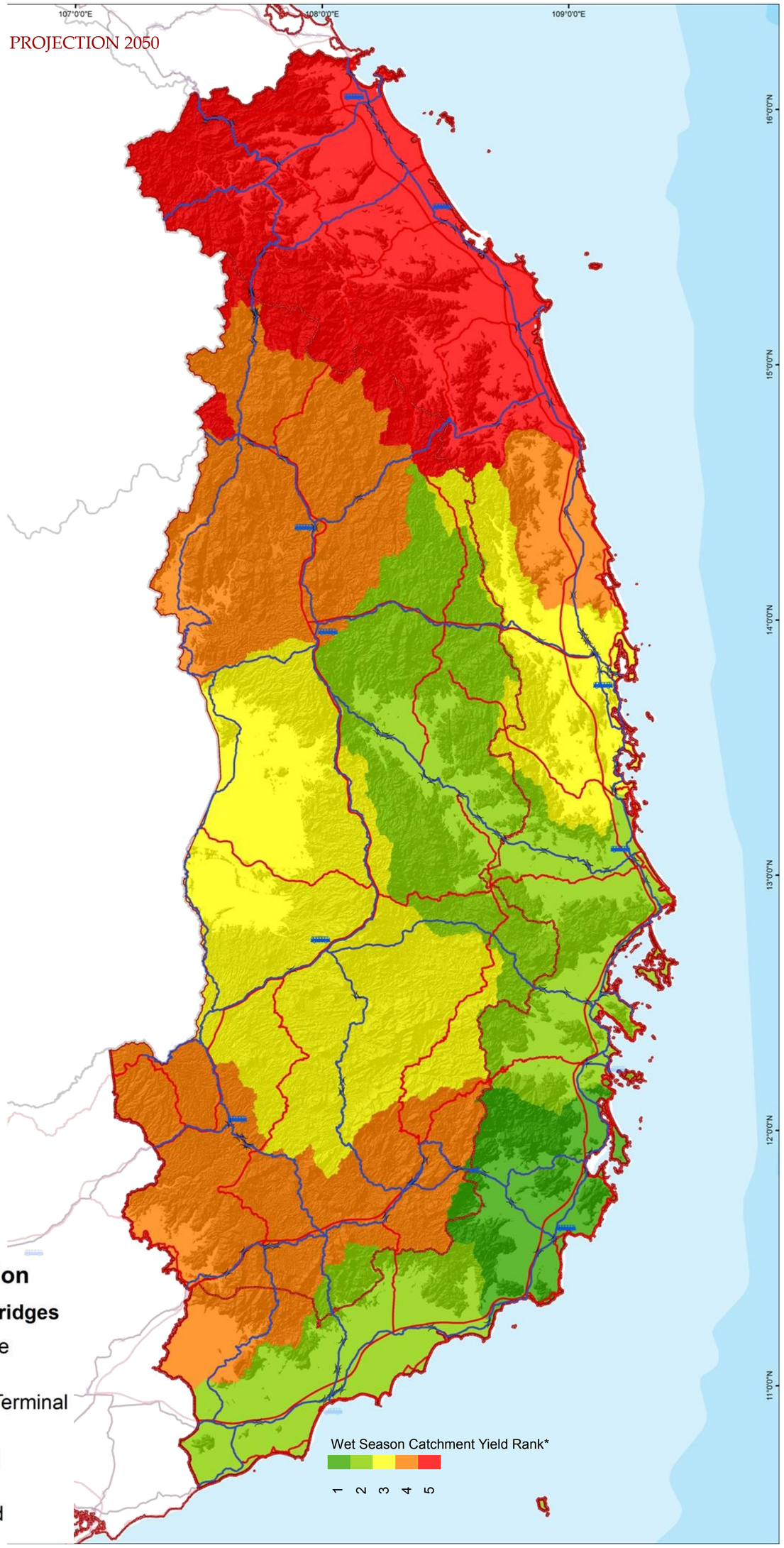


REGION 3 - ROADS AND BRIDGES (WET SEASON CATCHMENT YIELD)

BASELINE



PROJECTION 2050



Transportation

Roads and Bridges

Existing Bridge

Existing Bus Terminal

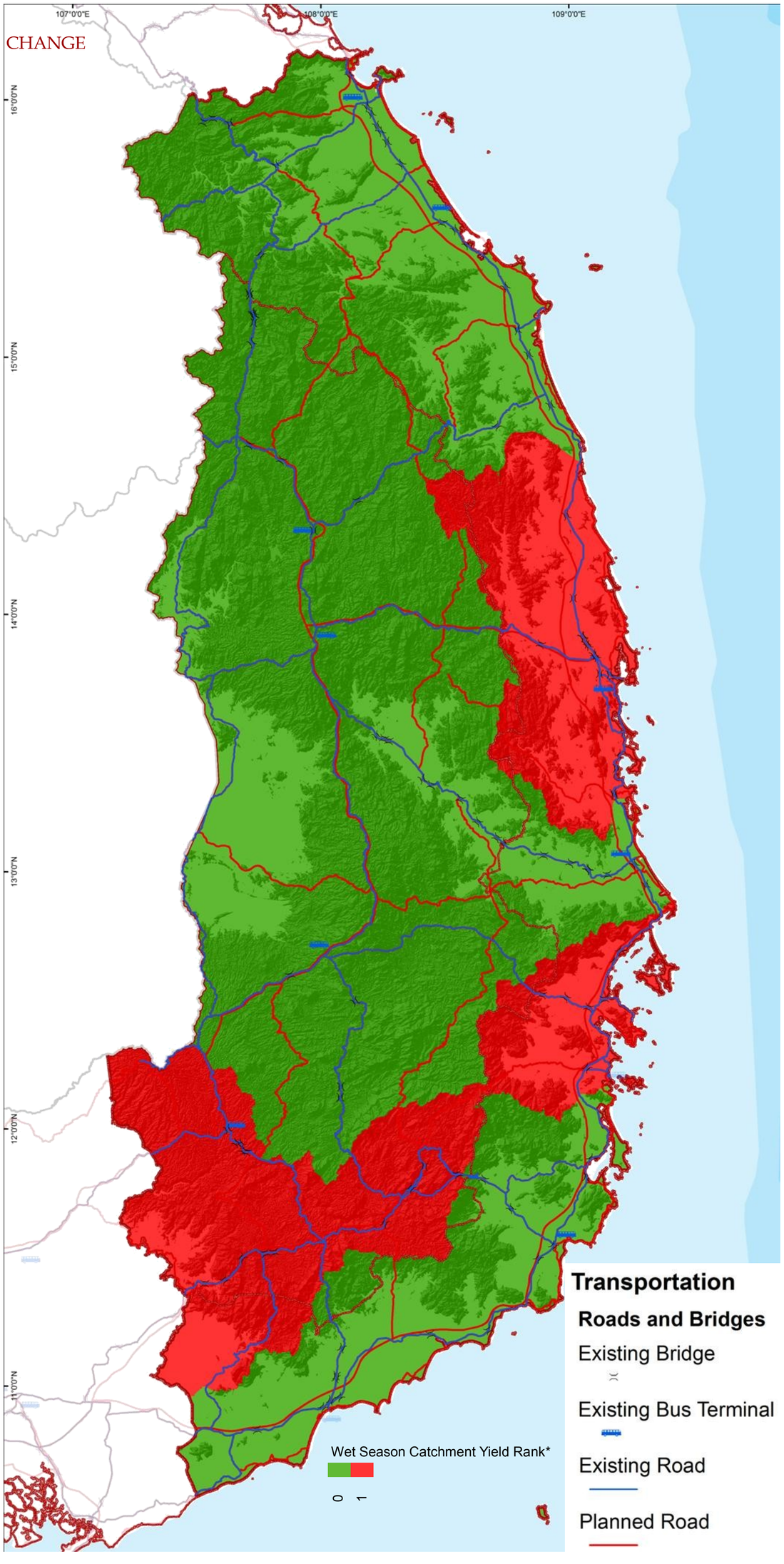
Existing Road

Planned Road

FUNDING AGENCIES

PARTNERS

COMPANIES

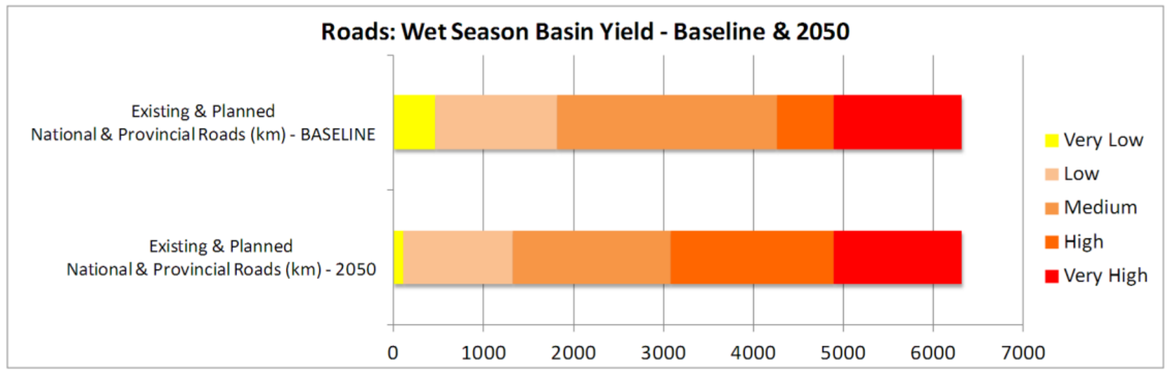


BASELINE

Impact scale	Possible Affected Region	Possible Affected Road
No impact or Very low	Gia Lai, Binh Dinh, Phu Yen, Dak Lak, Khanh Hoa, Ninh Thuan, Binh Thuan, Lam Dong.	1, 19, 25, 26, 27, 28, 55.
Low or Medium	Binh Dinh, Gia Lai, Dak Lak, Khanh Hoa, Lam Dong, Binh Thuan.	1, 14, HCM, 26, 27, 28, 20, 55.
High or Very high	Da Nang, Quang Nam, Kom Tum, Quang Ngai, Binh Dinh, Gia Lai.	14, HCM, 1, 24, 19.

2050 SCENARIO

Impact scale	Possible Affected Region	Possible Affected Road
No impact or Very low	Gia Lai, Phu Yen, Dak Lak, Khanh Hoa, Ninh Thuan, Binh Thuan, Lam Dong.	1, 19, 25, 26, 27, 28, 55.
Low or Medium	Binh Dinh, Phu Yen, Gia Lai, Dak Lak, Khanh Hoa, Lam Dong.	1, 19, 14, HCM, 26, 27.
High or Very high	Da Nang, Quang Nam, Kom Tum, Quang Ngai, Binh Dinh, Gia Lai, Lam Dong, Dak Lak, Binh Thuan.	14, HCM, 1, 24, 19, 28, 20, 55.



Region 3 includes the following provinces: Bình Định, Bình Thuận, Đà Nẵng, Đăk Lăk, Đăk Nông, Gia Lai, Khánh Hoà, Kon Tum, Lâm Đồng, Ninh Thuận, Phú Yên, Quảng Nam, Quảng Ngãi.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

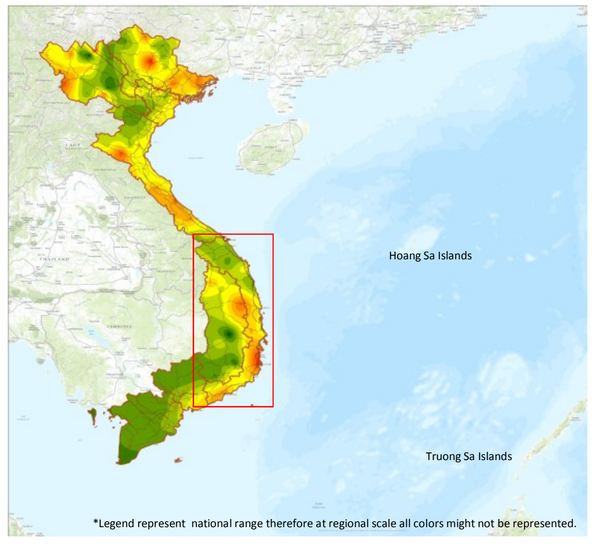
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

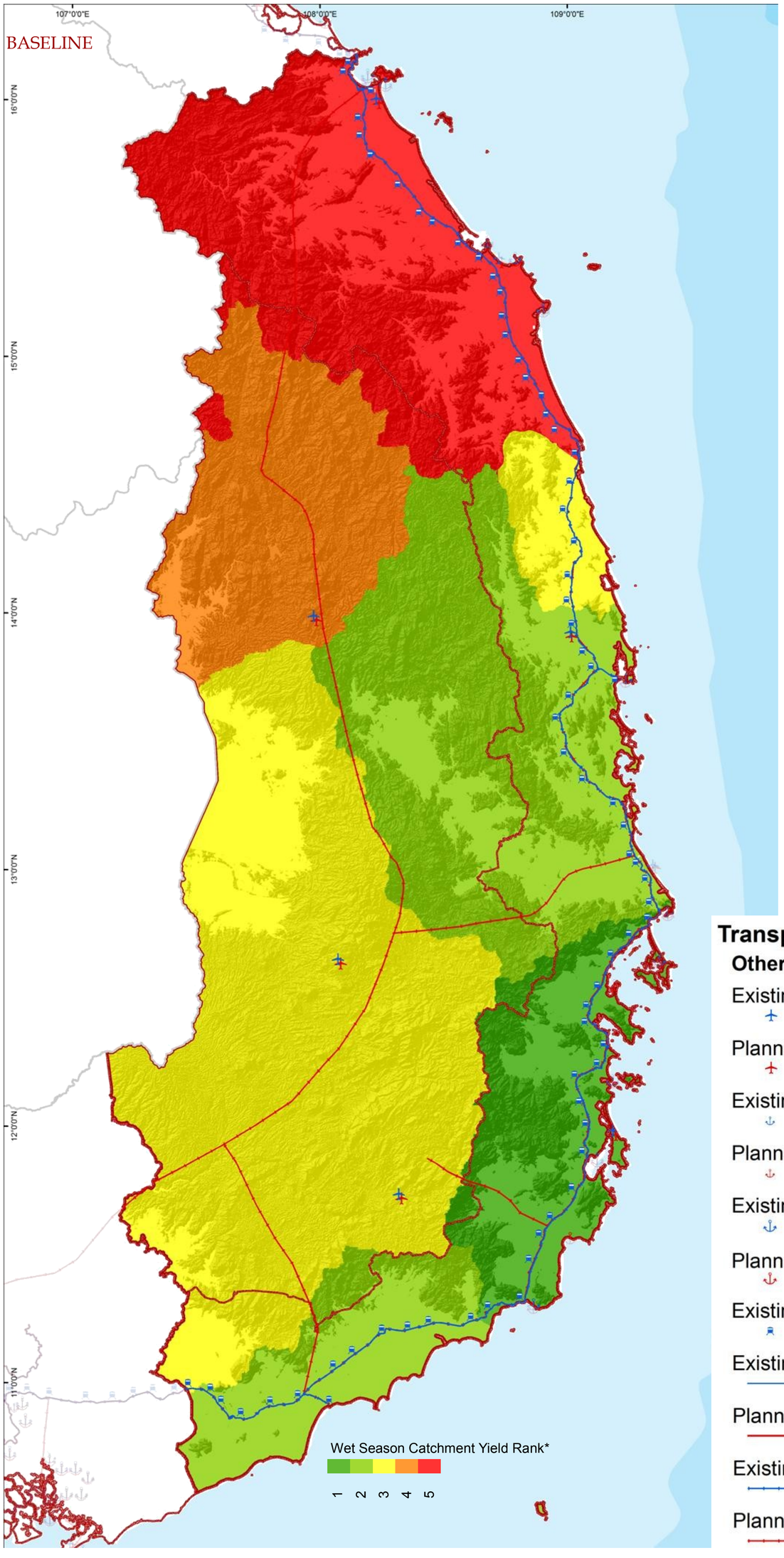
MAP SCALE - 1: 1,200,000

INDEX MAP

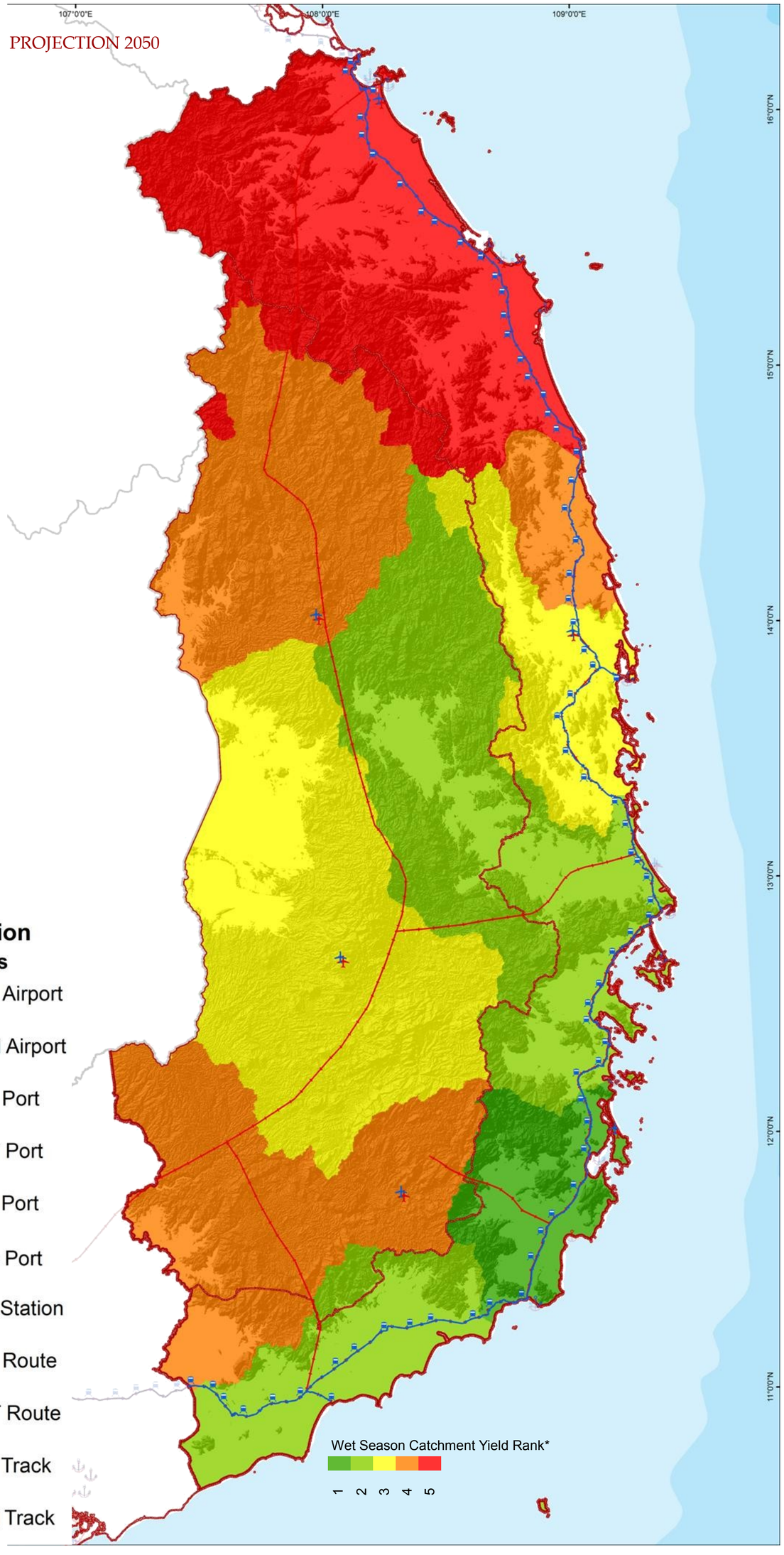


REGION 3 - OTHER TRANSPORT (WET SEASON CATCHMENT YIELD)

BASELINE



PROJECTION 2050



Transportation

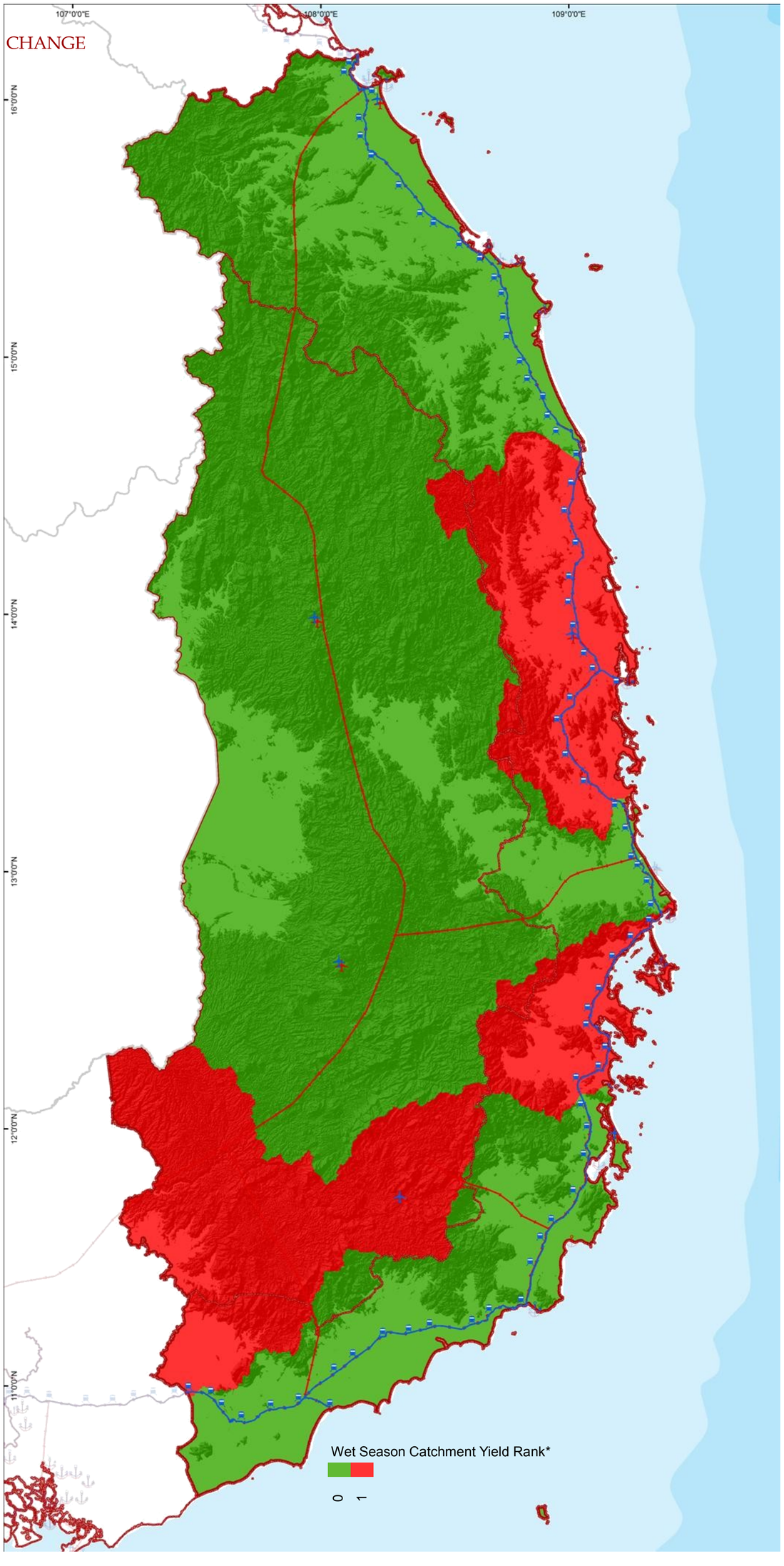
Other Assets

- Existing Civil Airport
- Planned Civil Airport
- Existing IWT Port
- Planned IWT Port
- Existing Sea Port
- Planned Sea Port
- Existing Rail Station
- Existing IWT Route
- Planned IWT Route
- Existing Rail Track
- Planned Rail Track

FUNDING AGENCIES

PARTNERS

COMPANIES

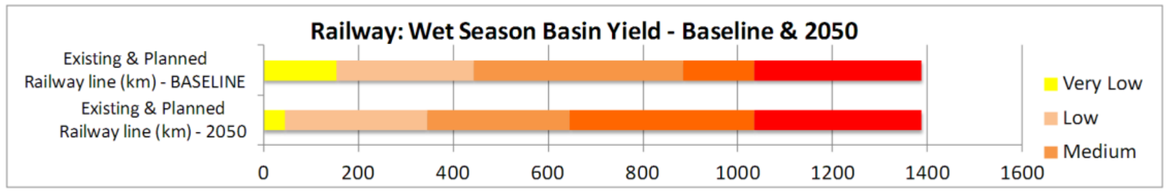


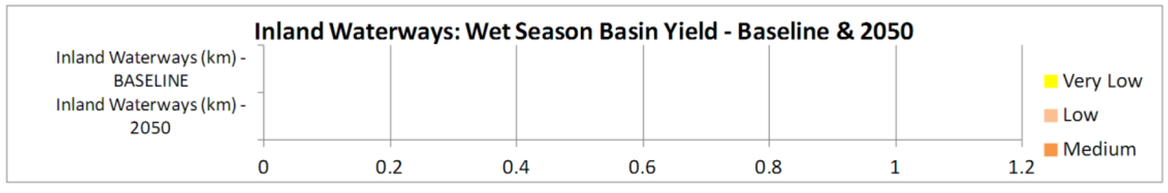
BASELINE

Impact scale	Possible Affected Region	Possible Affected Assets
No impact or Very low	Gia Lai, Binh Dinh, Phu Yen, Dak Lak, Khanh Hoa, Ninh Thuan, Binh Thuan, Lam Dong.	Rail: Ha Noi-Sai Gon, Da Nang-Dak Nong-Chon Thanh. Tuy Hoa-Buan Ma Thuat, Dak Nong-Binh Thuan, Thap Cham-Da Lat.
Low or Medium	Binh Dinh, Phu Yen, Gia Lai, Dak Lak, Khanh Hoa, Lam Dong, Binh Thuan.	Rail: Ha Noi-Sai Gon, Da Nang-Dak Nong-Chon Thanh. Tuy Hoa-Buan Ma Thuat, Dak Nong-Binh Thuan, Thap Cham-Da Lat.
High or Very high	Da Nang, Quang Nam, Kom Tum, Quang Ngai, Binh Dinh, Gia Lai.	Rail: Ha Noi-Sai Gon, Da Nang-Dak Nong-Chon Thanh.

2050 SCENARIO

Impact scale	Possible Affected Region	Possible Affected Assets
No impact or Very low	Gia Lai, Phu Yen, Dak Lak, Khanh Hoa, Ninh Thuan, Binh Thuan, Lam Dong.	Rail: Ha Noi-Sai Gon, Da Nang-Dak Nong-Chon Thanh. Tuy Hoa-Buan Ma Thuat, Dak Nong-Binh Thuan, Thap Cham-Da Lat.
Low or Medium	Binh Dinh, Phu Yen, Gia Lai, Dak Lak, Khanh Hoa, Lam Dong.	Rail: Ha Noi-Sai Gon, Da Nang-Dak Nong-Chon Thanh. Tuy Hoa-Buan Ma Thuat.
High or Very high	Da Nang, Quang Nam, Kom Tum, Quang Ngai, Binh Dinh, Gia Lai, Lam Dong, Dak Lak, Binh Thuan.	Rail: Ha Noi-Sai Gon, Da Nang-Dak Nong-Chon Thanh, Dak Nong-Binh Thuan, Thap Cham-Da Lat.





Region 3 includes the following provinces: Bình Định, Bình Thuận, Đà Nẵng, Đăk Lăk, Đăk Nông, Gia Lai, Khánh Hoà, Kon Tum, Lâm Đồng, Ninh Thuận, Phú Yên, Quảng Nam, Quảng Ngãi.

DATA SOURCES

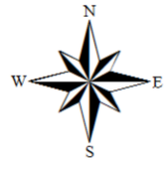
IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

IE - ENERGY INFRASTRUCTURE

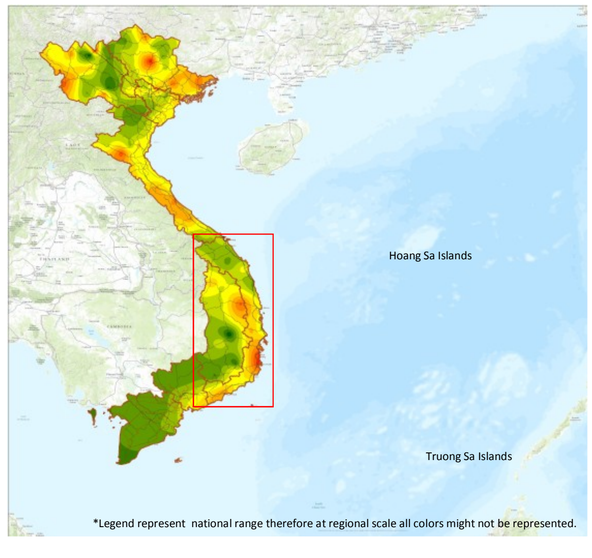
GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM



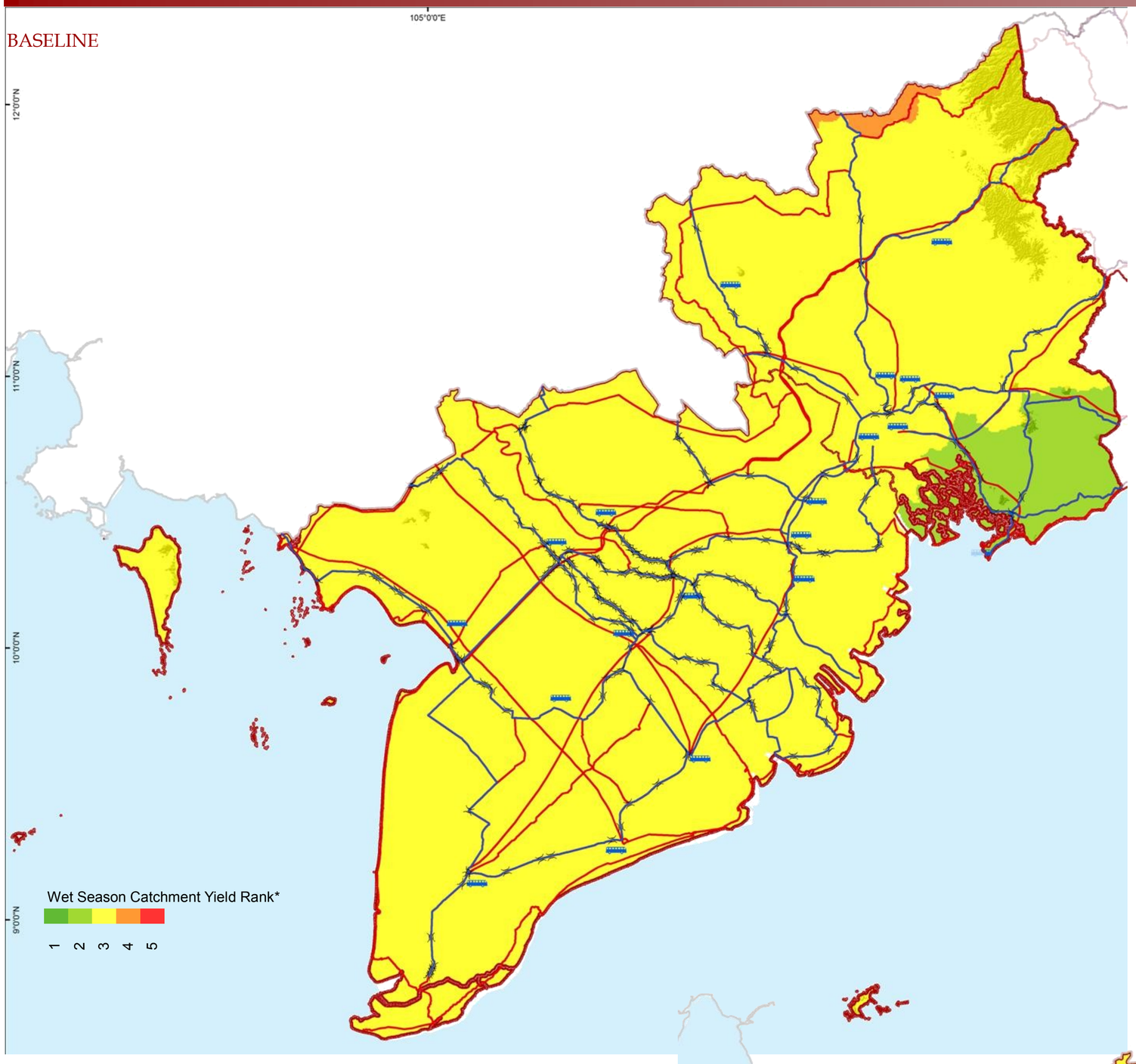
MAP SCALE - 1: 1,200,000

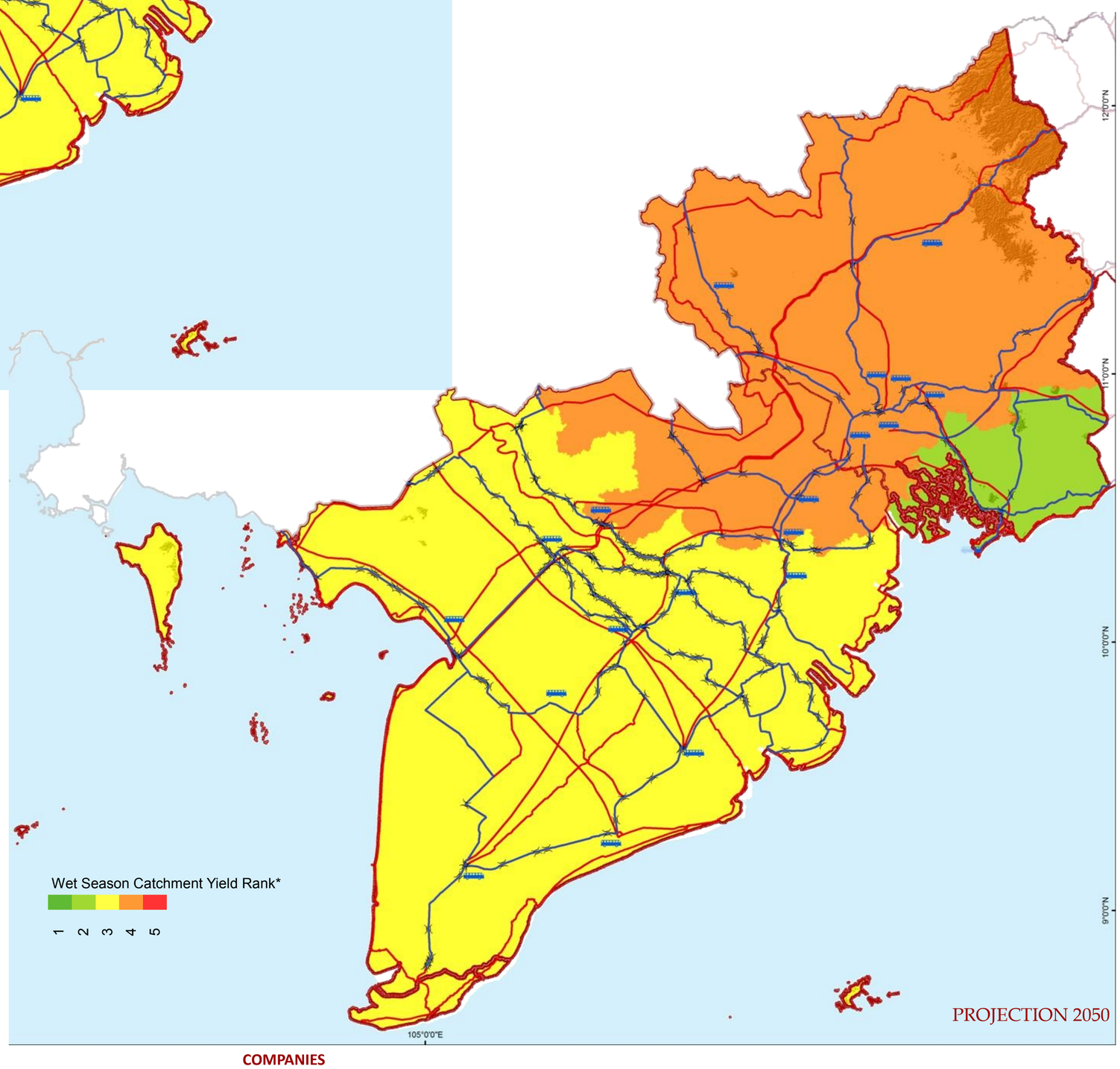
INDEX MAP



REGION 4 - ROADS AND BRIDGES (WET SEASON CATCHMENT YIELD)

BASELINE





Transportation

Roads and Bridges

Existing Bridge

Existing Bus Terminal

Existing Road

Planned Road

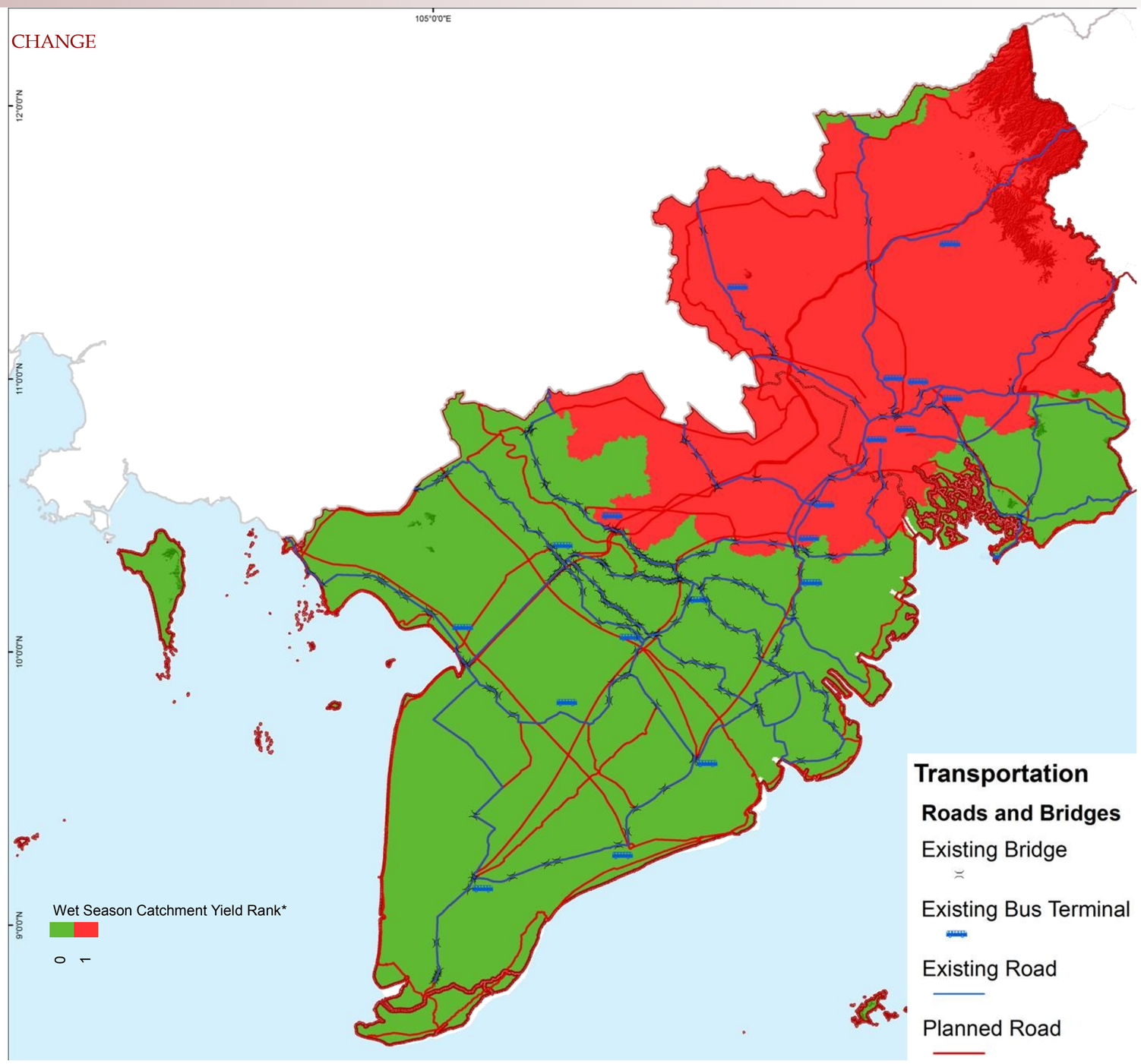
PROJECTION 2050

FUNDING AGENCIES

PARTNERS

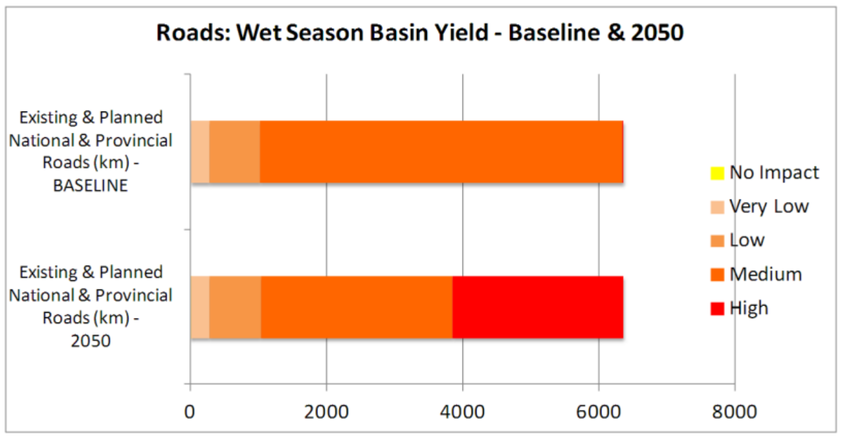
COMPANIES

CHANGE



BASELINE		
Impact scale	**Possible Affected Region**	**Possible Affected Road**
No impact or Very low	Dong Nai, Ba Ria Vung Tau, Long An	1, 55, 51, 56
Low or Medium	Binh Phuoc, Dong Nai, Binh Duong, Tay Ninh, Ho Chi Minh, Long An, Tien Giang. Ben Tre, Dong Thap, Tra Vinh, Vinh Long, An Giang, Can Tho, Soc Trang, Kien Giang, Bac Lieu, Ca Mau.	13, 14, 20, 1, 51, 50, 62, 60, 57, 30, 80, 53, 54, 91, 63.
High or Very high		

2050 SCENARIO		
Impact scale	**Possible Affected Region**	**Possible Affected Road**
No impact or Very low	Dong Nai, Ba Ria Vung Tau, Long An	1, 55, 51, 56.
Low or Medium	Dong Thap, An Giang, Ben Tre, Vinh Long, Can Tho, Kien Giang, Bac Lieu, Soc Trang, Ca Mau.	50, 60, 1, 57, 53, 54, 80, 30, 91, 61, 63.
High or Very high	Binh Phuoc, Dong Nai, Tay Ninh, Ho Chi Minh, Dong Thap.	14, 20, 13, 22, 1, 51, 50, 62.



Region 4 includes the following provinces: An Giang, Bà Rịa Vũng Tàu, Bạc Liêu, Bến Tre, Bình Dương, Bình Phước, Cà Mau, Đồng Nai, Đồng Tháp, Hậu Giang, Kiên Giang, Long An, Sóc Trăng, Tây Ninh, Tiền Giang, TP Cần Thơ, TP Hồ Chí Minh, Trà Vinh, Vinh Long.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

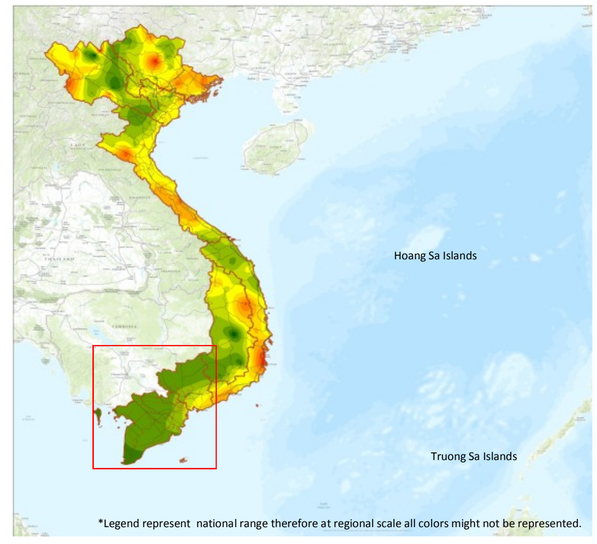
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

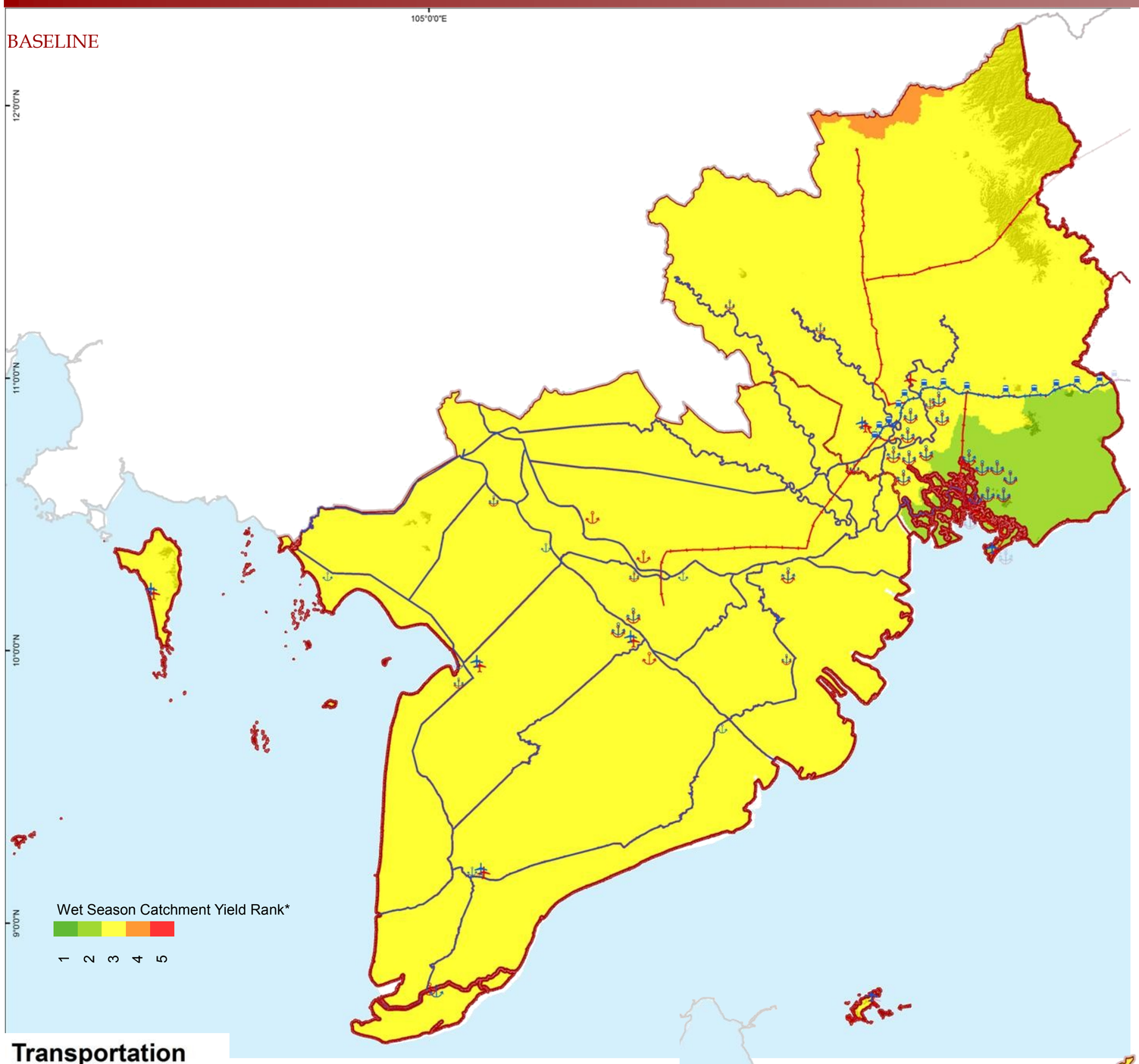
MAP SCALE - 1: 1,200,000

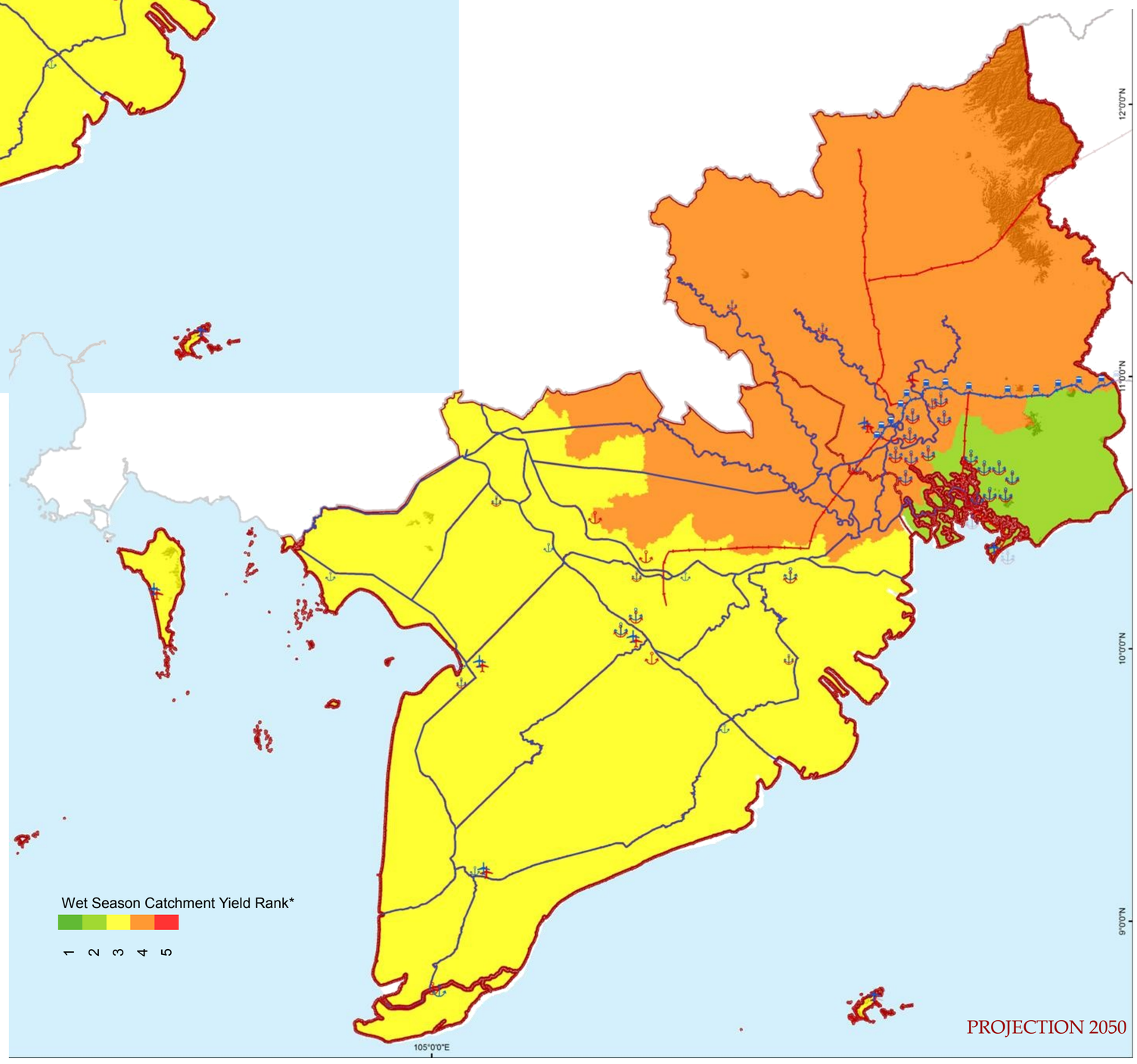
INDEX MAP



REGION 4 - OTHER TRANSPORT (WET SEASON CATCHMENT YIELD)

BASELINE





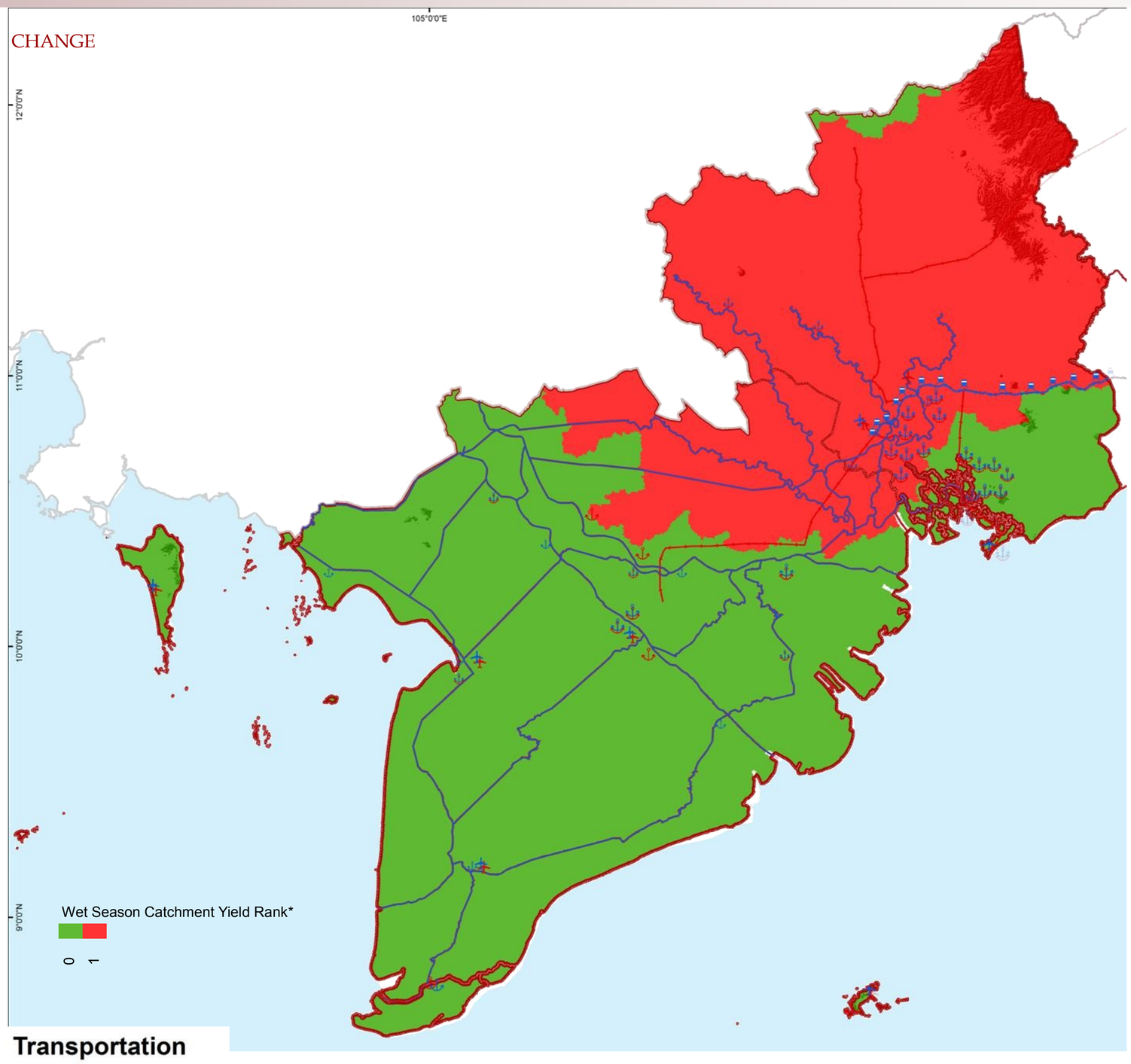
Transportation

Other Assets

- Existing Civil Airport
- Planned Civil Airport
- Existing IWT Port
- Planned IWT Port
- Existing Sea Port
- Planned Sea Port
- Existing Rail Station
- Existing IWT Route
- Planned IWT Route
- Existing Rail Track
- Planned Rail Track

PROJECTION 2050

CHANGE



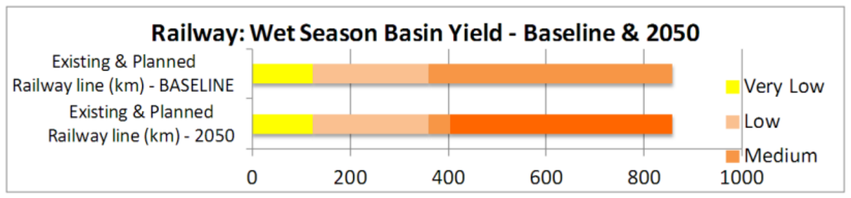
BASELINE		
Impact scale	**Possible Affected Region**	**Possible Affected Assets**
No impact or Very low	Dong Nai, Ba Ria Vung Tau, Long An	Rail: Ha Noi-Sai Gon, Tram Bom-Vung Tau IWT: Mekong-Thi Vai.
Low or Medium	Binh Phuoc, Dong Nai, Binh Duong, Tay Ninh, Ho Chi Minh, Long An, Tien Giang. Ben Tre, Dong Thap, Tra Vinh, Vinh Long, An Giang, Can Tho, Soc Trang, Kien Giang, Bac Lieu, Ca Mau.	Rail: Ha Noi-Sai Gon, Da Nang-Dak Nong-Chon Thanh, Ho Chi Minh-Loc Ninh, Tram Bom-Vung Tau, Ho Chi Minh-My Tho-Can Tho. IWT: Sai Gon-Hieu Liem, Sai Gon-Ben Suc, Sai Gon-Ben Keo, Sai Gon-Ca Mau, Sai Gon-Moc Hoa, Mekong-Thi Vai, Cua Tieu-Hong Ngu, Sai Gon-Kien Luong, Moc Hoa-Ha Tien, Dinh An-Tan Chau, Rach Gia-Ca Mau.
High or Very high		

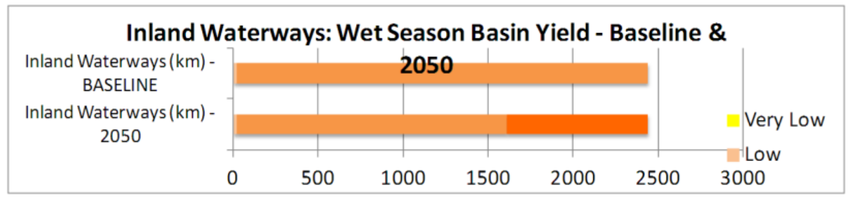
2050 SCENARIO		
Impact scale	**Possible Affected Region**	**Possible Affected Assets**
No impact or Very low	Dong Nai, Ba Ria Vung Tau, Long An	Rail: Ha Noi-Sai Gon, Tram Bom-Vung Tau IWT: Mekong-Thi Vai.
Low or Medium	Dong Thap, An Giang, Ben Tre, Vinh Long, Can Tho, Kien Giang, Bac Lieu, Soc Trang, Ca Mau.	Rail: HCM-My Tho-Can Tho. IWT: Sai Gon-Kien Luong, Moc Hoa-Ha Tien, Cua Tieu-Hong Ngu, Sai Gon-Ca Mau, Dinh An-Tan Chau, Rach Gia-Ca Mau.
High or Very high	Binh Phuoc, Dong Nai, Tay Ninh, Ho Chi Minh, Dong Thap.	Rail: Ha Noi-Sai Gon, Tram Bom-Vung Tau, Da Nang-Dak Nong-Chon Thanh, HCM-Loc Ninh, HCM-My Tho-Can Tho. IWT: Mekong-Thi Vai, Sai Gon-Hieu Liem, Sai Gon-Ben Suc, Sai Gon-Ben Keo, Sai Gon-Kien Luong, Sai Gon-Moc Hoa,

Transportation

Other Assets

- Existing Civil Airport
- Planned Civil Airport
- Existing IWT Port
- Planned IWT Port
- Existing Sea Port
- Planned Sea Port
- Existing Rail Station
- Existing IWT Route
- Planned IWT Route
- Existing Rail Track
- Planned Rail Track





Region 4 includes the following provinces: An Giang, Bà Rịa Vũng Tàu, Bạc Liêu, Bến Tre, Bình Dương, Bình Phước, Cà Mau, Đồng Nai, Đồng Tháp, Hậu Giang, Kiên Giang, Long An, Sóc Trăng, Tây Ninh, Tiền Giang, TP Cần Thơ, TP Hồ Chí Minh, Trà Vinh, Vinh Long.

DATA SOURCES

IMHEN - CLIMATE PROJECTION & BASELINE

TDSI - TRANSPORTATION INFRASTRUCTURE

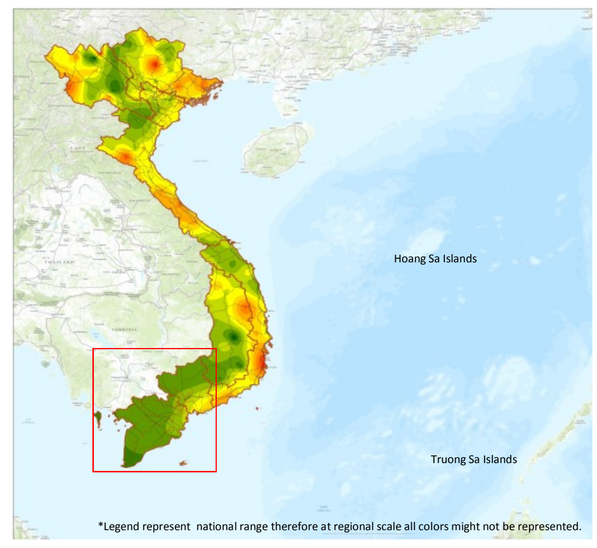
IE - ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

MAP SCALE - 1: 1,200,000

INDEX MAP



PROVINCIAL - DANANG

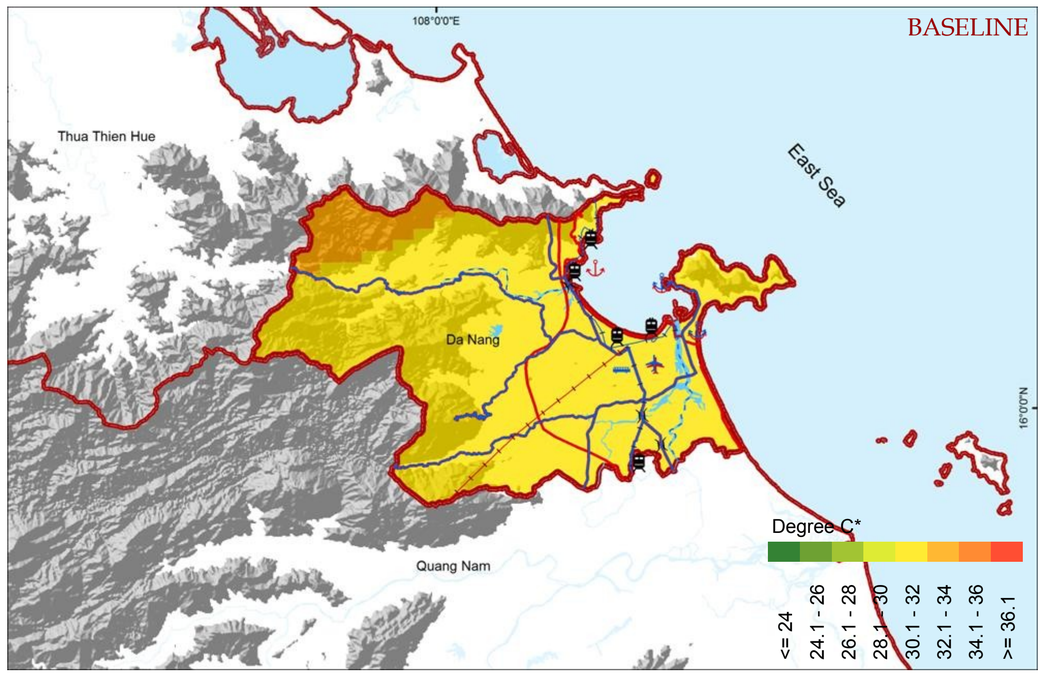
TRANSPORTATION - AVERAGE MAXIMUM TEMPERATURE (JUNE - AUGUST)

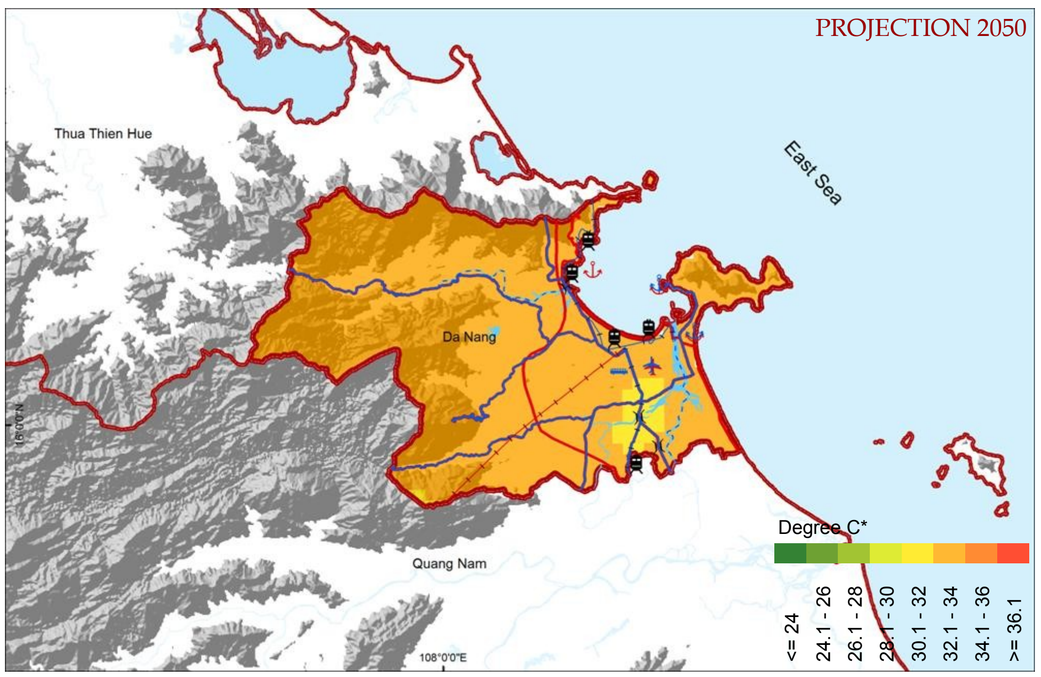
BASELINE

Da Nang's topography is extremely variable, ranging from sea level to 1,600 m within a very short distance. This rapid change in topography is reflected in the average maximum temperatures between June and August, which vary from 21 to 30°C, depending on the elevation. The amount of temperature increase in Da Nang doesn't correlate closely with elevation increases as mountainous regions cover a very limited area in the province and are also on the coast.

Damage to hard surfaces such as bitumen is likely to occur when temperatures exceed 36°C, however, it should be noted that a significant driver of heat stress damage to these surfaces is heavy traffic load.

The area that will experience the highest temperatures (up to 34°C) is in the northwest of Hoa Vang District. A section of Provincial Road 601 runs through this region and is potentially at risk of temperature damage, however, it is only trafficked by 2 wheelers due to its current surface condition and is not a critical link. Temperatures in the floodplain area range from 30 to 32°C. There is little risk to the railway, inland waterway and aviation sectors here, however road deformation has been noticed on National Road 14B and Thuan Phuoc Bridge which have heavy traffic loads that likely exceed regulations.



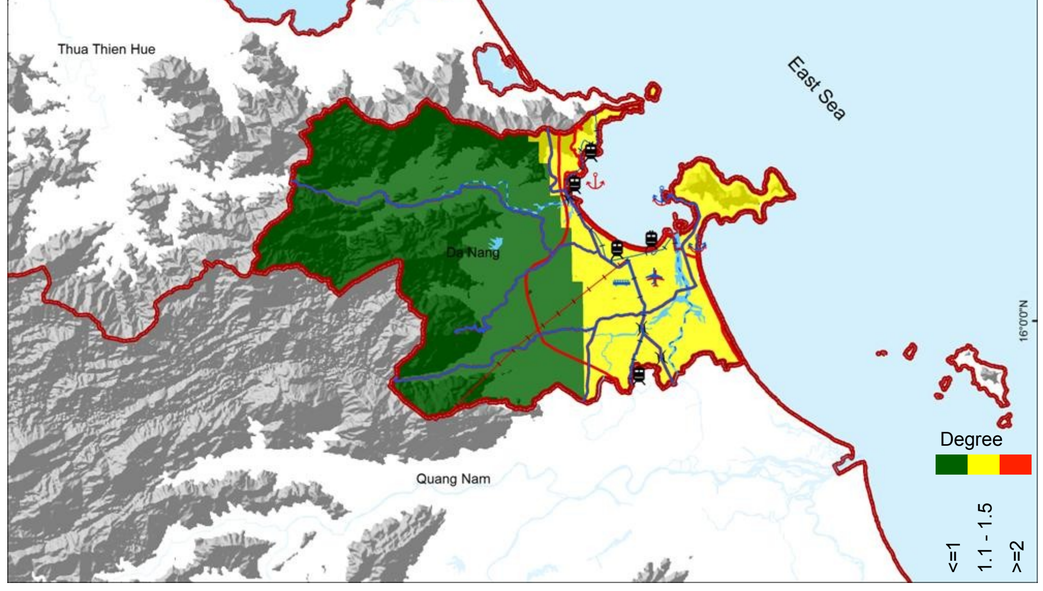


2050 SCENARIO

Temperatures in 2050 are projected to range between 32 and 34°C in all areas, apart from a small portion of the floodplain near Cam Le River. This increase in temperature throughout Da Nang could lead to more widespread road deformation, subsidence, melting and rutting of dark surfaces such as asphalt. Furthermore, given traffic projections for 2050, damages due to temperature could become widespread unless design changes are made.

SUMMARY OF PROJECTED CHANGES

The projected temperature change between the baseline and 2050 scenario varies from 0 to 1.5°C. A significant portion of the urban area is experiencing the greatest change in temperature. This, coupled with the urban heat island (large amount of dark surfaces which absorb heat) affect could result in an increased incidence of temperature damage to roads in the urban area.



Transportation Assets

- Existing Bridge
- Existing Bus Terminal
- Existing Rail Station
- Existing Civil Airport / Planned Civil Airport
- Existing Sea Port / Planned Sea Port
- Existing IWT Route / Planned IWT Route
- Existing Rail Track / Planned Rail Track
- Existing Road / Planned Road

DATA SOURCES

IMHEN—CLIMATE PROJECTION & BASELINE

TDSI—TRANSPORTATION INFRASTRUCTURE

IE—ENERGY INFRASTRUCTURE

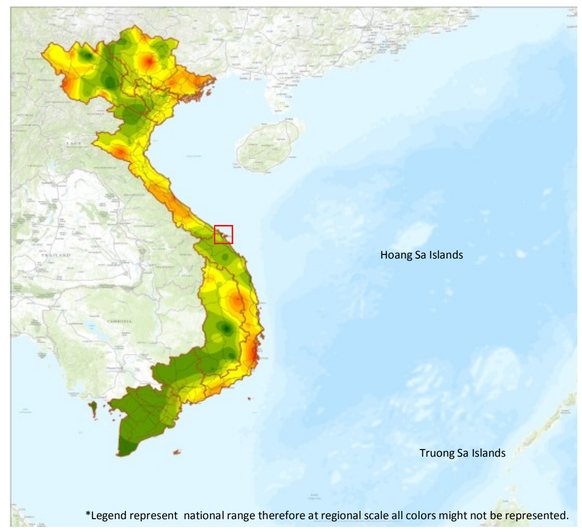
GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

N W E S

MAP SCALE - 1: 400,000

INDEX MAP



*Legend represent national range therefore at regional scale all colors might not be represented.

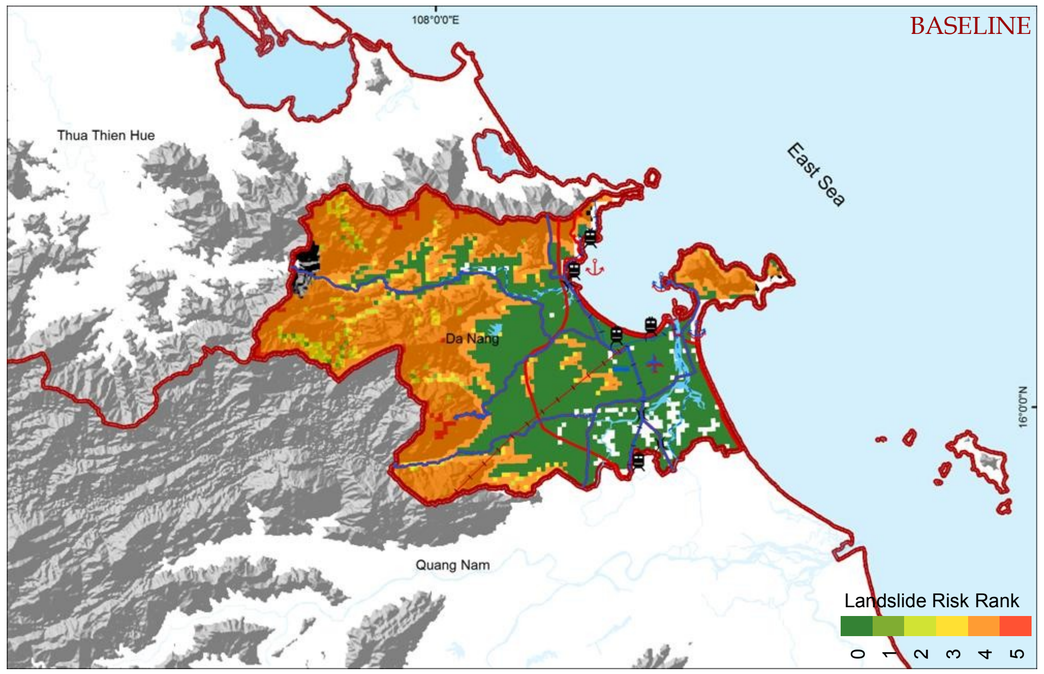
SHEET NUMBER 2

FUNDING AGENCIES ADB NDF

PARTNERS IMHEN TDSI IE

COMPANIES NIRAS icem RCEE NIRAS

TRANSPORTATION - RAINFALL ASSOCIATED LANDSLIDE RISK

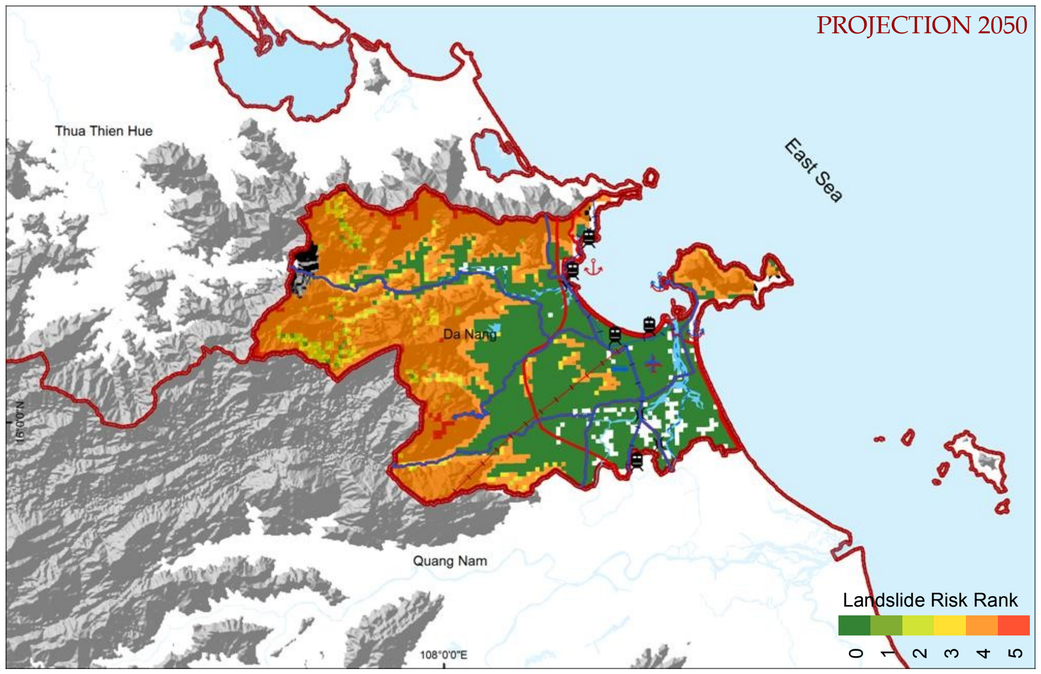


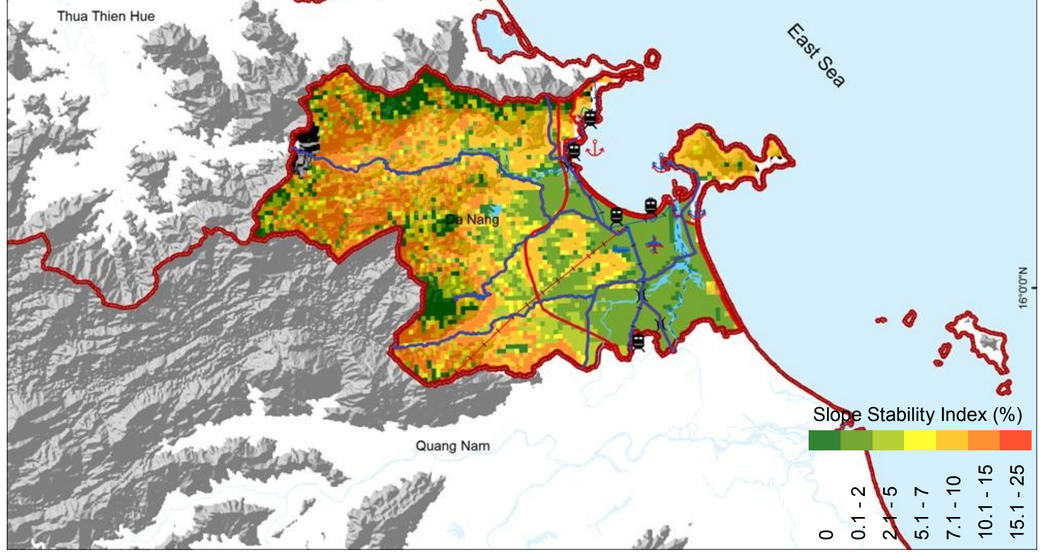
BASELINE

Damages from landslides can be catastrophic to assets, which is why it is the highest priority climate threat. There is significant landslide risk in the western mountainous regions in Hoa Vang district. Approximately 14.8% of existing and planned National and Provincial roads are ranked as high risk, which includes 12 km of Provincial Road 602. This road links traffic from National Road 1 and the urban area of Da Nang with the very popular tourist area of Ba Na Hill, and if impacted, will affect tourist revenue. A 2km segment of National Road 14G, a critical trade and passenger link between Da Nang and Quang Nam provinces, is also at high risk. Major landslides have frequently damaged this road due to unstable soils. No inland waterways are at risk.

2050 SCENARIO

There is no discernible difference in landslide risk in 2050 for the road or railway sectors. As in the Baseline scenario, sections of the planned Expressway (North-South/East, and Coastal) are at high risk of landslides in 2050. In addition, an 8km section of the planned Da Nang – Dak Nong – Chon Thanh railway line is also at high risk in Baseline and 2050. Designs for these planned assets should evaluate this risk further and incorporate climate resilience.

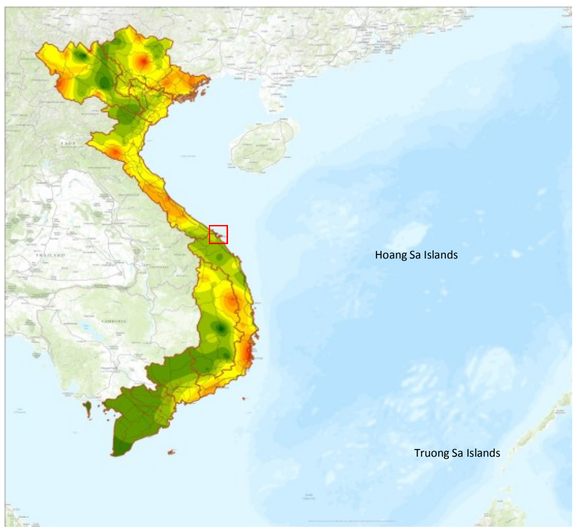




SUMMARY OF PROJECTED CHANGES

Da Nang's soil stability is increasing in 2050 when compared with the Baseline scenario. This is despite a projected increase in rainfall for the majority of the province. The reason for this is higher evaporation that exceeds the rainfall increase. This has resulted in little difference in landslide risk between the two scenarios, although there is currently a large adaptation deficit as landslides are already impacting assets. This result also does not take into account the influence of rapid rates of deforestation that are already occurring and will increase in the future and lead to further instabilities on hill slopes, endangering transportation and other sectoral assets.

INDEX MAP



SHEET NUMBER 3

DATA SOURCES

IMHEN—CLIMATE PROJECTION & BASELINE

TDSI—TRANSPORTATION INFRASTRUCTURE

IE—ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

N W E S

MAP SCALE - 1: 400,000

Transportation Assets

Existing Bridge	
Existing Bus Terminal	
Existing Rail Station	
Existing Civil Airport	Planned Civil Airport
Existing Sea Port	Planned Sea Port
Existing IWT Route	Planned IWT Route
Existing Rail Track	Planned Rail Track
Existing Road	Planned Road

FUNDING AGENCIES

ADB NDF

PARTNERS

IMHEN TDSI IE

COMPANIES

NIRAS icem RCEE NIRAS

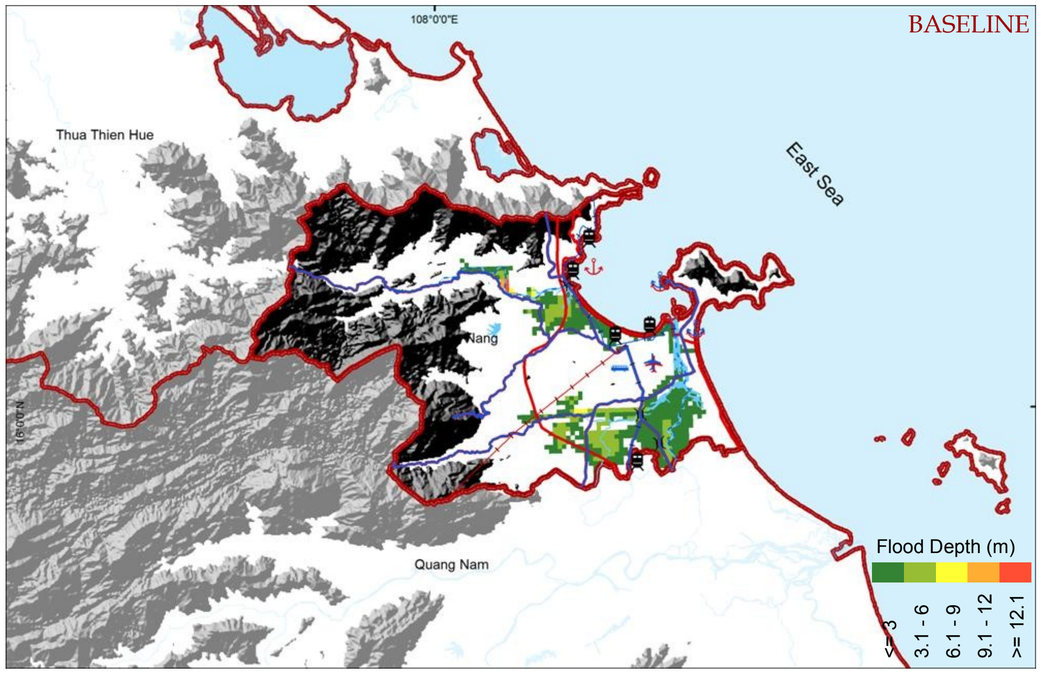
TRANSPORTATION - RIVERINE FLOODING 100 YEAR

BASELINE

Flooding occurs along the Cu De and Han Rivers. This affects only a small proportion (4.1%) of the existing and planned National and Provincial roads in Da Nang, which are at high risk of flooding. Small 2km segments of National Road 1, National Road 14B and National Road 14G are at risk, as well as the planned North-South (East) and Coastal Expressways. None of Da Nang's three provincial roads are at high risk of flooding. Damage or extended periods of inundation to any of these roads will impact traffic flow from Da Nang to Quang Nam province, which are key trade routes for economic development. Design of the planned Expressways should take into account this flood risk. Of the railway assets, the majority are only medium or low exposure to floods.

The majority of the existing and planned railway assets (81%) located in Da Nang are not at any risk of flooding, however, a short section of the Hanoi to HCMC railway is at high risk near Cam Le River crossing.

Inland waterways that are impacted by flooding are mostly at medium risk, which includes the Cang Han River – Cang Ky Ha route, which links Da Nang Bay to the Thu Bon River. This route is however being under utilised due to the increased cost of maintenance (dredging) and the time taken to move goods relative to road transport. Han River Seaport was also found to be at medium risk, however, administrative officials have said that inundation lasts only a day and causes little or no damage or disruption.



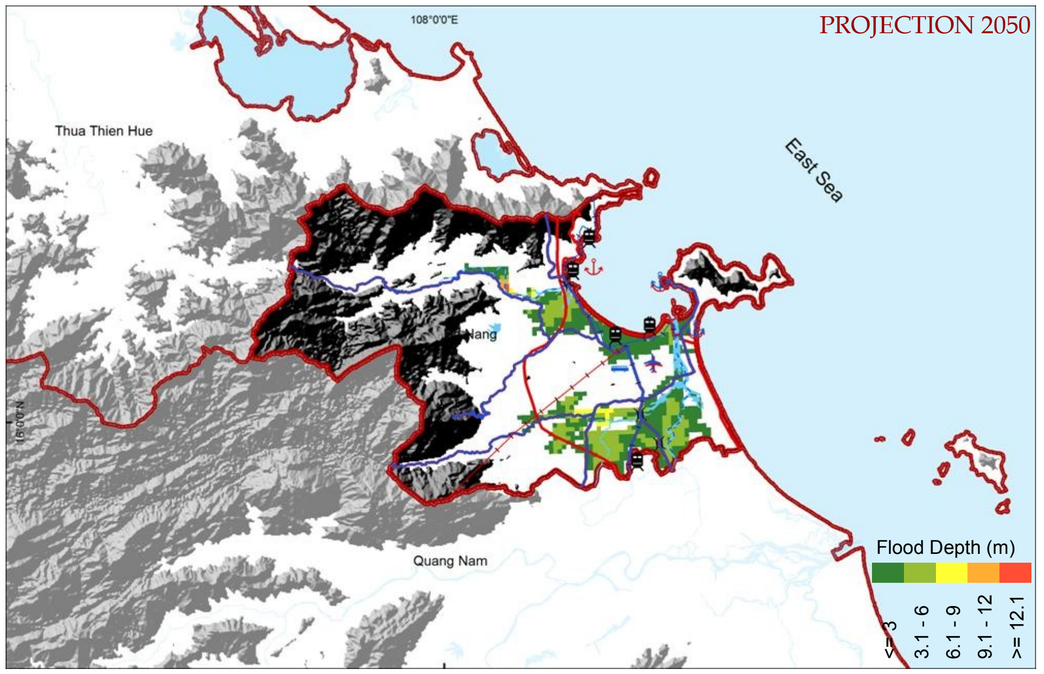
2050 SCENARIO

The extent of flooding in 2050 is projected to increase near the coastal areas around Han and Cu De Rivers, but does not significantly alter further upstream. This however doesn't take into account any changes in depth, velocity or duration of flooding, which will be a critical factor in damages. In addition, continuation of deforestation of the catchment and urban encroachment onto floodplains in Da Nang and Quang Nam provinces will have a significant influence on severity of flooding in the future.

There is a 4.9% increase in road assets at medium risk of flooding between baseline and 2050. A number of sections of road are also shifting from low to medium risk which will require a change in maintenance regimes as certain road sections will be experiencing new hydrological conditions that may cause more frequent and severe damage. Small segments of National Road 1 and Provincial Road 601, along with 8km of the planned Coastal Expressway, are projected to be exposed to an increased risk of flooding.

There is a large increase (10.8%) in medium risk of the total length of existing and planned railway lines, reflecting the influence of climate change. This includes segments of the Hanoi to HCMC (2km) and the Da Nang – Lien Chieu (8km) lines.

A 2km segment of Cang Han River – Cang Ky Ha inland waterway route is projected to increase in risk from no risk to medium. This is near the mouth of the Han River, and is likely due to high flood levels that are influenced by water levels in Da Nang Bay. Resulting damages could include increased riverbank erosion or reduced navigability from sedimentation.



Transportation Assets

- Existing Bridge
- Existing Bus Terminal
- Existing Rail Station
- Existing Civil Airport / Planned Civil Airport
- Existing Sea Port / Planned Sea Port
- Existing IWT Route / Planned IWT Route
- Existing Rail Track / Planned Rail Track
- Existing Road / Planned Road

DATA SOURCES

IMHEN—CLIMATE PROJECTION & BASELINE

TDSI—TRANSPORTATION INFRASTRUCTURE

IE—ENERGY INFRASTRUCTURE

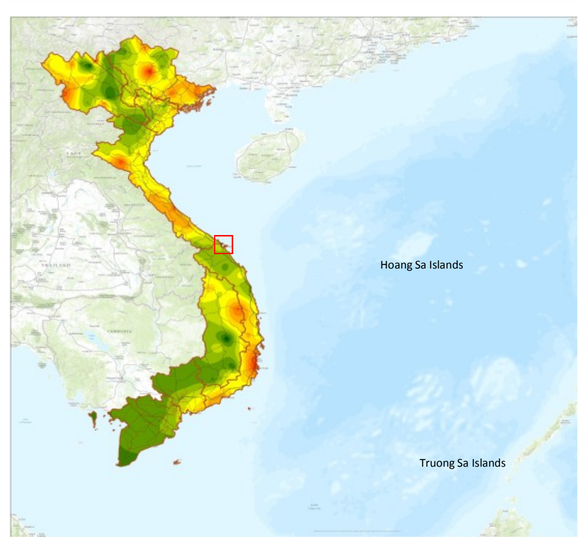
GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

N W E S

MAP SCALE - 1: 400,000

INDEX MAP



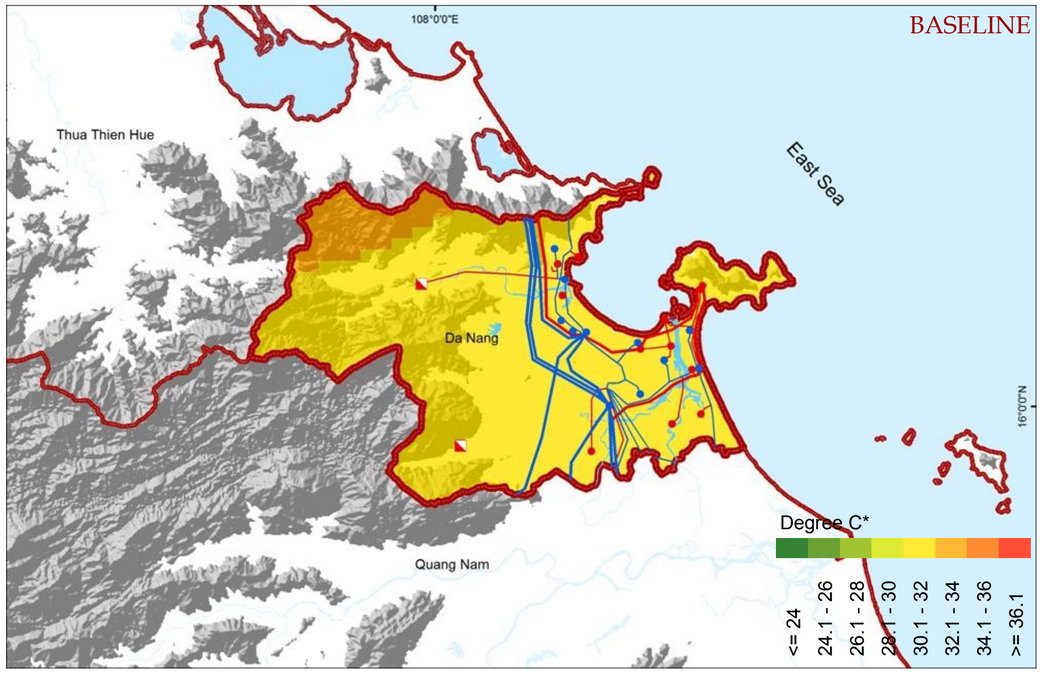
SHEET NUMBER 4

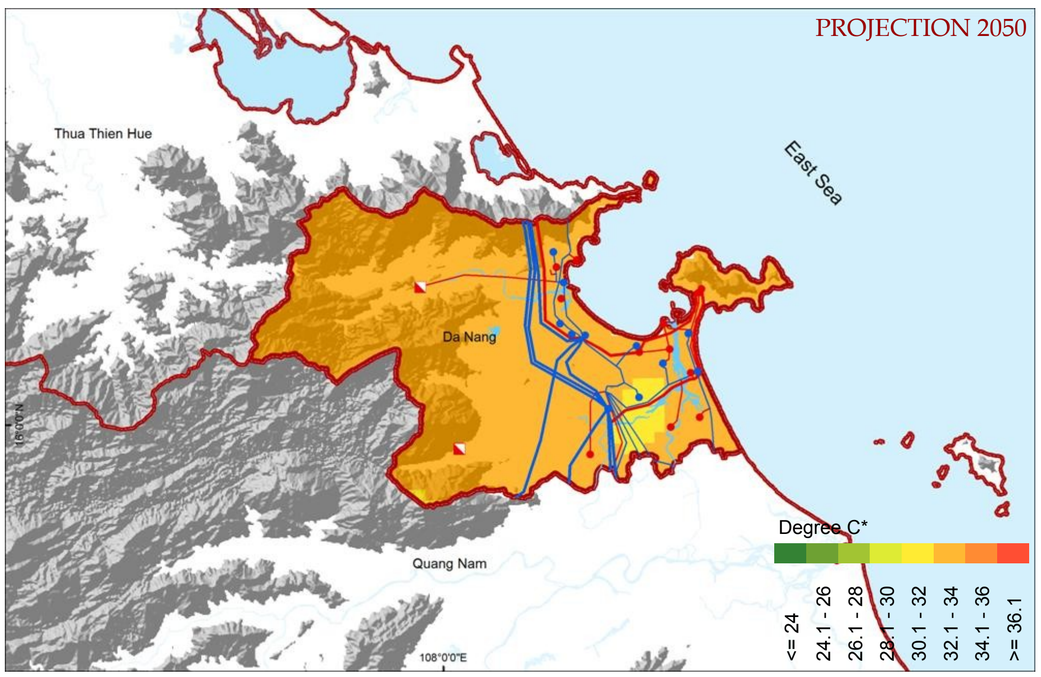
FUNDING AGENCIES ADB NDF

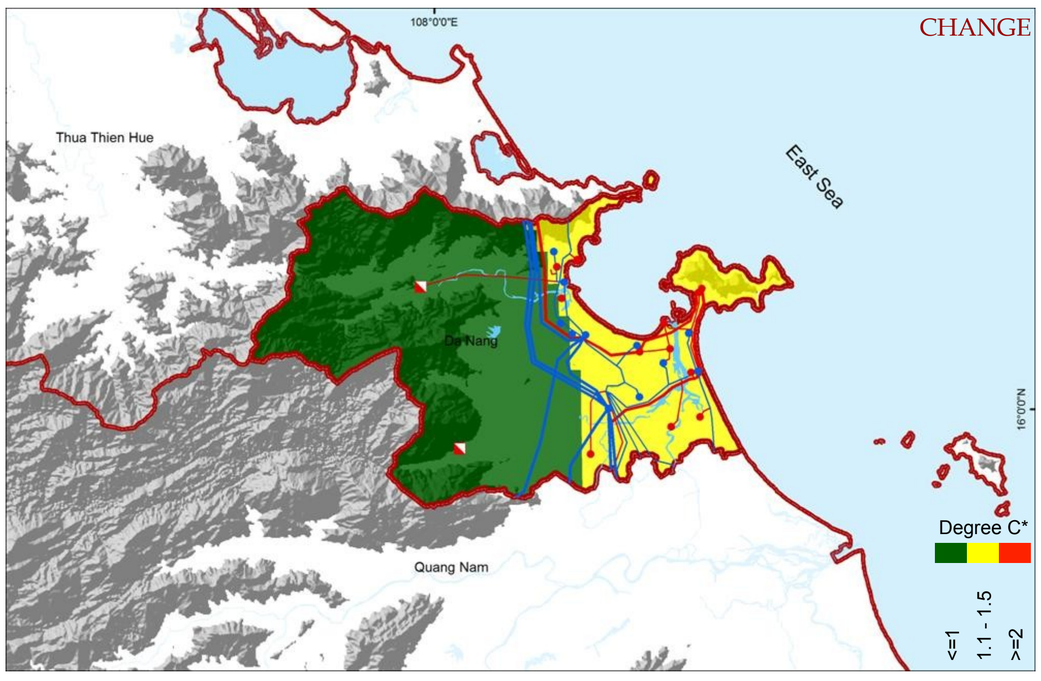
PARTNERS IMHEN TDSI IE

COMPANIES NIRAS icem RCEE NIRAS

ENERGY - AVERAGE MAXIMUM TEMPERATURE (JUNE - AUGUST)







SUMMARY OF PROJECTED CHANGES

The national assessment found that the sustained heat threat, measured by an increase in average maximum temperature during the hottest period, June to August, posed low or very low risks to the two planned hydropower plants in Da Nang and the existing and planned substation assets.

Further analysis undertaken in the provincial assessment on the 110/22kV substation, Hoa Khanh 2, found that the asset was projected to experience an increase in average maximum temperature in the June-August period of 1.2 degrees Celsius due to climate change, from 29.4 degrees in the baseline to 30.6 degrees in 2050. This was assessed as a medium impact to the asset due to the potential for higher ambient temperatures to reduce loadability of the transformer and increase system losses.

Energy Assets

- Planned Powerplant
  - Hydro Power Plant
- Existing Substation
- Planned Substation
- Existing TML
  - 110 kV TML
  - 220 - 500 kV TML
- Planned TML
  - 110 kV TML
  - 220 - 500 kV TML

DATA SOURCES

IMHEN—CLIMATE PROJECTION & BASELINE

TDSI—TRANSPORTATION INFRASTRUCTURE

IE—ENERGY INFRASTRUCTURE

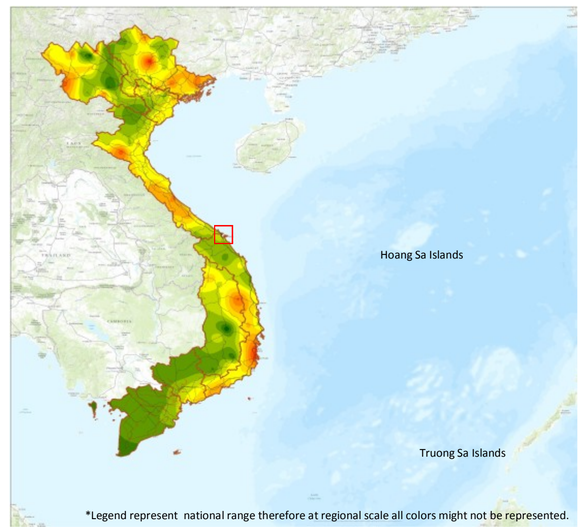
GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

N W E S

MAP SCALE - 1: 400,000

INDEX MAP



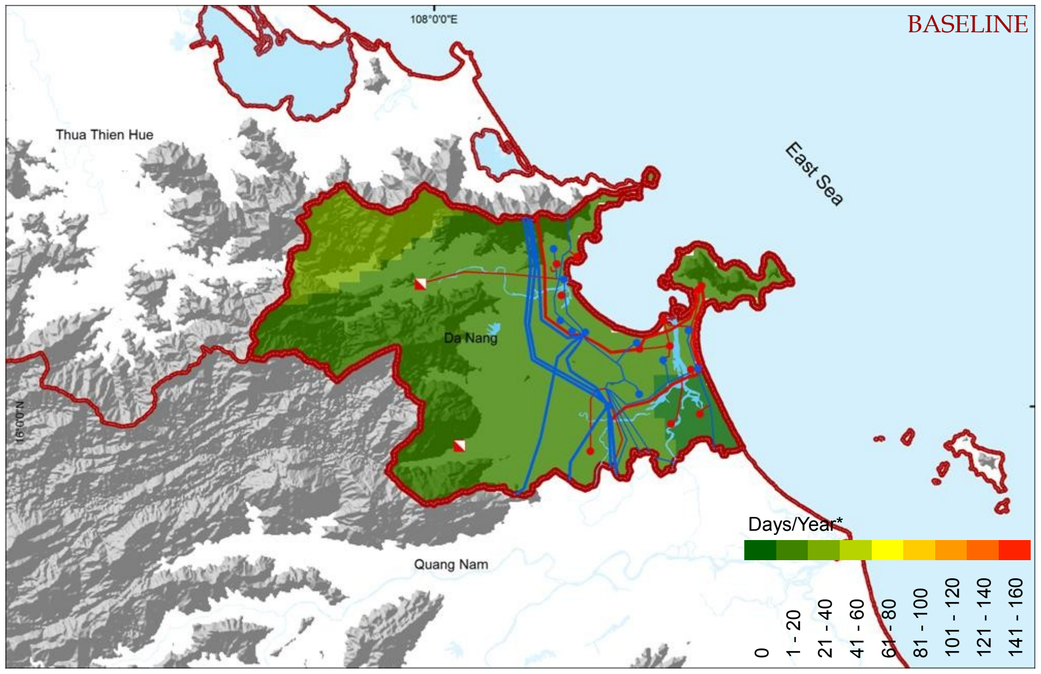
*Legend represent national range therefore at regional scale all colors might not be represented.

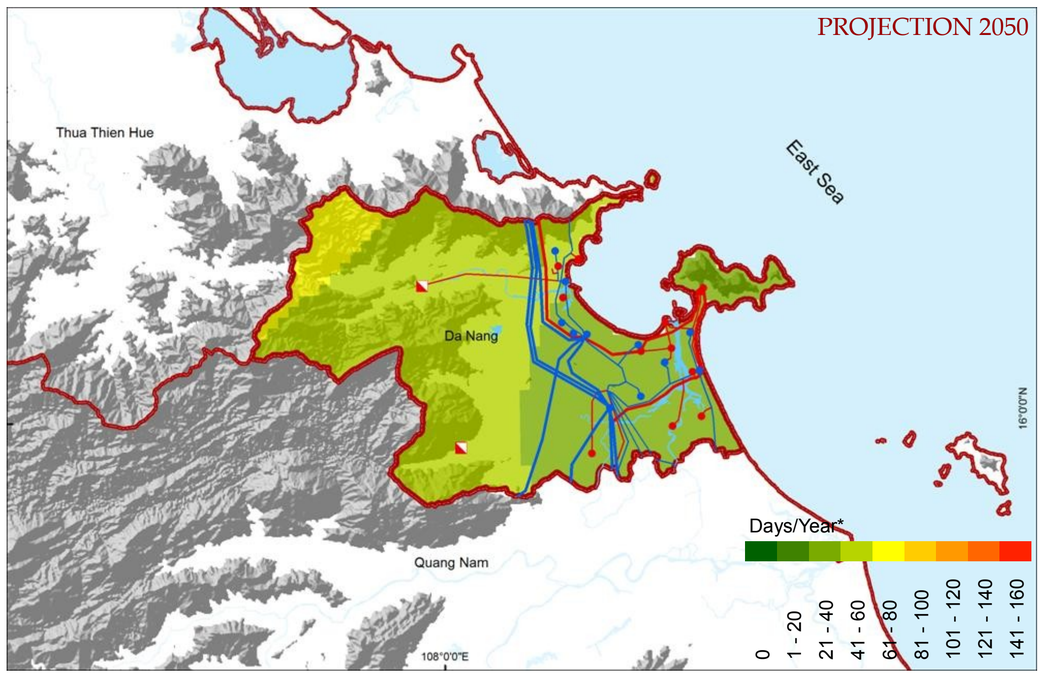
FUNDING AGENCIES

PARTNERS

COMPANIES

ENERGY - NUMBER OF HOT DAYS





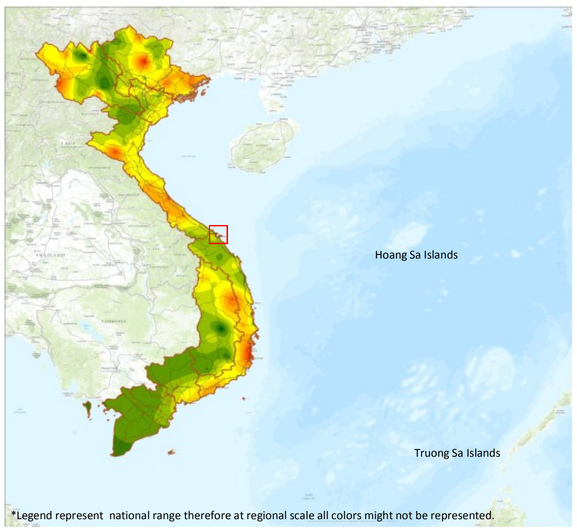
SUMMARY OF PROJECTED CHANGES

The national assessment found that the extreme heat threat, measured by an increase in the number of hot days each year, posed a medium threat to the two planned hydropower plants in Da Nang and low or very low risks to the existing and planned substation assets.

Further analysis undertaken in the provincial assessment on the 110/22kV substation, Hoa Khanh 2, found that the asset was projected to experience an increase in the number of hot days from 8 in the baseline to 39 in 2050 due to climate change. This led to an assessment of high impact to the asset due to the potential for extreme temperatures to reduce efficiency and operational life time of the transformer. A literature review conducted for the assessment found that every 1 degree C increase in the operating temperature of the transformer above its design temperature leads to about 0.4% in load losses.

The risk to hydropower assets, which were ranked medium in the national assessment, has been determined to be a lower order risk as field visits have confirmed that their powerhouses are usually not significantly affected by increased ambient temperatures.

INDEX MAP



*Legend represent national range therefore at regional scale all colors might not be represented.

SHEET NUMBER 7

DATA SOURCES

IMHEN—CLIMATE PROJECTION & BASELINE

TDSI—TRANSPORTATION INFRASTRUCTURE

IE—ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

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MAP SCALE - 1: 400,000

Energy Assets

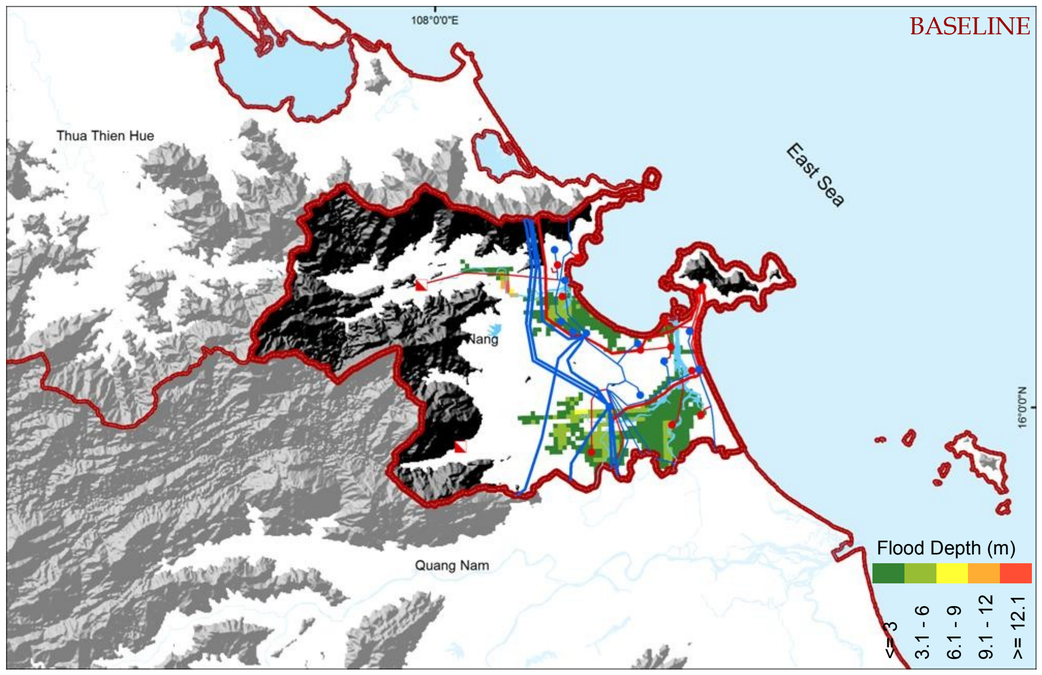
Planned Powerplant
Hydro Power Plant
Existing Substation
Planned Substation
Existing TML
110 kV TML
220 - 500 kV TML
Planned TML
110 kV TML
220 - 500 kV TML

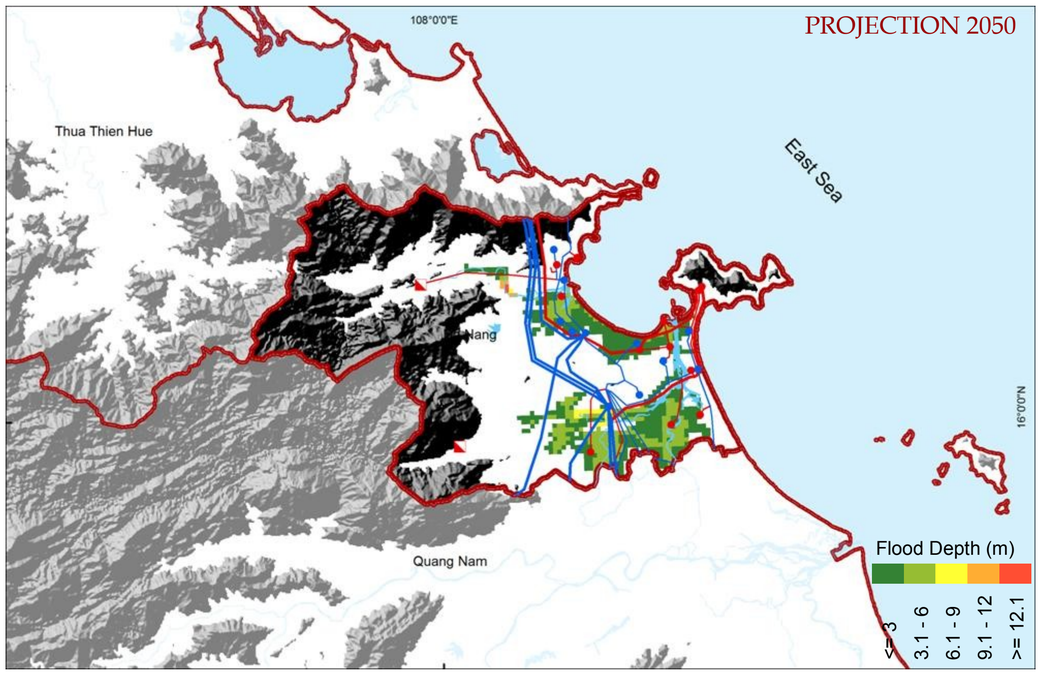
FUNDING AGENCIES

PARTNERS

COMPANIES

ENERGY - RIVERINE FLOODING 100 YEAR





2050 SCENARIO

In both the baseline and 2050 scenario, the substations found to be at the highest risk from flooding in the provincial analysis is the planned 220/110kV substation, Hòa Khương, followed by medium risk to the existing 110/22kv substation, Hoà Khánh 2, and the planned 110/22kV substations, Hòa Xuân and Hòa Liên. The affect of climate change on the flooding threat by 2050 is not projected to be significant, however, the impact assessment shows there is a risk of flooding existing and planned substations under current conditions.

The risk of flooding to generation assets was not specifically analyzed in the provincial assessment for Da Nang, however, the national assessment found that the two planned hydropower plants in Da Nang were projected to be at a very high risk of flooding using the wet season catchment yield indicator.

Energy Assets

- Planned Powerplant
  - Hydro Power Plant
- Existing Substation
- Planned Substation
- Existing TML
  - 110 kV TML
  - 220 - 500 kV TML
- Planned TML
  - 110 kV TML
  - 220 - 500 kV TML

DATA SOURCES

IMHEN—CLIMATE PROJECTION & BASELINE

TDSI—TRANSPORTATION INFRASTRUCTURE

IE—ENERGY INFRASTRUCTURE

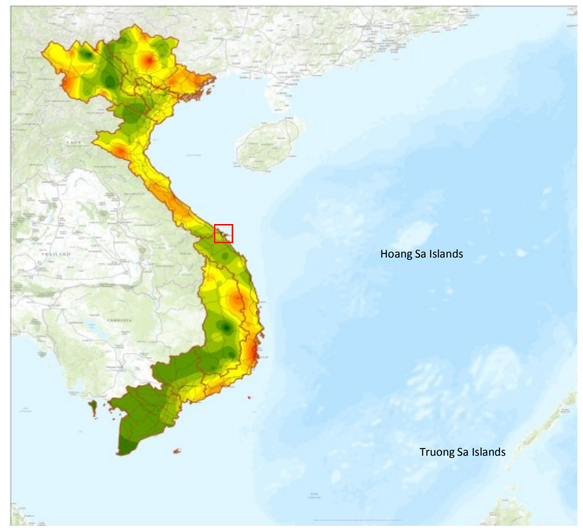
GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

N W E S

MAP SCALE - 1: 400,000

INDEX MAP

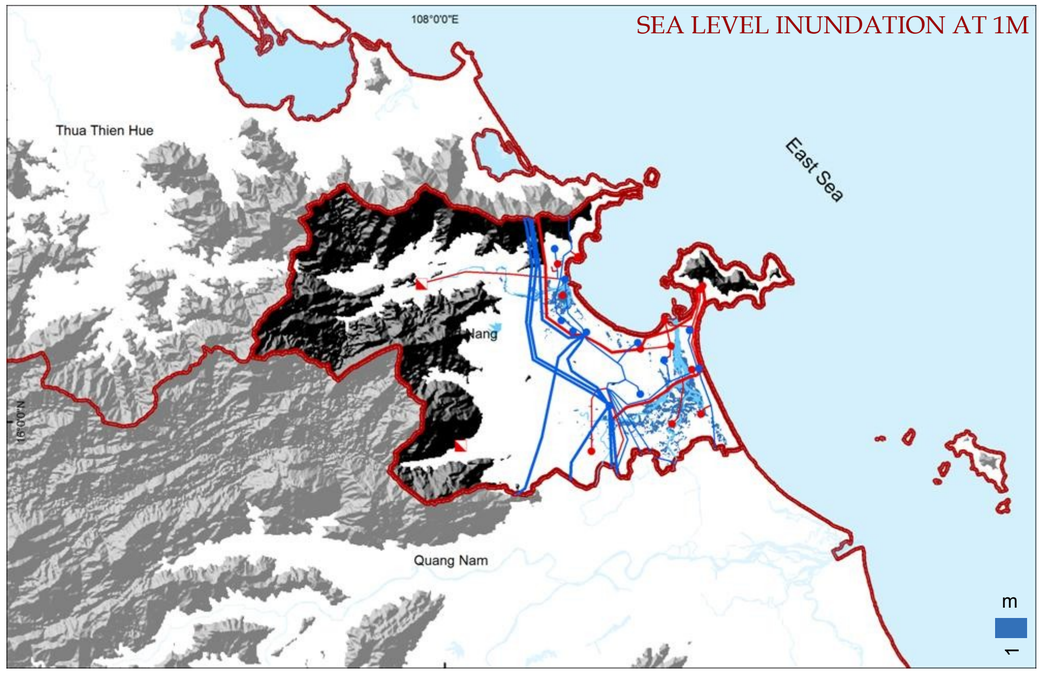


FUNDING AGENCIES ADB NDF

PARTNERS IMHEN TDSI IE

COMPANIES NIRAS icem RCEE NIRAS

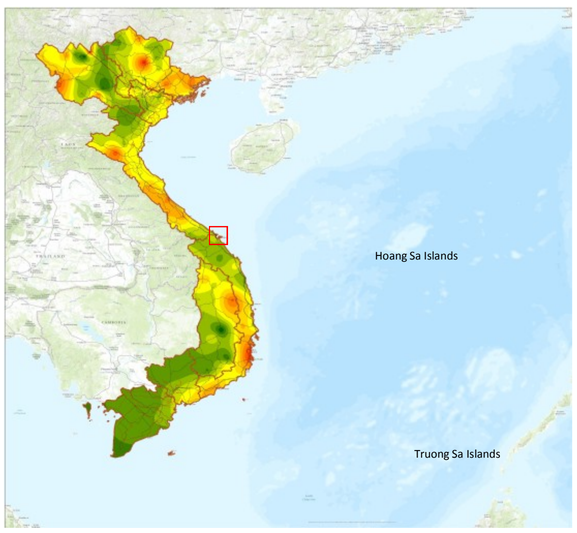
ENERGY - SEA LEVEL RISE (1M)



INUNDATION DUE TO SEA LEVEL RISE OF 1M

Only one planned substation, Hòa Liên, was found to be at medium risk of sea level rise of 1m as a result of climate change in the provincial assessment for Da Nang. With an elevation of 2 meters above sea level, Hòa Liên was estimated to be likely to be inundated by 1m of sea level rise and storm surge. Sea level rise was found to pose little risk to the other existing and planned substation assets in Da Nang, with no risk for 2 substations found and low risk for 13 substations. Generation assets were not assessed for their risk from sea level rise in the provincial assessment in Da Nang.

INDEX MAP



SHEET NUMBER 9

DATA SOURCES

IMHEN—CLIMATE PROJECTION & BASELINE

TDSI—TRANSPORTATION INFRASTRUCTURE

IE—ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

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MAP SCALE - 1: 400,000

Energy Assets

Planned Powerplant
Hydro Power Plant

Existing Substation

Planned Substation

Existing TML
110 kV TML
220 - 500 kV TML

Planned TML
110 kV TML
220 - 500 kV TML

FUNDING AGENCIES

PARTNERS

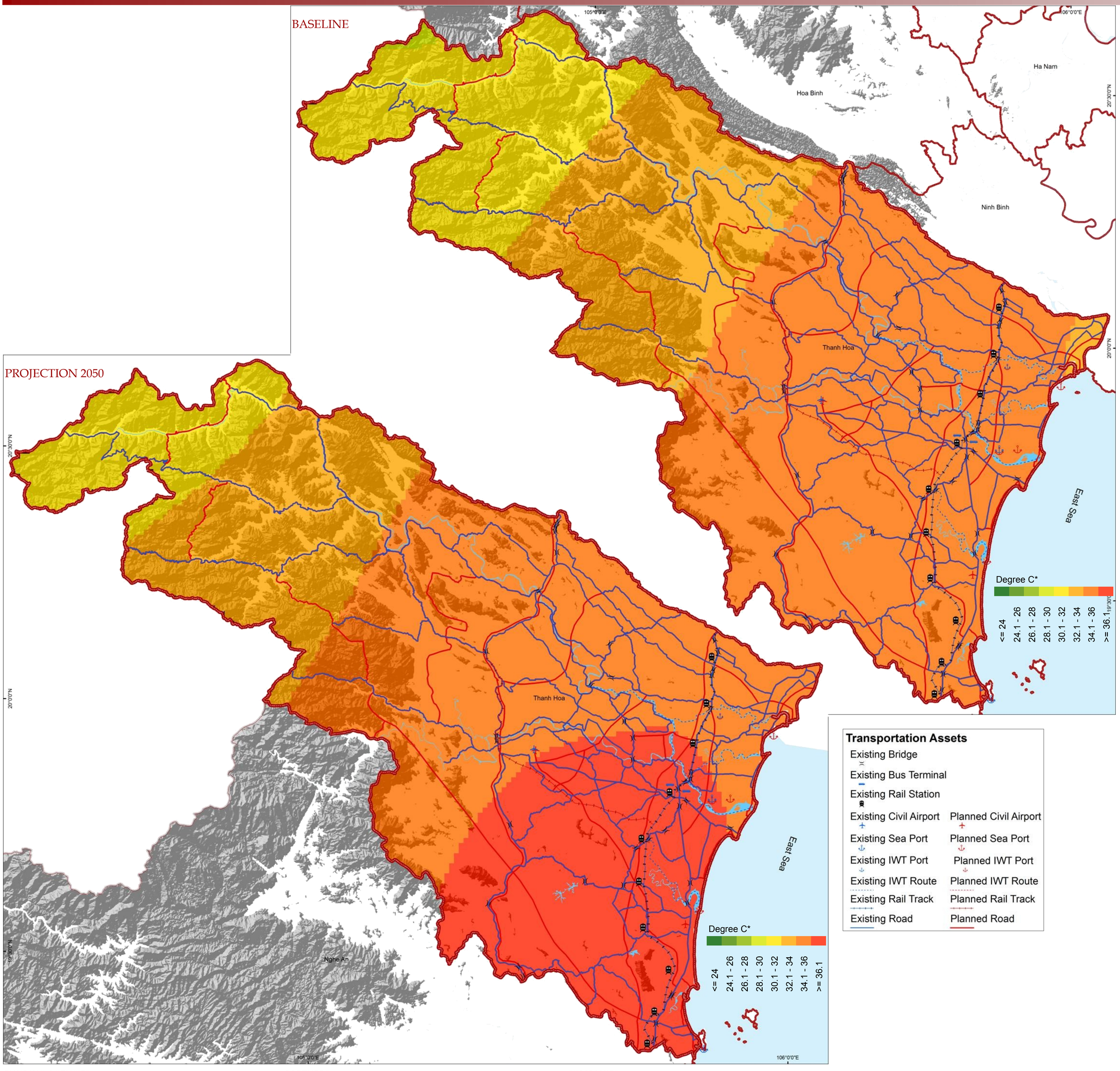
COMPANIES

PROVINCIAL - THANHHOA

TRANSPORTATION - AVERAGE MAXIMUM TEMPERATURE (JUNE - AUGUST)

BASELINE

PROJECTION 2050



FUNDING AGENCIES

PARTNERS

COMPANIES

BASELINE

Thanh Hoa province has higher elevations in the west and drops down towards the coast in the East. The average temperature is 23-24°C, with the mountainous areas being much cooler than the coast.

High temperatures can lead to damages to Thanh Hoa's transportation assets, including softening and melting of asphalt surfaces. This is likely to occur when temperatures exceed 36°C, however, it should be noted that a significant driver of heat stress damage to these surfaces is heavy traffic load. The impact is gradual over time and is not considered to be severe relative to impacts from floods or landslides.

Thanh Hoa's coastal areas experience the highest temperatures of 34-36°C from June-August, whereas the mountainous regions have temperatures between 30-34°C. Temperature damages are not limited to specific roads but are spread throughout the plain and coastal region and are also dependant on the type of traffic loads as well as the mix and construction quality of the surface. Segments of National Roads 1 and 47, as well as Hoang Long bridge have experienced temperature deformation. These assets are also trafficked by heavy vehicles. There is little risk to the railway, inland waterway and aviation sectors.

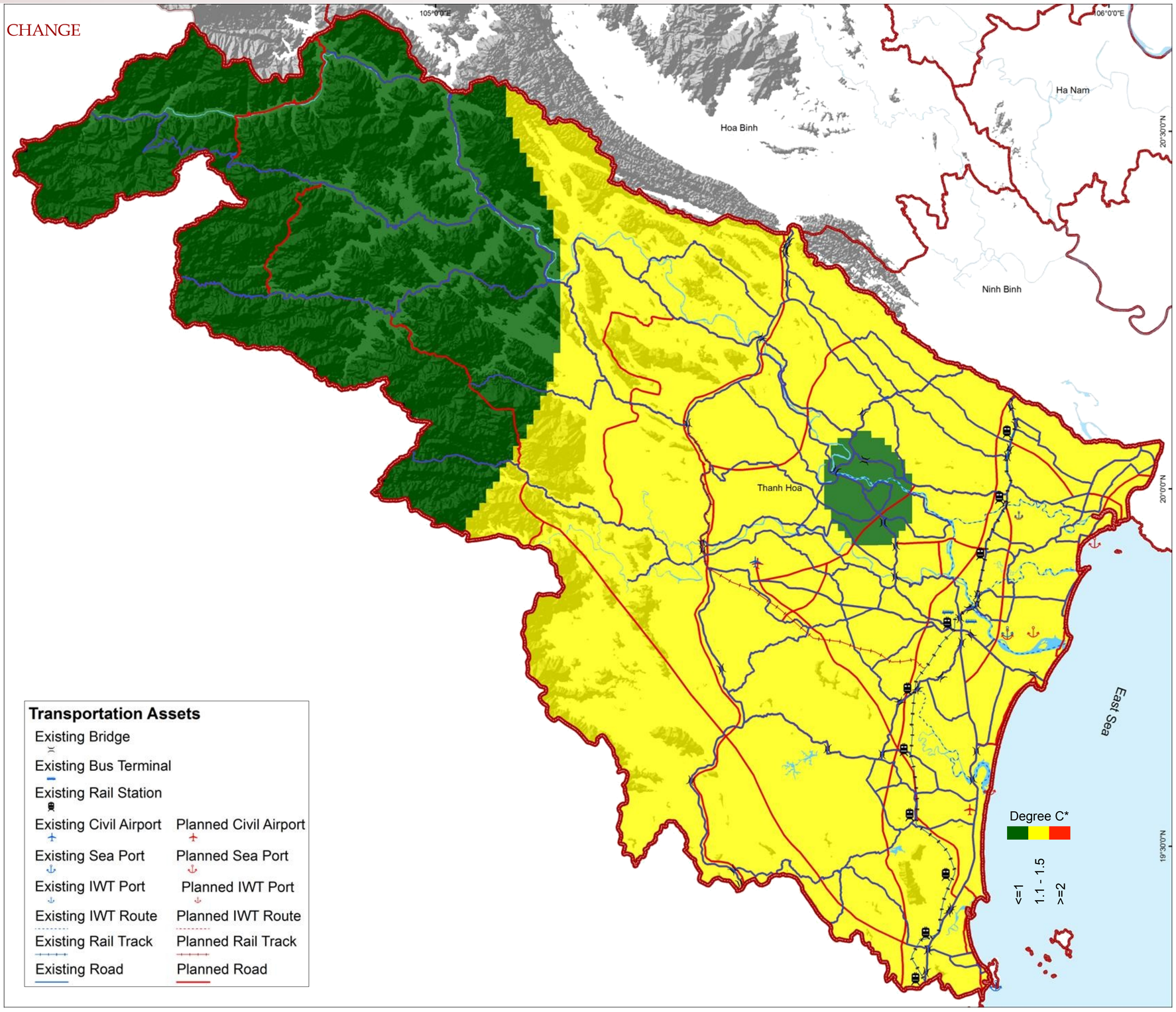
2050 SCENARIO

The south-east districts of Thanh Hoa will experience average maximum temperatures in excess of 36°C in 2050. This increase in temperature could lead to more widespread road deformation, subsidence, melting and rutting of dark surfaces such as asphalt. Furthermore, given traffic projections for 2050, damages due to temperature could become widespread unless design changes are made. Changes to temperature may also affect planes when taking off and landing, however, this needs further study.

SUMMARY OF PROJECTED CHANGES

There are greater projected increases at higher altitudes than lower altitudes. This, combined with generally lower temperatures at higher elevations, means that the temperature change by per cent is much larger in higher elevations (5%) than lower elevations (4%). The increase in the lower plains ranges between 1.0-1.5°C. Greater temperatures could also result in more severe and common damage to hardstand surfaces, which need to be reflected in maintenance regimes. As a result, more frequent inspections and maintenance may be required.

CHANGE



DATA SOURCES

IMHEN—CLIMATE PROJECTION & BASELINE

TDSI—TRANSPORTATION INFRASTRUCTURE

IE—ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

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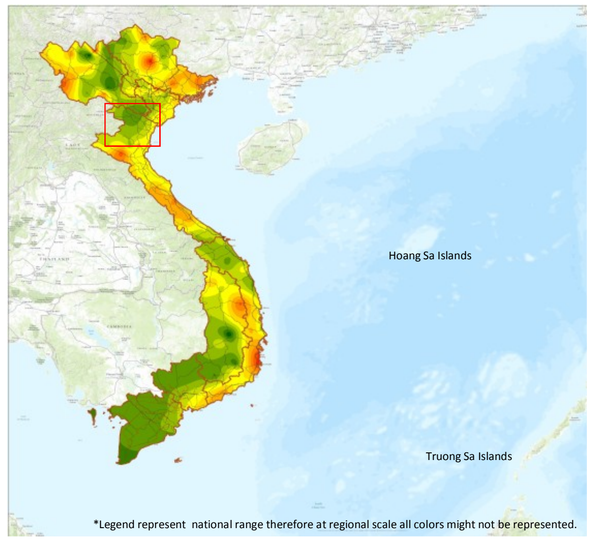
MAP SCALE - 1: 400,000

INDEX MAP

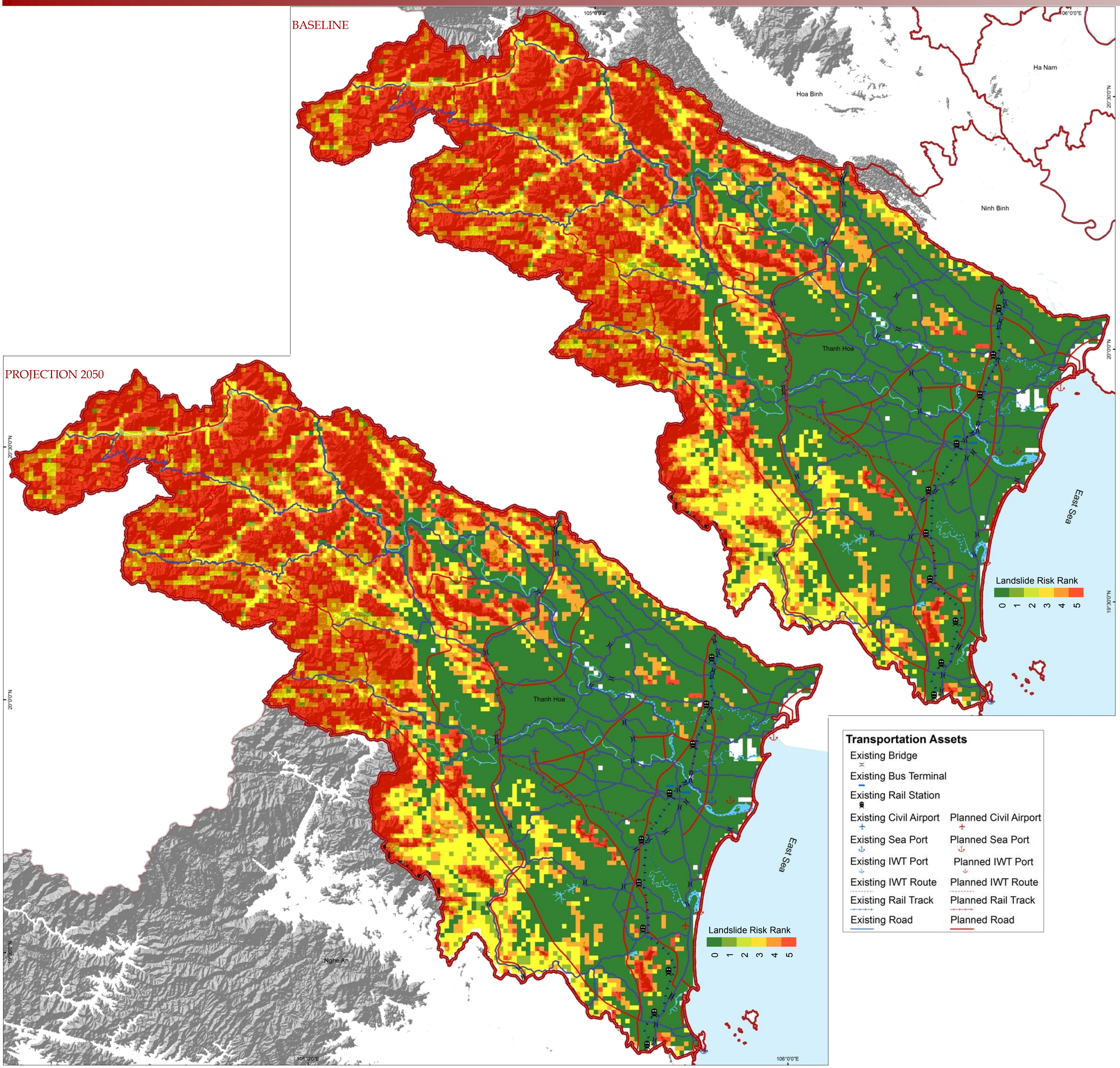


*Legend represent national range therefore at regional scale all colors might not be represented.

TRANSPORTATION - RAINFALL ASSOCIATED LANDSLIDE RISK

BASELINE

PROJECTION 2050



FUNDING AGENCIES

PARTNERS

COMPANIES

BASELINE

Damages from landslides can be catastrophic to assets, which is why it is the highest priority climate threat. Baseline results show that the western mountainous regions are highly susceptible to landslides. This corresponds well with Thanh Hoa's long history of landslide damages in its mountainous districts, with many roads being subject to catastrophic failure from upslope and downslope landslides.

Approximately 2.2% of existing and planned National and Provincial roads in Thanh Hoa are at high risk of landslides, and 5.1% are at medium risk. There is 25km of National Road 217 at medium risk of landslides. This road is a major access point from Thanh Hoa province into Lao PDR (begins from National Road 1) as well as providing remote villages access to the coastal areas. Although modeling results show that it is only medium risk, it has been impacted by landslides many times in the past, and has been recognized by DOT as one of the most strategically significant assets. Whilst the risk doesn't change in the 2050 scenario, there is still a need for solutions.

Provincial Road 520 is another significant road that begins from National Road 15A and provides the only access to and from remote communities in the mountains close to the Lao PDR border. Approximately 35km of this road has been found at High risk of landslides. These communities are very poor and are also inhabited by minorities, and therefore if Provincial Road 520 becomes damaged, they have no access to the rest of the province.

Provincial Road Thanh Hoa West provides a link to the Nghi Son Industrial Zone. Approximately 30km of this road was found to be at Medium risk of landslides, and 5 km at High risk. In addition, there are small segments of three planned roads found at High risk, totaling approximately 15km, or 5km segments of each road. These road alignments should be very carefully assessed and designed to limit potential damages.

No railway assets or inland waterways are at risk as they are at much lower elevations.

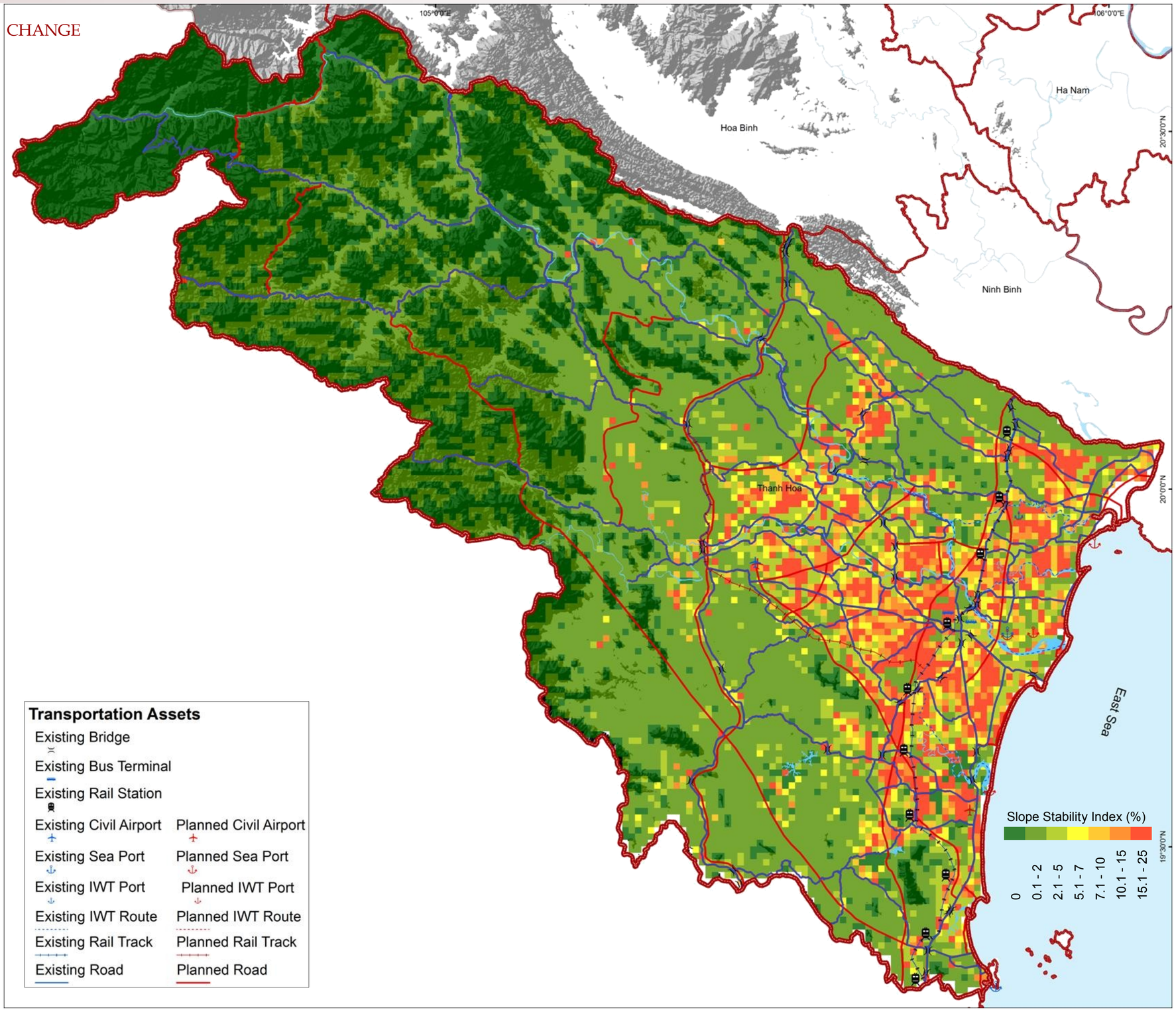
2050 SCENARIO

There is no discernible difference in landslide risk in 2050 for the road sector. As in the Baseline scenario, sections of the planned National Road Thanh Hoa West, North-South (West) Expressway, Provincial Road 507 – 217, and Provincial Road Thanh Hoa West - NS are at high risk of landslides in 2050. Designs for these planned assets should evaluate this risk further and incorporate climate resilience.

SUMMARY OF PROJECTED CHANGES

Thanh Hoa's soil stability is increasing in 2050 when compared with the Baseline scenario. This is due to a projected decrease in rainfall, and higher rates of evaporation for the majority of the province. This has resulted in little difference in landslide risk between the two scenarios, although there is currently a large adaptation deficit as landslides are already impacting assets. This result also does not take into account the influence of rapid rates of deforestation that will increase in the future and lead to unstable hill slopes, endangering transportation and other sectoral assets.

CHANGE



DATA SOURCES

IMHEN—CLIMATE PROJECTION & BASELINE

TDSI—TRANSPORTATION INFRASTRUCTURE

IE—ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

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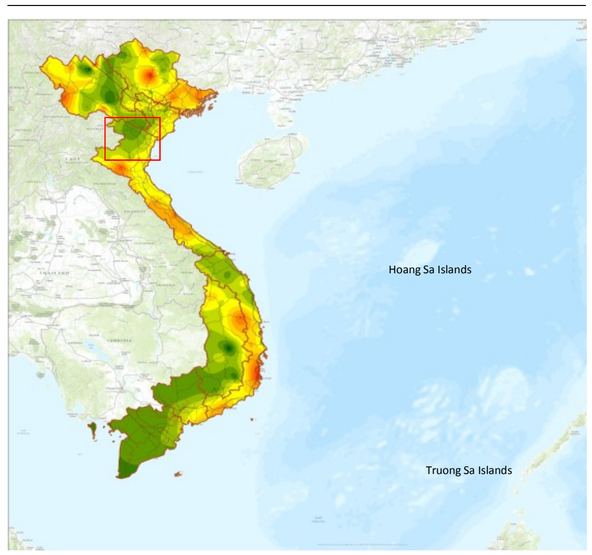
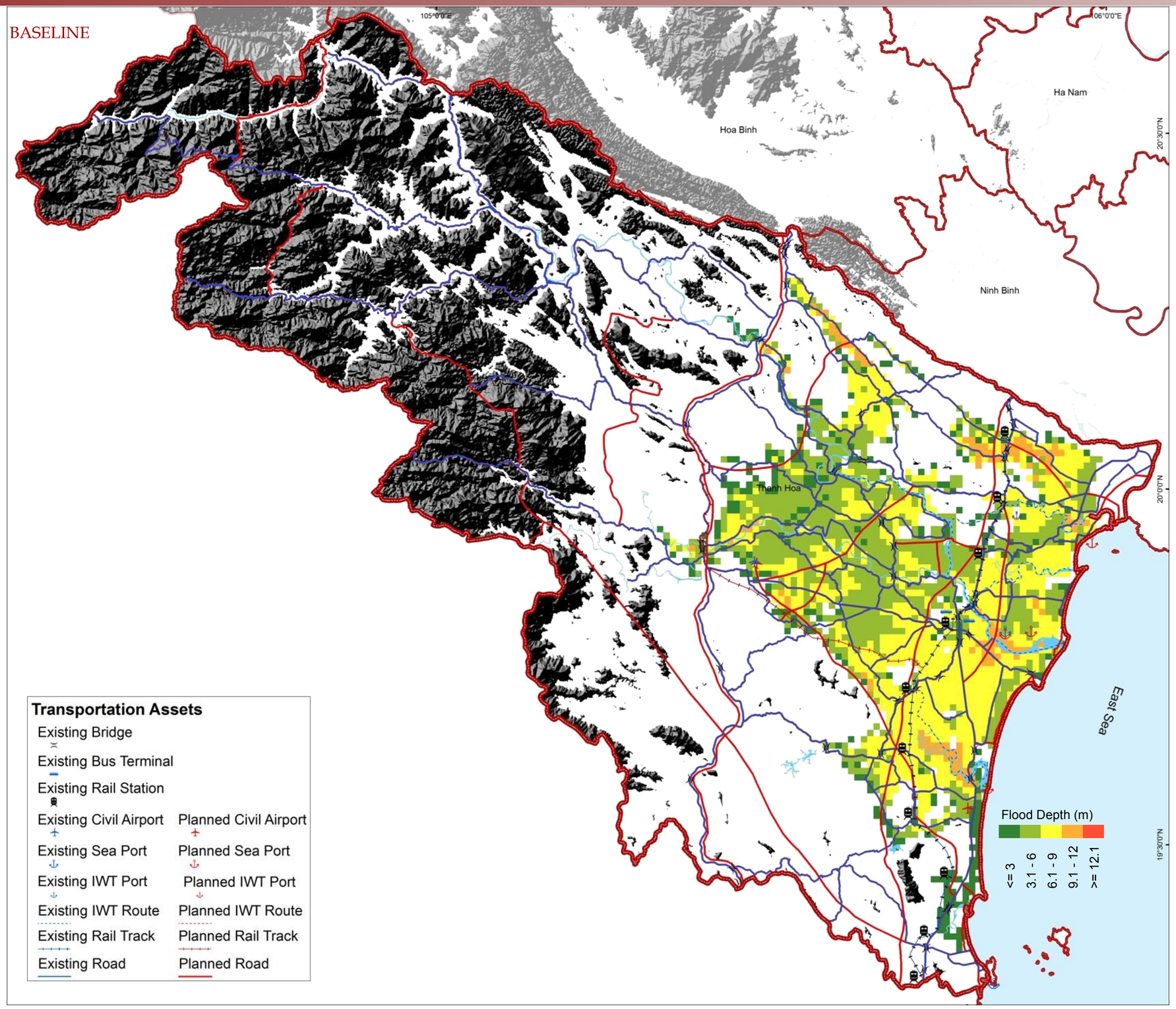
MAP SCALE - 1: 400,000

INDEX MAP



TRANSPORTATION - RIVERINE FLOODING 100 YEAR

BASELINE



BASELINE

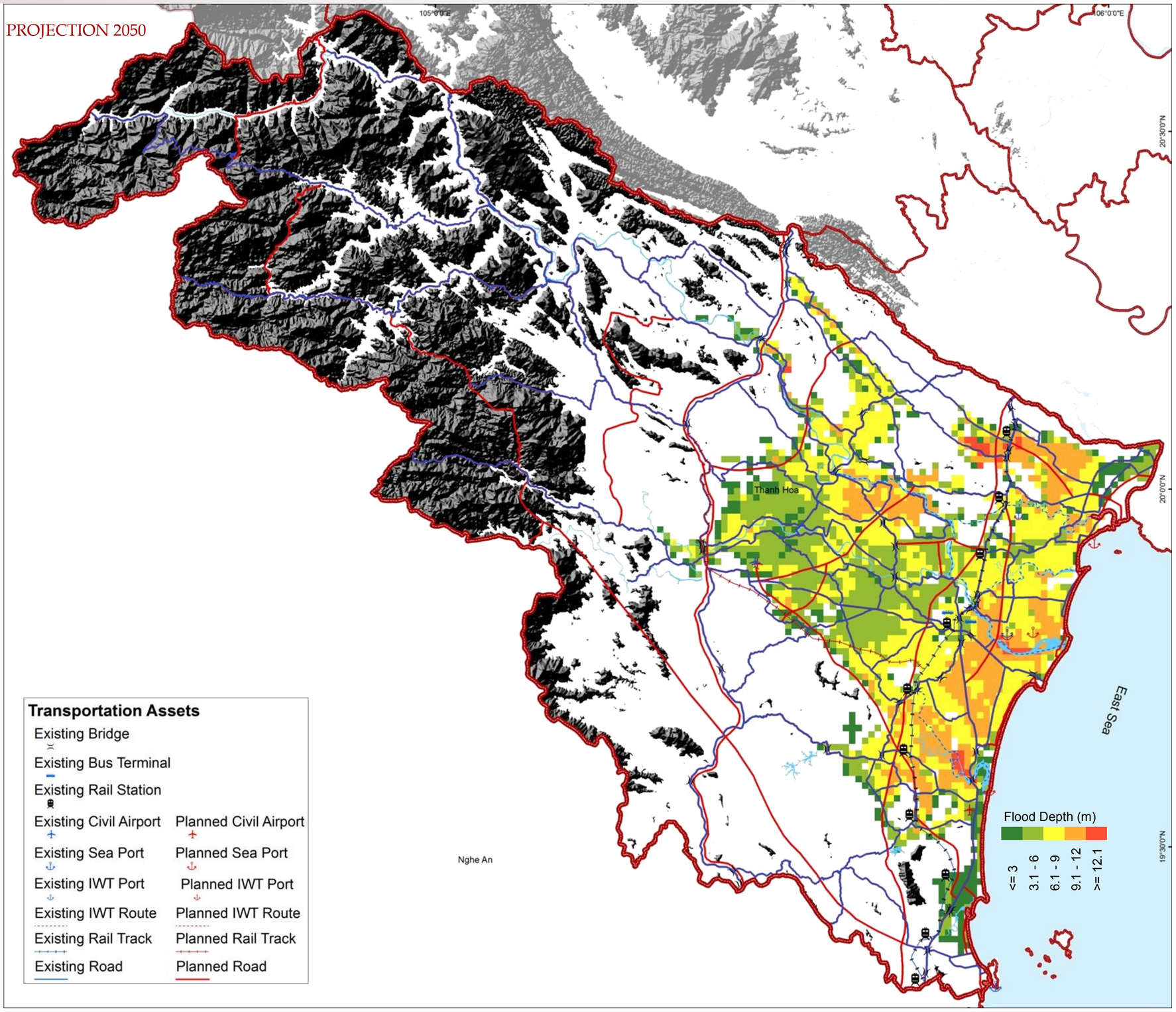
Major flooding in Thanh Hoa is concentrated along the Ma River and upstream estuaries, including Truong Giang, Len and Chinh Dai Rivers.

Approximately 10% of the existing and planned National and Provincial roads are at high risk of flooding, mostly located in the plain area as expected. National Road 45, which runs from Thanh Hoa City to Ninh Binh province, has 35 km at High risk in the baseline. This is likely because it crosses both the Chu and Ma Rivers and therefore is exposed to flood water from both. Damage to this road will result in disruption of traffic from Ninh Binh to Thanh Hoa. Provincial Road 506, which runs between National Road 45 and the border gate to Lao PDR, has 25 km at High risk to flooding. This road runs parallel to the Chu River on the right bank for a long distance (and may be elevated on a dyke for some of this), and is therefore at exposed to floods from the river.

There is 20.6% of the existing and planned railway network at high risk of flooding. This includes a significant length of the Hanoi to HCMC line, which is expected as it is located near the bottom of the catchment and crosses all major rivers in the province. It should be noted however that the railway is likely to be elevated from the surrounding ground, and therefore will not necessarily be subject to flooding unless the flood level exceeds the embankment height. A small section of the planned Nam Vinh – Ngoc Lac alignment, close to the junction with the Ha Noi to HCMC line, is also at High risk of flooding as it runs close to two minor tributaries of the Yen River. As this is still in the design phase, efforts should be made to incorporate climate resilience to alleviate the flood risk.

A high proportion of 33% of inland waterways are at High risk from flooding in the Baseline scenario. A number of different routes are at High risk of flooding, the most significant of which is the Song Ma – Cua Hoi – Le Mon – Ha route, which runs along the Ma River. Flooding in this river does occur annually and depending on the bridge heights, could cause delays in river traffic and contribute to erosion of the riverbanks. Flooding in the Ma River also puts the existing Le Mon Seaports and planned Quang Chau Seaport at high risk of inundation.

PROJECTION 2050



2050 SCENARIO

Climate change is projected to influence the flood extent, depth, duration and velocity of flooding experienced. Added to this issue is the rate of deforestation in Thanh Hoa province, which is causing more runoff to flow into rivers and increase flooding. Urban development is constricting floodplains and encroaching on river channels in the plain and coastal areas. These two issues combined with climate change will exacerbate flooding in the province.

There is an increase of approximately 3.5% of road assets from low and medium risk in Baseline to high risk in 2050. These roads may not have been historically as impacted by flooding but are projected to have greater exposure due to climate change. National Road 45 will have an additional 10km length at high risk in 2050, as will National Road 10, National Road 1A and Provincial Road 504 amongst others.

The length of railway assets at high risk of flooding will increase by 2.9% in 2050, which is along the Hanoi to HCMC line (35km length). Approximately 51.5% of the inland waterway routes are at high risk of flooding in 2050. This increase in risk is on Cau Vay – Cau Lach Ghep, Song Tao and Song Len routes.

DATA SOURCES

IMHEN—CLIMATE PROJECTION & BASELINE

TDSI—TRANSPORTATION INFRASTRUCTURE

IE—ENERGY INFRASTRUCTURE

GEOGRAPHIC REFERENCE INFORMATION

GEOGRAPHIC LAT LONG WITH WGS-84 DATUM

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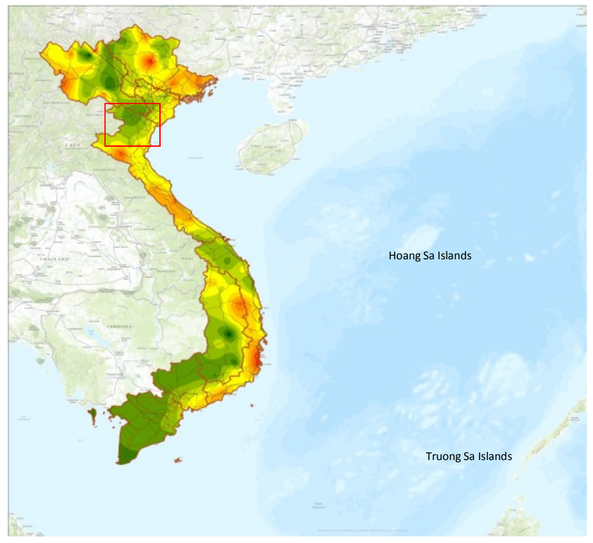
MAP SCALE - 1: 400,000

INDEX MAP



ENERGY - AVERAGE MAXIMUM TEMPERATURE (JUNE - AUGUST)

BASELINE

PROJECTION 2050

Hoa Binh
Ha Nam
Ninh Binh
Thanh Hoa
Nghe An
East Sea

105°0'0"E
106°0'0"E
20°30'0"N
20°0'0"N
19°30'0"N

Degree C*
<= 24
24.1 - 26
26.1 - 28
28.1 - 30
30.1 - 32
32.1 - 34
34.1 - 36
>= 36.1

Energy Assets

Existing Powerplant
- Hydro Power Plant
- Hydro Power Plant

Planned Powerplant
- Hydro Power Plant
- Thermal Power Plant

Existing Substation

Planned Substation

Existing TML
- 110 kV TML
- 220 - 500 kV TML

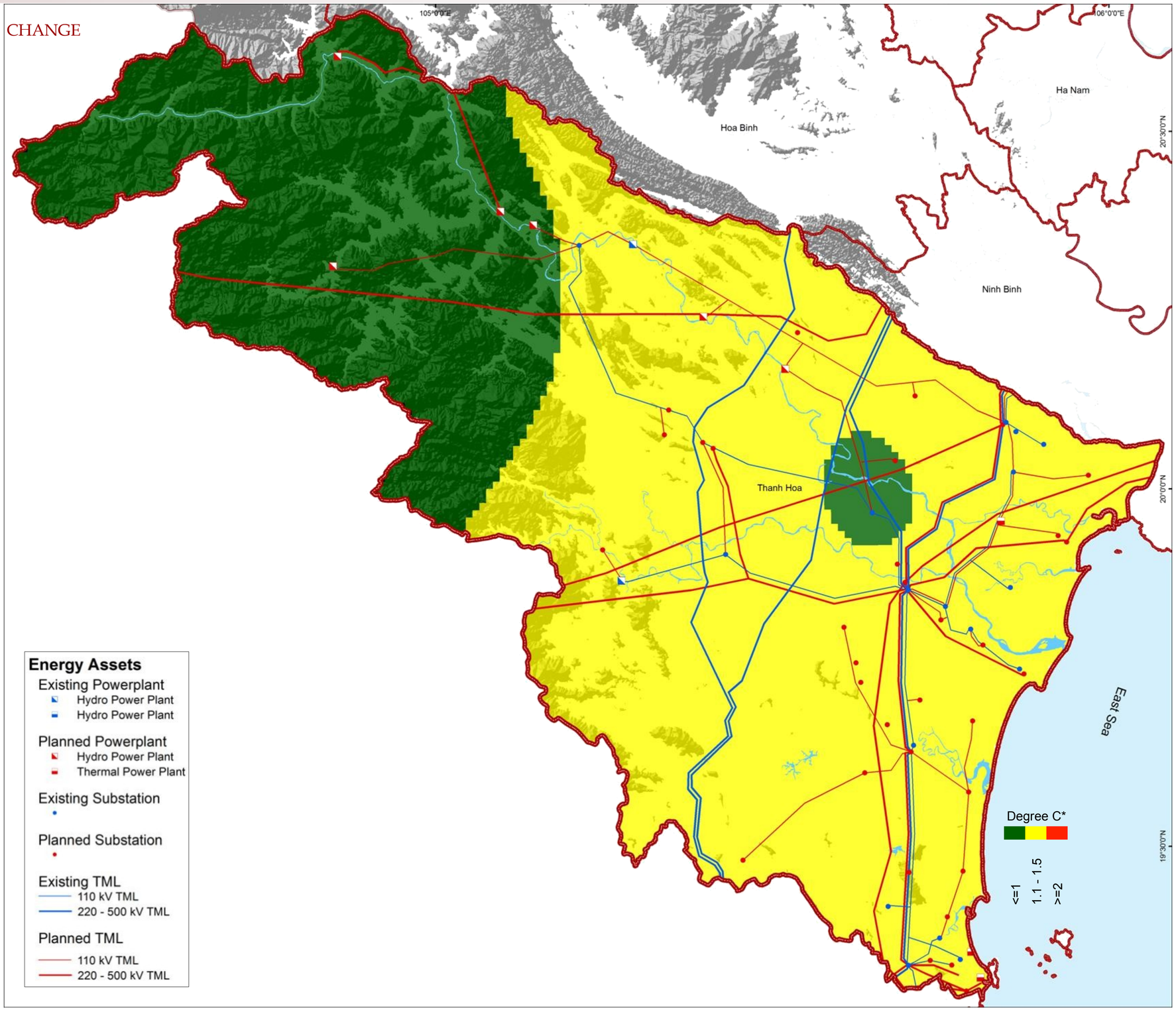
Planned TML
- 110 kV TML
- 220 - 500 kV TML

FUNDING AGENCIES

PARTNERS

COMPANIES

CHANGE



SUMMARY OF PROJECTED CHANGES

The sustained heat threat poses the greatest risk to the three planned thermal plants and planned 500/220kV substations located in the coastal area of Thanh Hoa. In this area, an increase of 1.1 – 1.5 degrees Celsius in average maximum temperatures from June – August is projected, while in the mountainous areas to the West, an increase of less than 1 degree Celsius is projected. These assets were found to be in the medium impact category in the national assessment, making them in the lower end of the range compared to other national assets. Nevertheless, this threat should be taken into account during asset design as higher temperatures can cause:

- Higher cooling water temperatures for thermal plants, compromising plant economics and operational lifetimes of equipment; and
- Overheating of transformers in substations, reducing operational lifetimes of equipment and increased grid system losses.

DATA SOURCES

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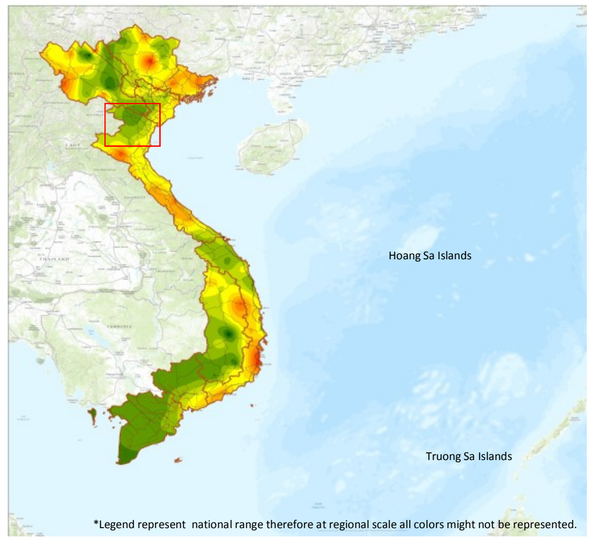
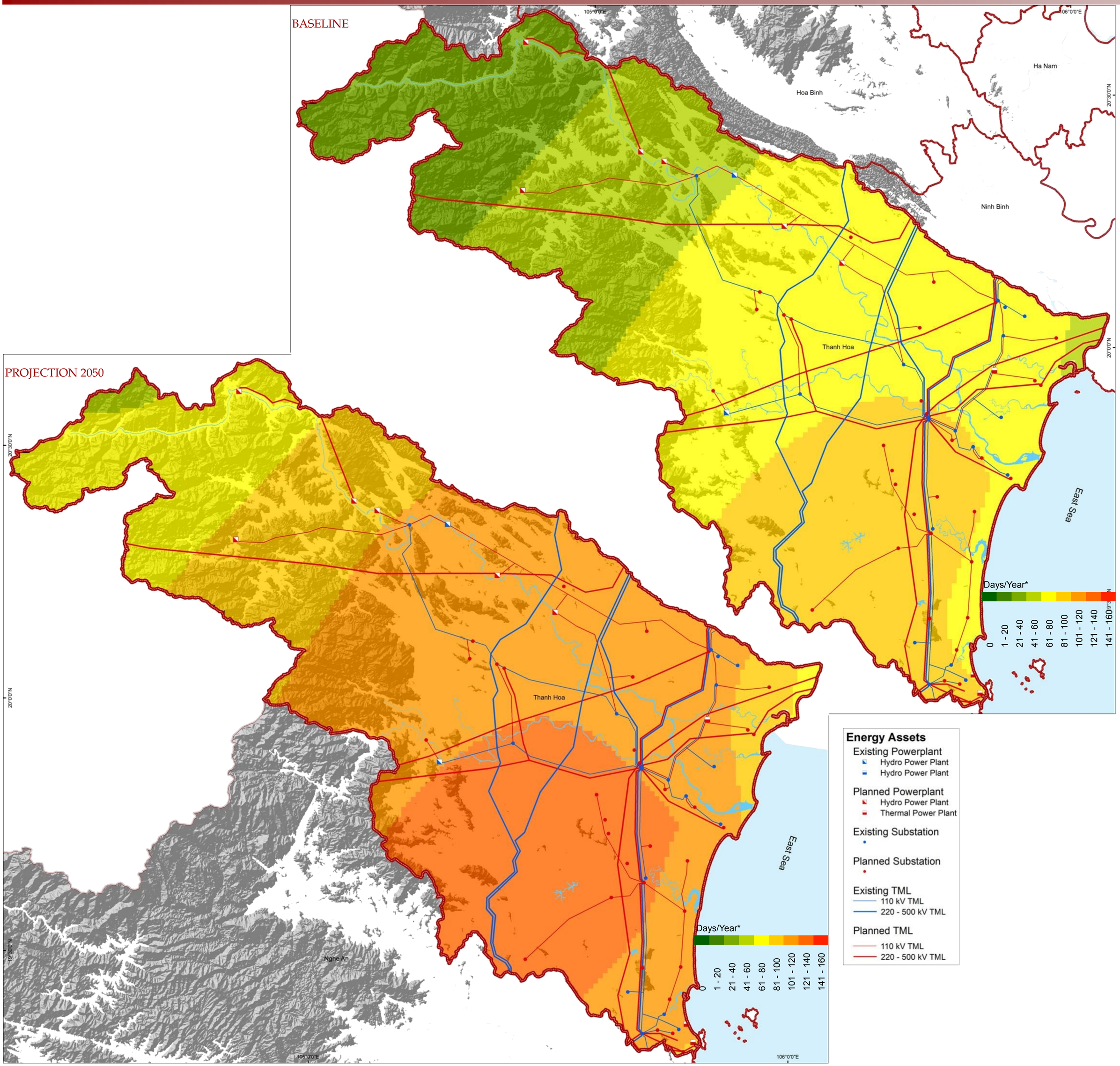


ENERGY - NUMBER OF HOT DAYS

BASELINE

PROJECTION 2050

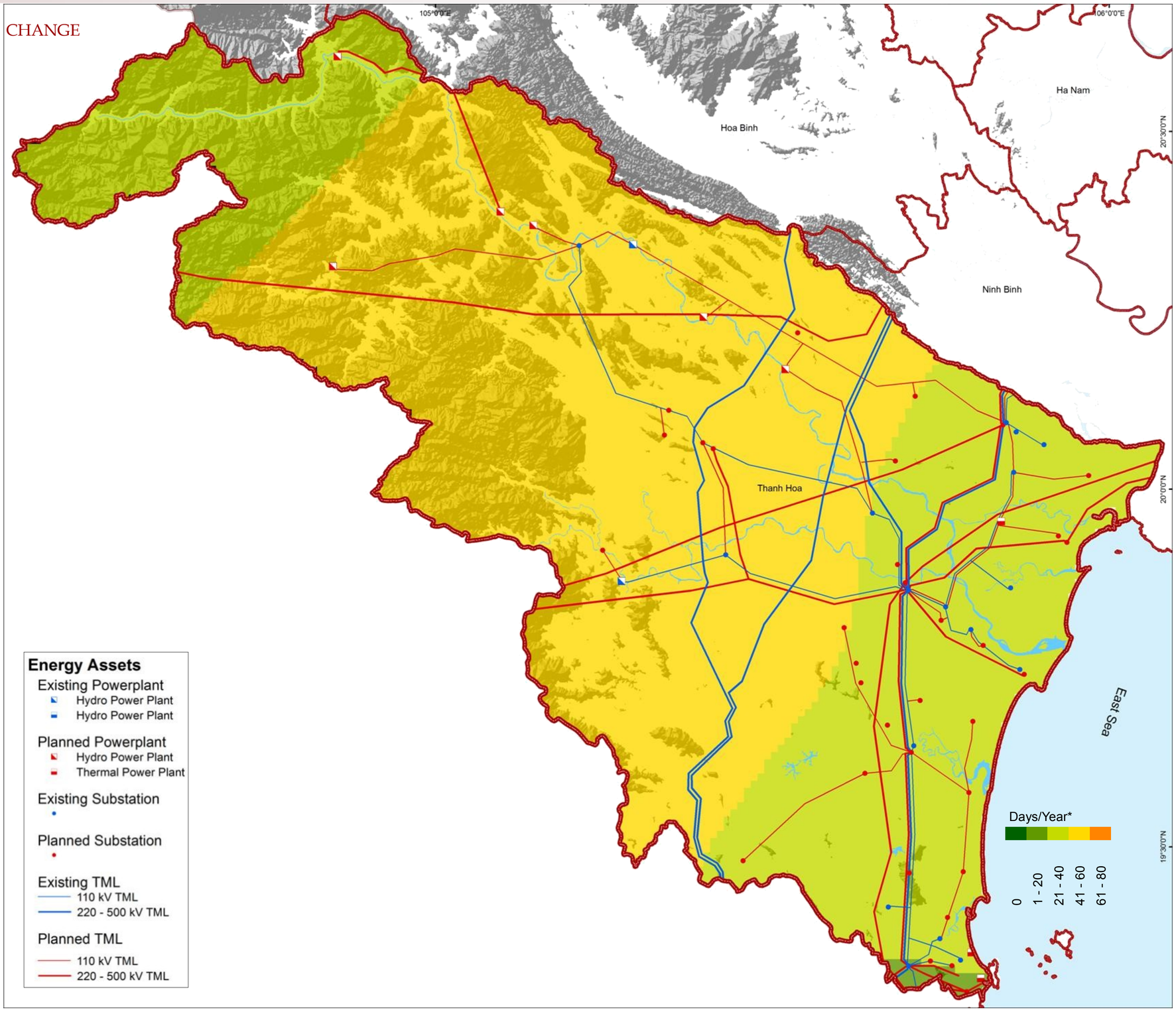


FUNDING AGENCIES

PARTNERS

COMPANIES

CHANGE



SUMMARY OF PROJECTED CHANGES

As for the sustained heat threat, the planned thermal plants in the coastal area of Thanh Hoa is most at risk from extreme heat, where about 21-40 more hot days annually are projected due to climate change from the current 81-120 in the baseline. Existing and planned transmission infrastructure is also at risk of transformer overheating causing reduced efficiency and operational lifetimes across the province, especially in central areas where up to 60 more hot days are projected. The risk to hydropower assets, which are also ranked medium and high for this threat, has been determined to be a lower order risk as field visits have confirmed that their powerhouses are usually not significantly affected.

DATA SOURCES

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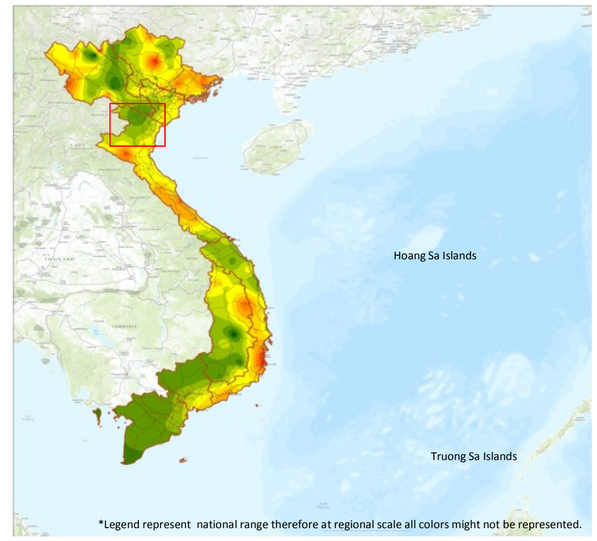


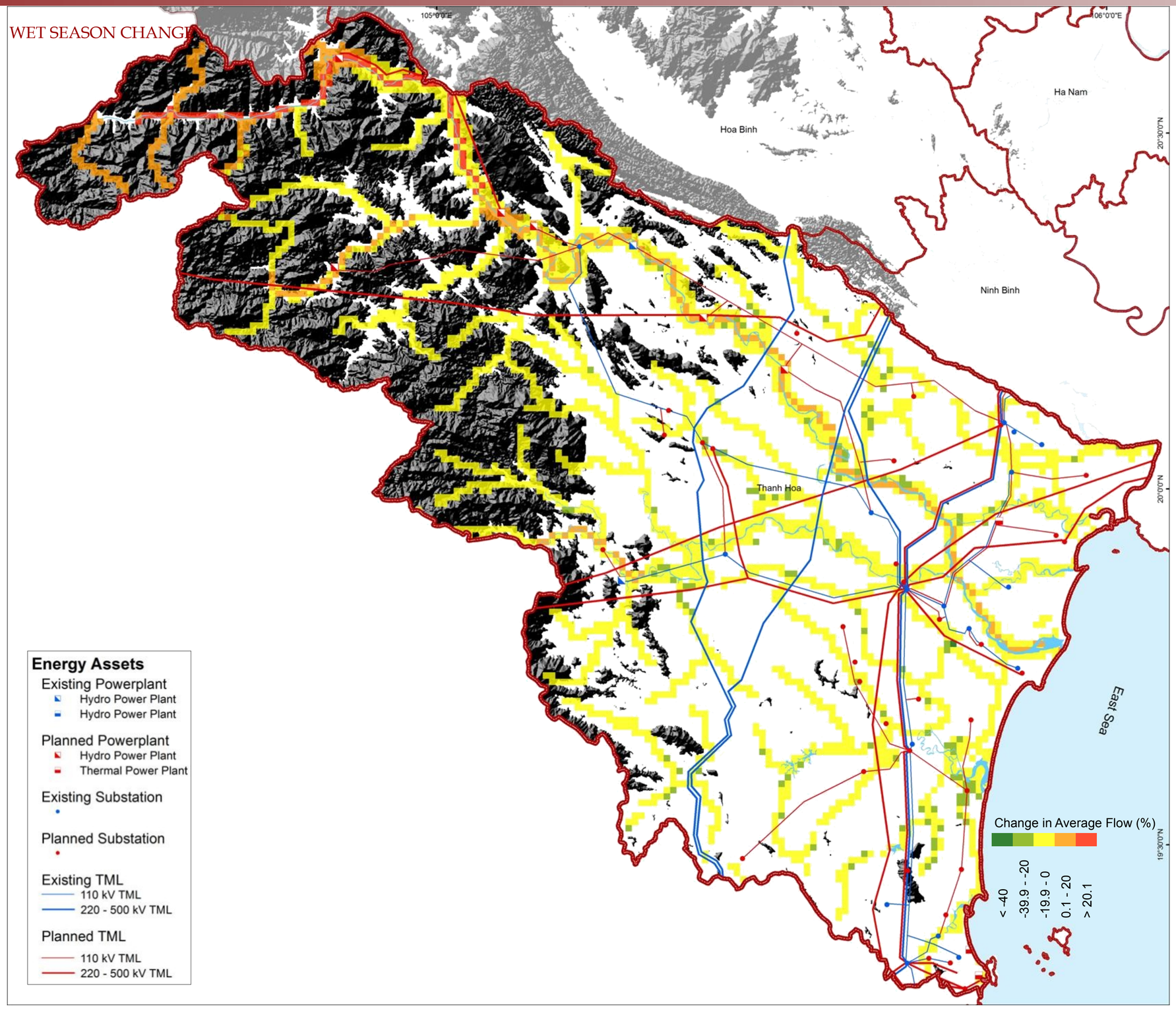
*Legend represent national range therefore at regional scale all colors might not be represented.

ENERGY - AVERAGE CHANGE IN RIVER DISCHARGE IN WET AND DRY SEASON

INTRODUCTION

The threat of increases or decreases in river discharge due to climate change is relevant to hydropower plants only, whose design is directly dependent on river flow. The national assessment, based on a proxy indicator wet season catchment yield, ranked all existing and planned hydropower as a medium impact.

As Thanh Hoa is planning a significant expansion of hydropower, further analysis of the flooding threat was undertaken in the provincial assessment using projected changes in wet and dry season flow rates in Thanh Hoa.



WET SEASON DISCHARGE

The change in wet season river flow, measured by average river discharge from May to November in the baseline and 2050, shows increases of up to 21.9% are experienced by the eight existing and planned hydropower plants in Thanh Hoa. The analysis shows that the six plants on the Ma River have a high risk from increased wet season flow rates due to climate change, as shown in the table.

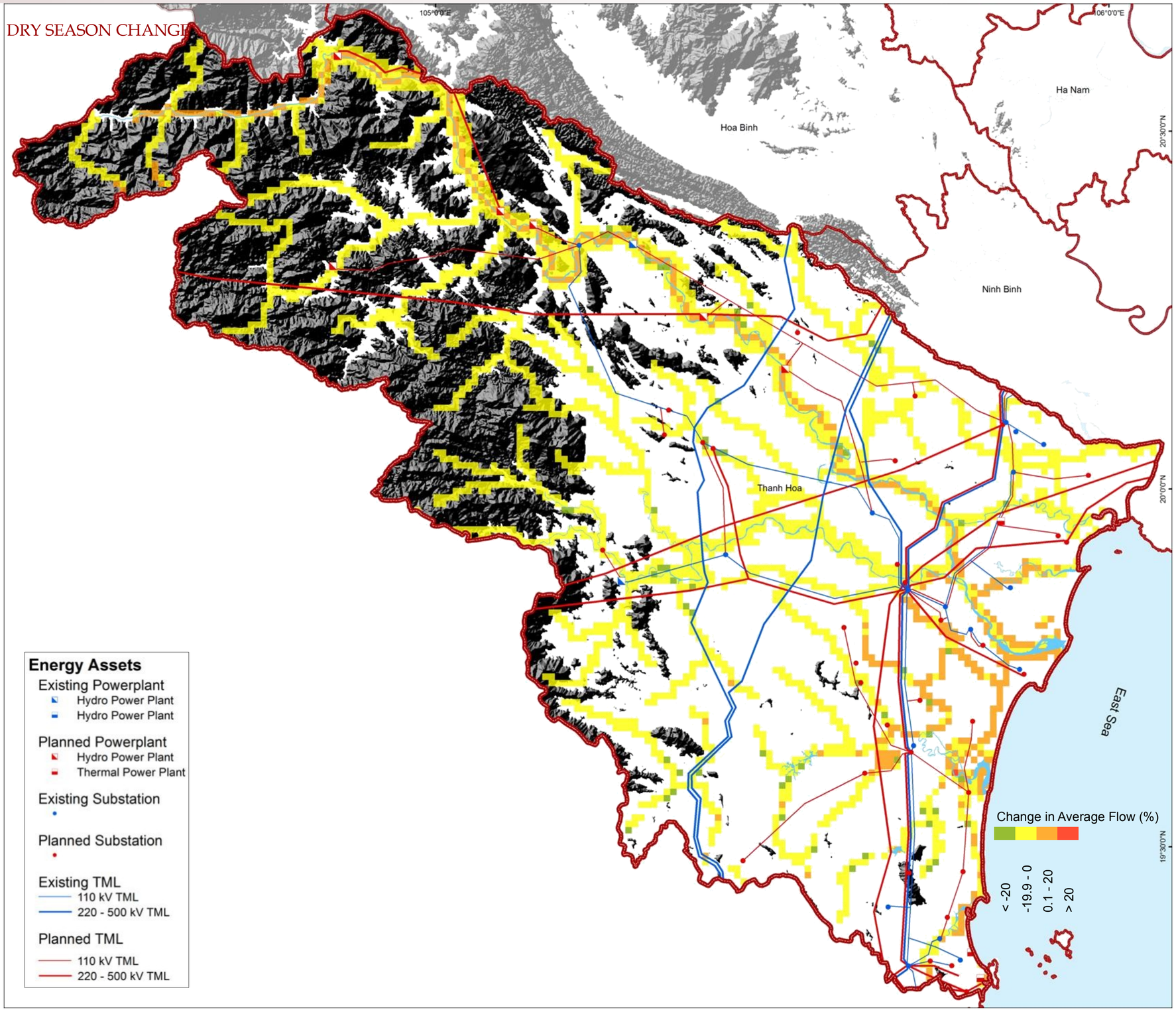
For these high risk hydropower plants, the increased river discharge may be greater than can be managed by the plants spillway capacity, which poses a risk to dam failure and catastrophic risks downstream. Some hydropower plants with large reservoirs can have a flood control benefit by storing flood discharge and releasing it more slowly, however, the benefits very much depend on good operational management and communication within plant cascades and downstream assets where large releases become necessary.

Of the existing hydropower plants, only Ba Thuoc 2 is forecast to be at high risk with an increase in average wet season discharge of 16.7%, while the other existing hydropower plant, Cua Dat was determined to be low risk. All but one of the planned hydropower plants are found to be at high risk of the increased wet season river discharge. The Thanh Hoa provincial assessment includes further detailed analysis of the Ba Thuoc 2 plant to analysis this and other threats, which can provide lessons for planned plants.

Plant name	Status	Average discharge (m^3/s) Baseline	Change (%) 2050	Risk
Cửa Đạt	Existing	256.5	0.5	Low
TD Song Luong III 1&2	Planned	48.3	0.9	Low
TD Cam Thuy 2	Planned	838.0	16.0	High
TD Cam Thuy 1	Planned	828.0	16.3	High
TD Ba Thuoc 2	Existing	814.8	16.7	High
TD Ba Thuoc 1	Planned	793.9	17.3	High
Hồi Xuân	Planned	750.2	18.5	High
Td Trung Sơn	Planned	637.8	21.9	High

DRY SEASON DISCHARGE

The change in dry season flow, measured by average river discharge from December to April in the baseline and 2050, shows minimal risk to Thanh Hoa's eight existing and planned hydropower plants. As shown in the table, only one plant, Song Luong III 1&2, is projected to experience a decrease in river discharge due to climate change, by 4.8%. This is not a significant impact and would result in a small reduction in generation output.



Plant name	Status	Average discharge (m^3/s) Baseline	Change (%) 2050	Risk
Cửa Đạt	Existing	147.8	0.0	None
TD Song Luong III 1&2	Planned	25.2	-4.8	Low
TD Cam Thuy 2	Planned	374.9	1.4	None
TD Cam Thuy 1	Planned	369.1	1.5	None
TD Ba Thuoc 2	Existing	361.0	1.7	None
TD Ba Thuoc 1	Planned	349.7	2.1	None
Hồi Xuân	Planned	324.1	2.6	None
Td Trung Sơn	Planned	267.3	4.5	None

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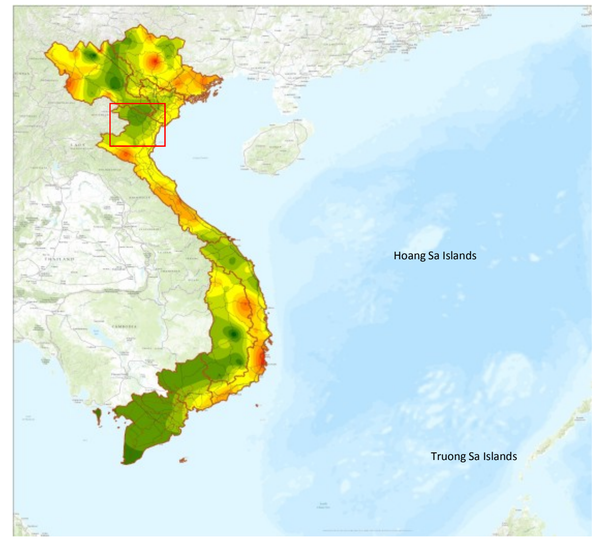
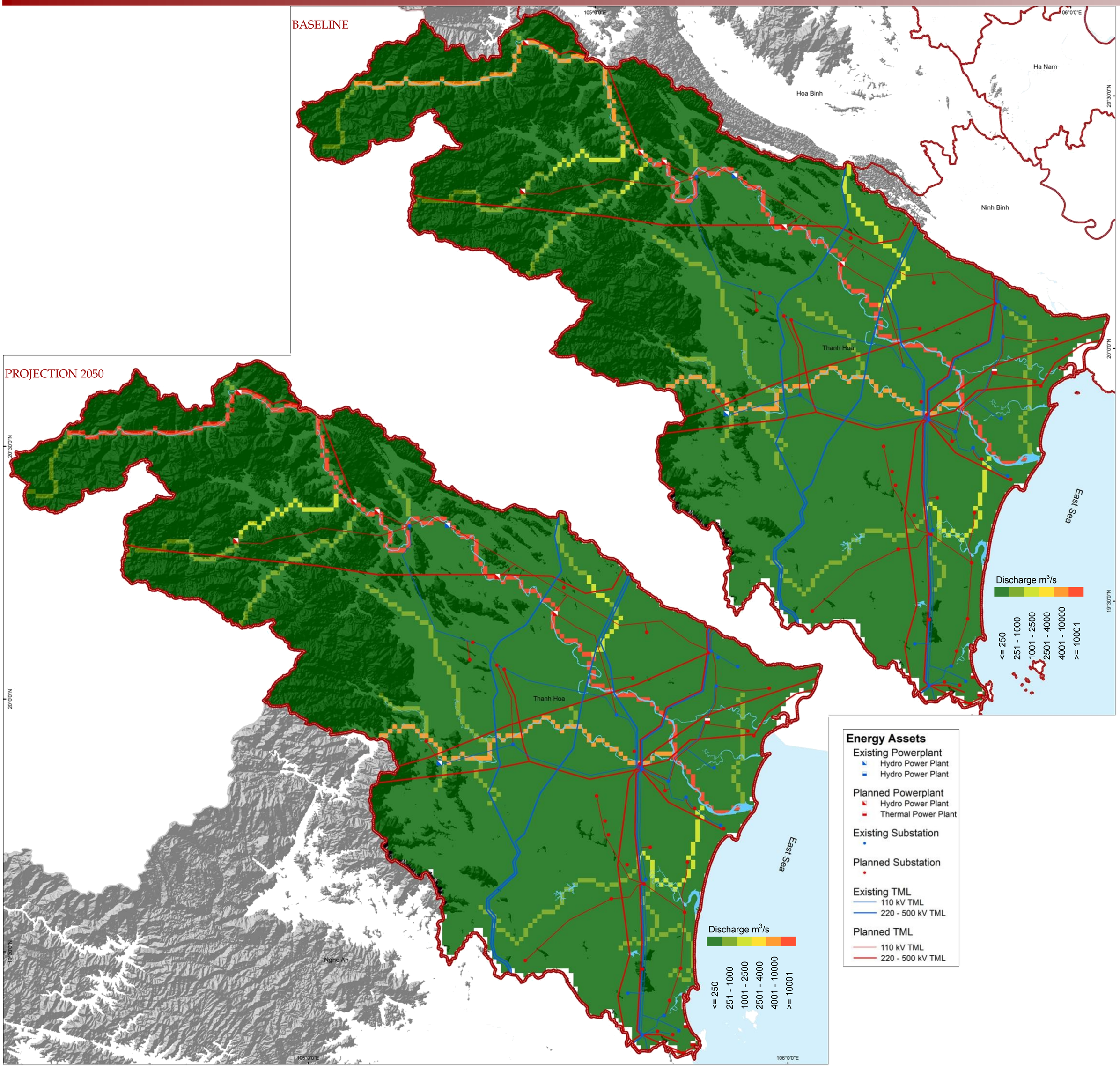


ENERGY - MAXIMUM DISCHARGE 100 YEAR

BASELINE

PROJECTION 2050



FUNDING AGENCIES

PARTNERS

COMPANIES

BASELINE

Extreme flooding, measured by maximum river discharge with a 100 year return period, was analyzed for Thanh Hoa to gain a better understanding of extreme riverine flooding in Thanh Hoa. In the baseline, this threat is shown to be pronounced on the Ma River, where six of the eight existing and planned hydropower plants are located. River discharge flow rates for this 100 year extreme flood are shown to range from 4,000 m^3/s in the upper reaches of the Ma River to more than 10,000 m^3/s further downstream. Other rivers in the province are shown to have extreme flooding flow rates of 4,000 m^3/s.

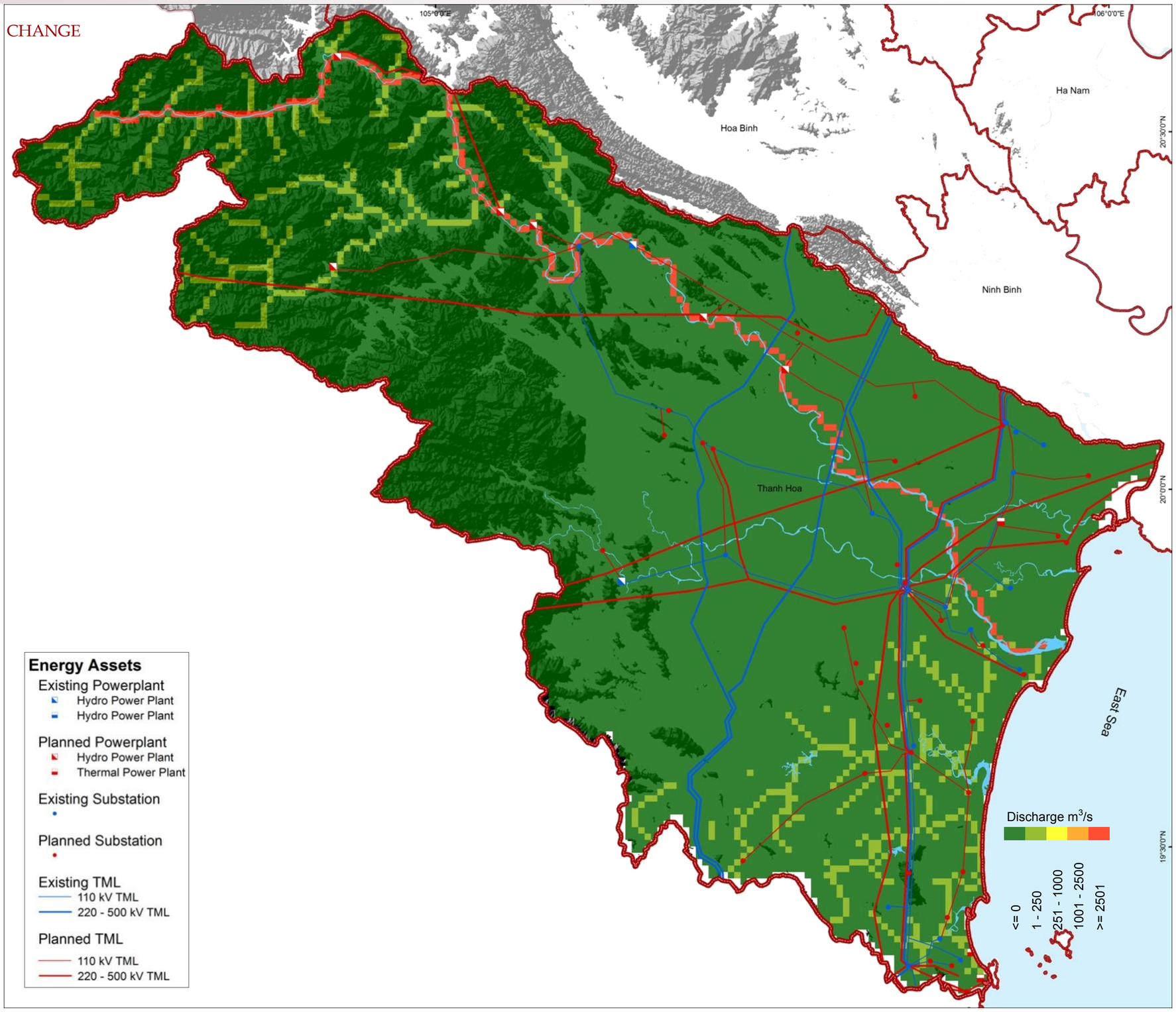
2050 SCENARIO

Climate change modeling projects that river discharge flow rates for this 100 year extreme flood will increase significantly due to climate change, especially on the Ma River where flow rates above 10,000 m^3/s are projected for its entire length. The increase due to climate change is projected to be over 2,500m^3/s for the Ma River, while its upper and lower tributaries are projected to experience smaller increases of up to 1,000 m^3/s.

SUMMARY OF PROJECTED CHANGES

Six of the eight existing and planned hydropower plants are on the Ma River and therefore exposed to this extreme flooding risk with high flow rates, based upon a 100 year return period. The provincial assessment for Thanh Hoa includes a detailed analysis of the Ba Thuoc 2 hydropower plant, the only existing plant on the Ma River, which shows that the plant is exposed to extreme flooding risk in the baseline with flow rates of 10,418 m^3/s and this is projected to increase to 13,525 m^3/s by 2050 due to climate change. When combined with the effect of flooding releases from the planned reservoir plant upstream, Trung Son, these extreme flow rates would exceed the spillway capacity of Ba Thuoc 2 by 6% in the baseline and 25% in 2050, which would result in overtopping of the dam wall (concrete) exposing the plant and the downstream to a risk of catastrophic dam failure.

CHANGE



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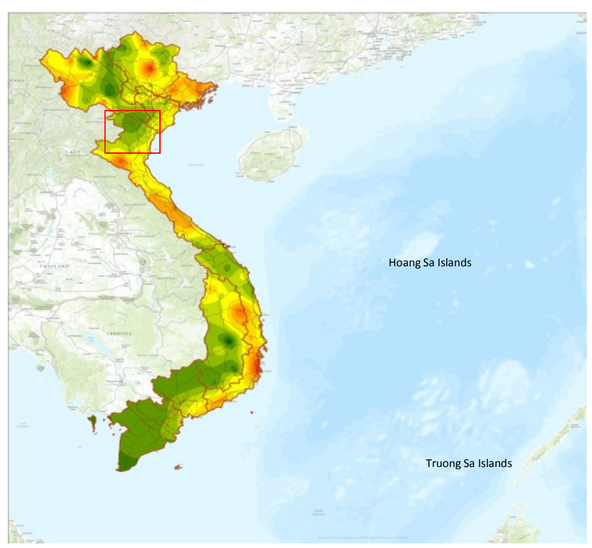
INDEX MAP