Draft Environment and Social Impact Assessment

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29 April 2022

Lao PDR: Monsoon Wind Power Project
Part 10: Main Report

Prepared by Impact Energy Asia Development Limited (IEAD) for the Asian Development Bank.

Monsoon Wind Power Project, Sekong and Attapeu Provinces, Lao PDR

Environmental and Social Impact Assessment

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ERM

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8.6.2 Risks from Climate Change

The objective of a climate change physical risk assessment is to understand the physical threats in terms of climate driven natural hazards likely to affect the said project.

Accordingly, this assessment was performed with an aim of qualitative evaluation of the natural hazards likely to affect the said projects under present (baseline) and future scenarios (climate change scenarios) of projected greenhouse gas emissions.

This assessment was conducted in accordance with the requirements of The Equator Principles. The Equator Principles Financial Institutions (EPFIs) support the objective of the 2015 Paris Agreement and recognize that EPFI's have a role to play in improving the availability of climate related information, such as the Recommendations of the Task Force on Climate Related Financial Disclosures (TCFD[150]) when assessing potential transition and physical risks of the projects financed under the Equator Principles. Equator Principles states that the Climate Change Risk Assessment should be aligned with Climate Physical Risk and Climate Transition Risk categories of the TCFD (Equator Principles 2020).

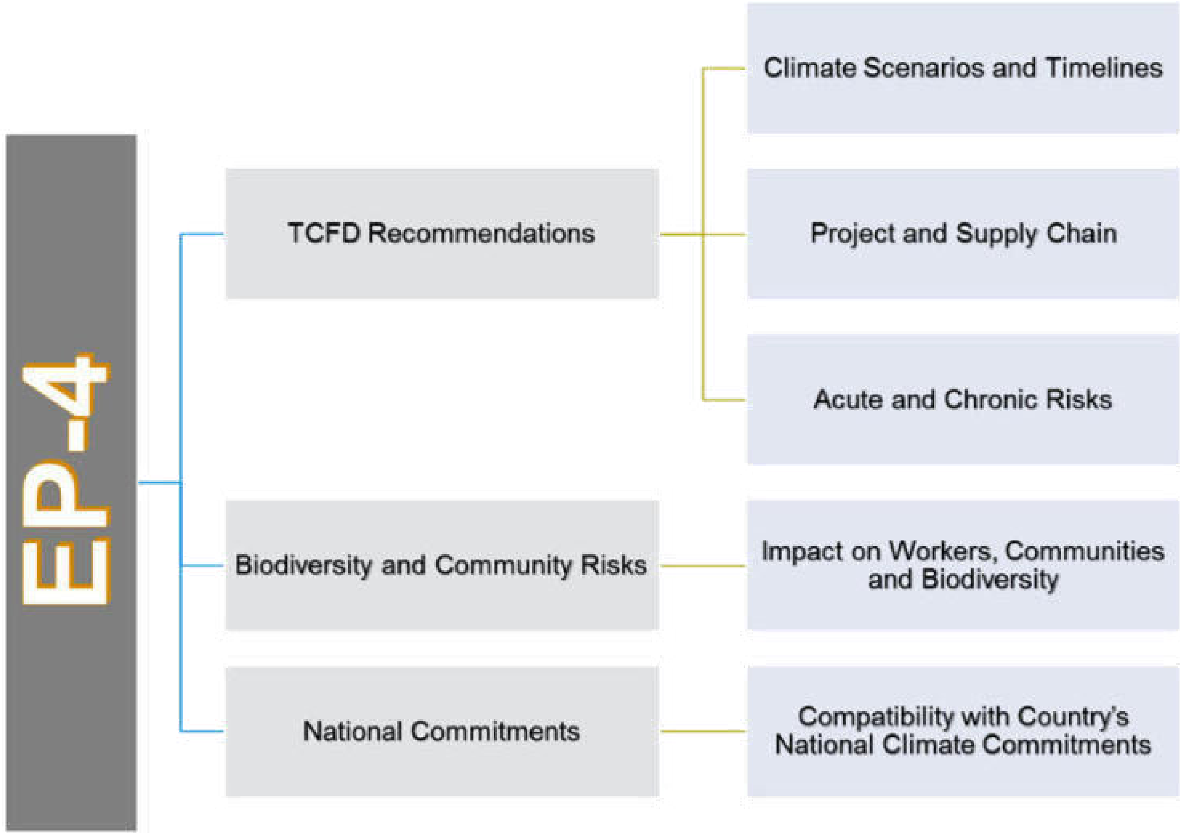
EP-4 is a risk management process that facilitates the process of determining, assessing and managing environmental and social risks risk in financing major projects. It provides a minimum standard for due diligence to support responsible risk decision making. The key features of EP-4 which relate to physical risk assessment are summarised below-

- The framework recognizes the importance of biodiversity, human rights, and climate change. As per EP-4, negative impacts on project that affects ecosystem, communities, and the climate should be avoided where possible. If these impacts are unavoidable, then the process considers how these can be minimized, mitigated and/or offset.
- In reference to climate change, the EP-4 recommends the developer to include assessment of potential climate change risks as part of ESIA or other assessment. The depth and nature of the climate change risk assessment is reported to depend on the type of Project as well as the nature of risks, including their materiality and severity. Further, climate risk assessment is required to be aligned with climate change physical risk and climate transition risk categories of the TCFD. Additionally, the climate risk assessment is required to consider the Project's compatibility with the host country's national climate commitments, as appropriate.
- TCFD recommends assessment of financially material climate related physical risks including acute and chronic risks over different relevant time horizons and scenarios including 2°C or lower scenario. The assessment may include impacts on products and services, supply chain and/or value chain, adaptation and mitigation activities, investment in research and development, and operations.

Figure 8.61 provides an overview of EP-4 in relation to the physical risk assessment.

[150] TCFD, 2017. Implementing the Recommendations of the Task Force on Climate-related Financial Disclosures. Available at: https://www.fsb-tcfd.org/wp-content/uploads/2017/06/FINAL-TCFD-Annex-062817.pdf

Figure 8.61 Key Components of EP-4 Related to Physical Risk Assessment



This assessment was conducted with the following objectives.

- Evaluate and identify the potential hazards to the Project arising from current and future climate variables for the site and the supply chain network;
- To understand the likely implications of theses hazards on proposed project, communities and ecology in the surrounding area;
- To assess any implication of the project which may exacerbate climate change impacts on climate change of communities and ecology; and
- To evaluate how the present project considerations can accommodate potential impacts of climate change in terms of physical risks.

8.6.2.1 Area for Assessment

The Area of Assessment for the Climate Change Risk Assessment (hereinafter referred to as 'CCRA') was selected based on the TCFD's recognition that physical risk can have a wide range of financial implications: supply chain disruption, impacts on availability of raw material and other natural resources, etc.

Accordingly, the study area was selected to include the major project components from all Assets as presented in ***Table 8.89***, while all Key Assets were included in one single Study area.

Table 8.89: Key Project Assets

Study Area	Assets	Major Components
Wind Turbines concession area, transmission line route, and access roads	1. GW-155-4.5MW 8. GW-165-4.0MW	2. Wind Turbine (WTG) 3. Inverter 4. Transmission Lines and Towers 5. Storage Room 6. Site Office 7. Access Road

8.6.2.2 Potential Risks

Overview of Climate Change Physical Risks in Laos DPR

Natural Hazards Profile

Lao is vulnerable to a wide range of natural disasters. Floods, including flash floods, severe storms, monsoons, and landslides are prevalent in the country. Additionally, Lao is susceptible to droughts, earthquakes, and epidemics with varying degrees of impact and severity in different regions.

The frequency of the extreme weather events in Lao PDR increased from about once every two years before 1992 to every year or even twice a year after 1992. Approximately three-fourths of the disasters in Lao PDR have been climate related. During 1966 to 2009, flooding was the most frequently occurring climate change hazard, followed by storms and drought.

Most storms are followed by severe flooding, threatening livelihoods almost every year, and with more frequent and intensified flooding in recent years. Flash floods in the northern mountainous areas are common (such as in the Project Area). Flooding has an adverse impact on housing, health and education, industrial activities, and infrastructure.

Lao PDR is also experiencing increasingly frequent episodes of drought, with shortages or delays in rainfall contributing to water stress. Severe droughts occurred in 1996, 1998 and 2003. It is estimated that 6 out of 17 provinces are already at high risk of droughts.

Climate Change Projections

As reported in Lao PDR's Country climate profile[151], climate change projections indicate a fairly quick and drastic change in the spatial distribution of bioclimatic conditions across the northern and mountainous regions of the country (in which the Project is located). A significant warming and modification of rainfall patterns is predicted for 2030, with further intensification in these trends by 2060.

Temperatures are projected to increase across the country as well as in the Lower Mekong Basin and across seasons. By 2060, the average annual temperature basin-wide increase could be as low as 0.1˚C or as high as 4.0˚C depending on the global emissions trajectory and pattern of changes that follow.

[151] https://climateknowledgeportal.worldbank.org/sites/default/files/2021-06/15505-Lao%20PDR%20Country%20Profile-WEB.pdf

Rainfall could increase or decrease with significant variation in the magnitude of change and the location of impacts. Average change in rainfall by 2060 under the dry and high emission scenario is projected to be 1.7%, under the wet, and high emission scenario up to +6.0% in the most part of the country.

Climate Change Risks in Lao PDR

Eckstein (2021)[152] ranked Lao PDR 45th based on overall climate risk. Lao PDR's rank based on fatalities per 100000 inhabitants was evaluated to be 28, rank based on losses in million USD was evaluated to be 86, and rank based on losses in GDP as percentage was evaluated to be 66. The ranking was developed based on evaluation of data from 180 countries. This indicates that Lao PDR falls within top 30% of the countries in the world with highest exposure to climate related physical risks.

Climate Change Risks to Wind Farms

Climate change is causing more frequent and more severe extreme weather events, increasing the likelihood of critical coping thresholds being exceeded. Wind Energy projects may suffer infrastructure damage, project delays and constraints on water supplies, lost production/ generation, power supply transmission disruption, and variability in energy generation. Threats to health and safety of employees, business reputation, violation of regulatory standards, social license to operate and financial disruptions may become more prevalent. ***Table 8.90*** presents the potential impacts of different climatic parameters on a typical wind energy project.

Table 8.90: Potential Impacts on Wind Energy Sector

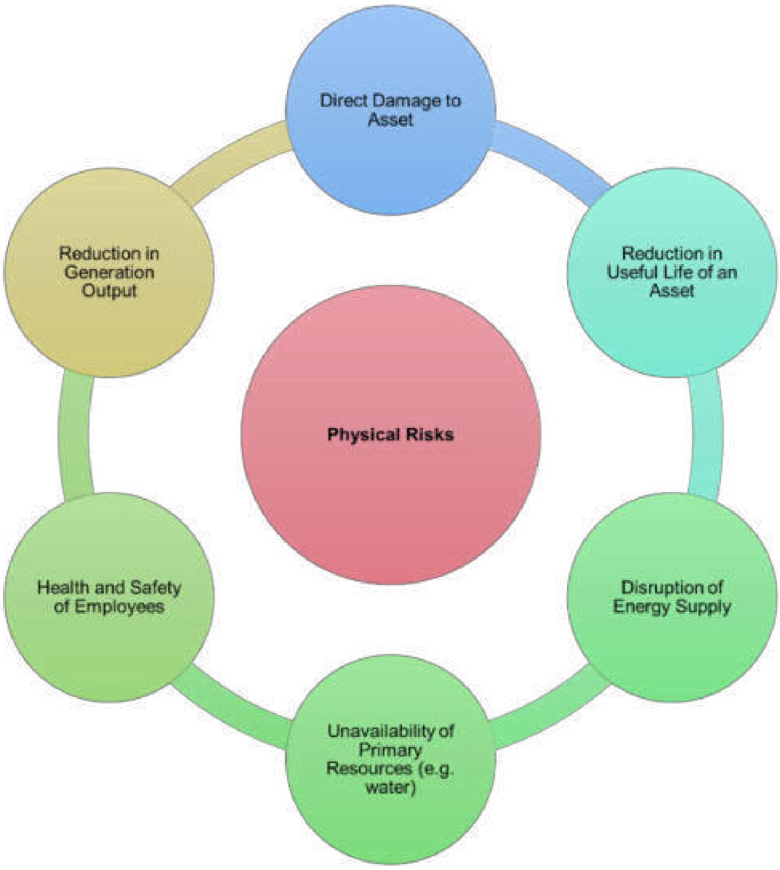
Wind Power	
Wind speed	• Changes in wind speed can reduce generation (turbines cannot operate in very high or very low winds) • Within operational wind speeds, output is greatly affected by wind speed. • Changes in wind patterns and duration affect output (e.g., ability to forecast output)
Air temperature	• Changes in extreme cold periods can affect output (e.g., through turbine blade icing)
Storm surges	• Damage to offshore wind farms
Extreme events	• Damage to infrastructure • Difficult access to offshore locations (e.g., for maintenance)

Source: ADB (2013), Guidelines for Climate Proofing Investment in the energy Sector

Figure 8.62 presents the general risks on wind energy projects as a result of climate change. Anticipated impacts of these changes in climate were reported to be flooding, damage to building construction, disruption of energy transmission, increased insurance premiums, higher operating costs, early retirement of assets, decreased production capacity, and high variability in availability of water.

[152] David Eckstein, Vera Kunzel, and Laura Schafer, Global Climate Risk Index. 2021. https://germanwatch.org/sites/default/files/Global%20Climate%20Risk%20Index%202021_2.pdf

Figure 8.62: General Risks from Climate Change to Wind Farms



ADB's Guidance on Climate Proofing Investment in Energy Sector

Energy production and distribution can be highly vulnerable to impacts of climate change through various phases of the project including designing, construction, and operations. Insufficient attention to these impacts may result in increased long-term costs of energy sector investments and reduce the benefits that these investments could deliver.

Therefore, ADB published a guidance document on Climate Proofing of Investment in Energy Sector in May 2013, with an aim to assist its developing member countries (DMC) to enhance the climate resilience of vulnerable sectors including energy sector153.

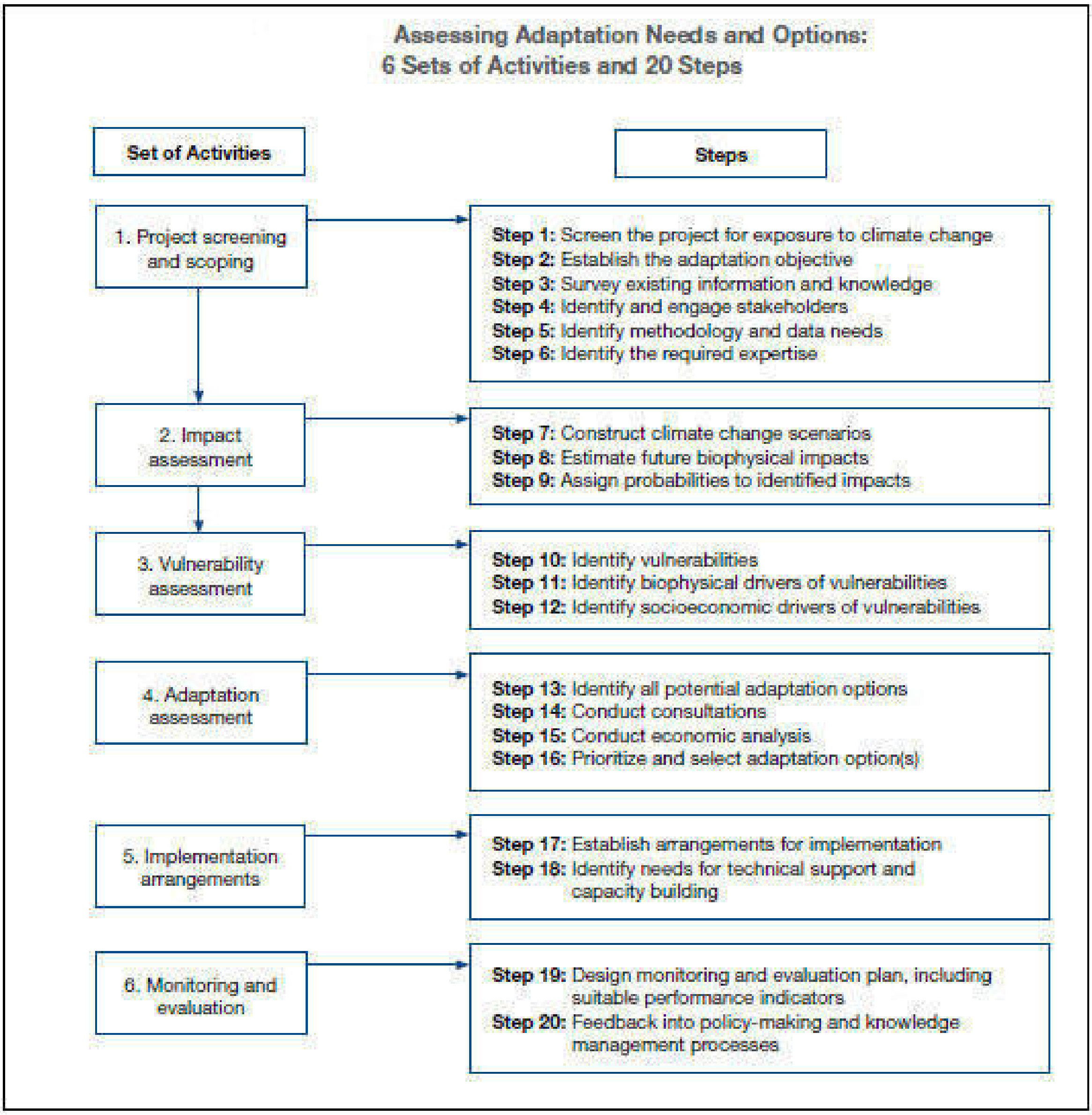
A climate change assessment is deemed to be best integrated into the activities of the project at concept stage. The methodological approach for Climate risk screening and scoping presented in this Guidelines for building adaptation into energy investment projects is divided into six different sets of activities as presented in Figure 8.63. The process begins with scoping the project and defining the assessment and its objectives. The core activities related to project design fall under impact assessment, vulnerability assessment, and adaptation assessment. Finally, the process ends with defining implementation arrangements and monitoring frameworks.[154]

However, the scope of present assessment is limited to screening level assessment of natural hazard and climate change physical risks as presented in. The screening level assessment is followed by identification of high level implications of the climate related physical risk on the project.

[153] https://www.adb.org/sites/default/files/institutional-document/33896/files/guidelines-climate-proofing-investment-energy-sector.pdf

[154] https://www.adb.org/sites/default/files/institutional-document/33896/files/guidelines-climate-proofing-investment-energy-sector.pdf

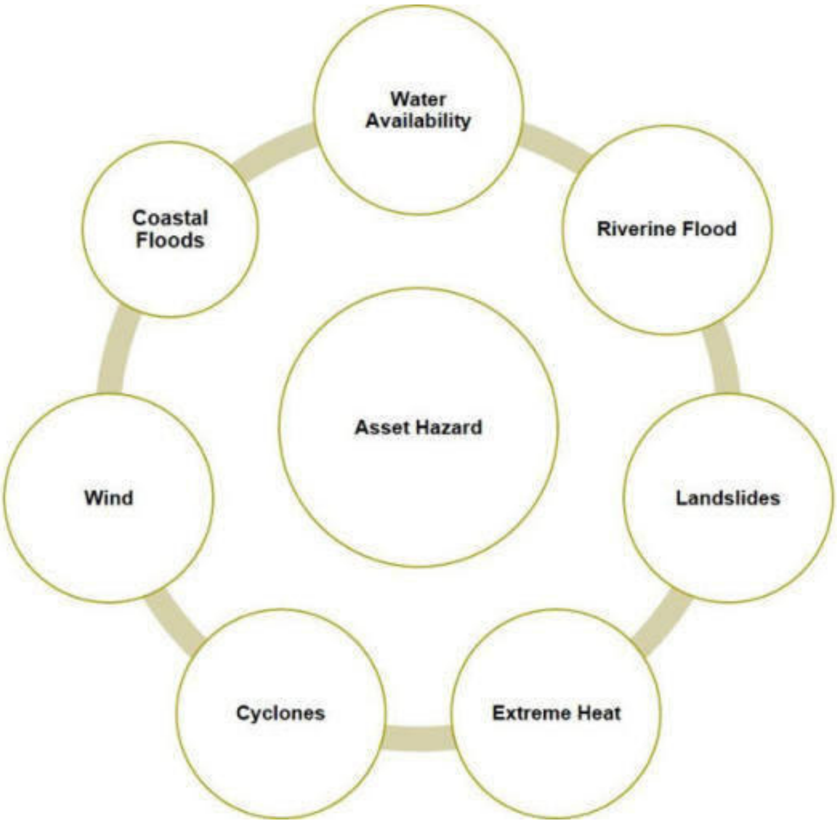
Figure 8.63 Climate Change Risk Assessment Methodology



Approach

The assessment in general starts with the collection of geospatial information for the Study Area to be assessed. Present study aims at evaluation of natural hazards which are likely to be experienced along various roads under the purview of Project Astro (***Figure 8.64***).

Figure 8.64: Hazards Evaluated in this Assessment

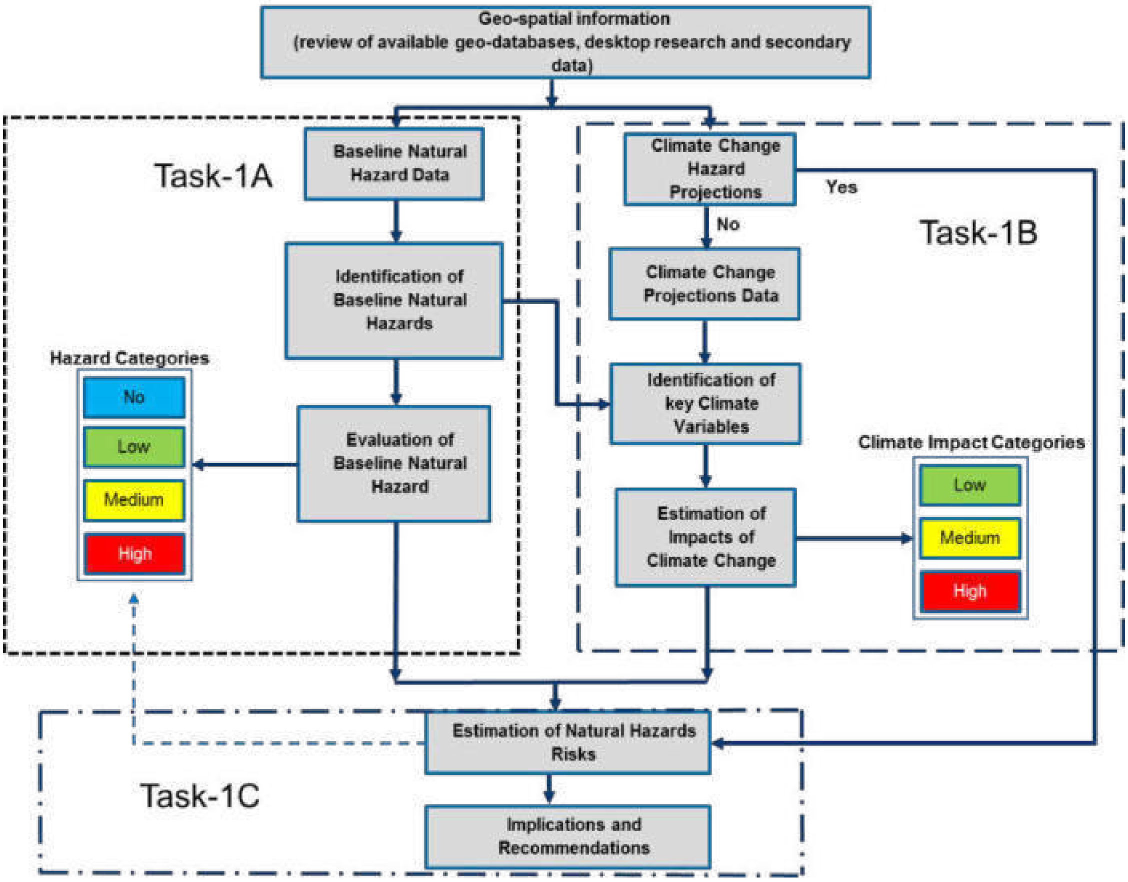


Based on the geospatial information, baseline natural hazards and the climate change projection data was collected and collated. It should be noted that the present assessment utilizes data sources which are readily available as open source. A brief description of the various steps performed in this study is provided below.

- Task – 1A: The first step focuses on evaluation of historical data on natural hazards in the area of interest to evaluate the existence and magnitude of identified natural hazards. This assessment was performed qualitatively based on the availability of historical data. The potential impact of each natural hazard was evaluated on a scale of three levels categorized as **Low, Medium, and High.** The hazard categorization was based on the potential impact on built and natural environment considering intensity/ magnitude, and/or frequency of the hazard in the region.
- Task – 2A: The second step constitutes evaluation of climate change projections to assess the extent of changes in climatic variables such as precipitation, and temperature. This provided information on any significant changes in temperature and precipitation in the upstream of the Site which may have impact on the Site operations in future.
- Task – 3A: The third step involves the evaluation of baseline risk from each natural hazard; the outputs from climate change projections are overlaid qualitatively on the baseline conditions for each hazards to categorize the climate change risk using only the hazard intensity.

Figure 8.65 provides the framework for the current assessment for the extraction of historical and projected data, evaluation of baseline natural hazards and superimposition of climate change projections. The final output is in terms of a semi-quantitative hazard matrix which presents cumulative hazard levels for each study area under baseline and climate change scenario. Based on this outcome, ERM evaluated the high-level implications and the corresponding recommendations for the project components.

Figure 8.65: General Framework for a Natural Hazard and Climate Change Impact Assessment



It should be noted that the present assessment does not aim at a detailed evaluation of asset specific climate related hazards or adequacy of existing design consideration and management plans to adapt the climate change impacts. However, it provides a high level understanding of various natural hazards which are likely to be experienced under baseline and climate change scenario in the areas/ regions in which the Project is located.

Natural Hazard and Climate Change Assessment

This section documents the baseline for natural hazards based on historical data from global, regional, and national databases followed by qualitative evaluation of impacts of climate change on natural hazards.

It should be noted that this is a very high-level review of publicly available information and no detailed site-specific analysis or modelling has been undertaken. Hence, further investigation may be required to quantify the risks in more detail for consideration of adaptation measures.

The likely changes in natural hazards presented here are based on the possible relation between the natural hazards and climatic parameters.

Water Availability

Availability of water is critical to any type of development as water is required throughout the various phases of the project i.e. construction and operational phases. Water availability in itself is not a hazard. However, unavailability of water may impact the project operations as well as health of people working at the project and nearby communities.

Water availability may be impacted by drought i.e. reduced water supply due to below normal rainfall and high evapotranspiration rates, high competition among for common water resource among multiple stakeholders including industry, agriculture and domestic, and seasonal variability

- **Baseline Water Availability**

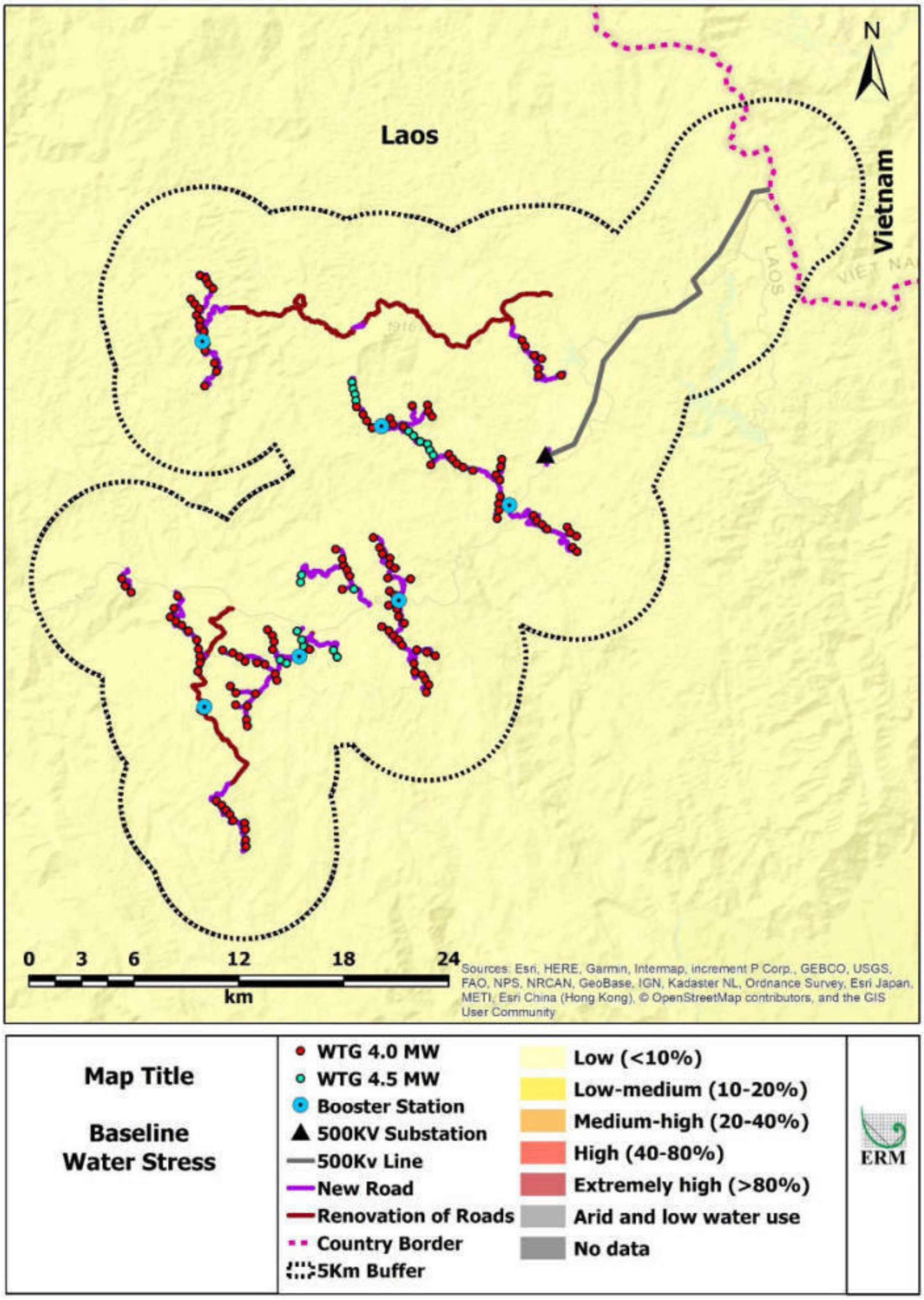
The baseline water stress map as presented in ***Figure 8.66*** indicates 'Low' water stress within the study area. Low baseline water stress may be considered to indicate higher availability of water resources or low competition for common water resource.

Water stress is a good indicator to indicate the competition for available water resource and overall availability of water. However, water availability may vary from season especially for countries dependent on seasonal rainfall. Seasonal variability results in higher availability of water during rainy (wet) season and lower availability of water (drought like conditions) during lean period. This may result in acute water scarcity during the lean periods. Therefore, in addition to the water stress parameter, seasonal variability was also assessed as part of present assessment.

The seasonal variability map presented in ***Figure 8.67*** indicates 'Medium-High' seasonal variability in the study area. Accordingly, the hazard towards availability of water due to seasonal variability is considered to be '***High'*** on a conservative basis.

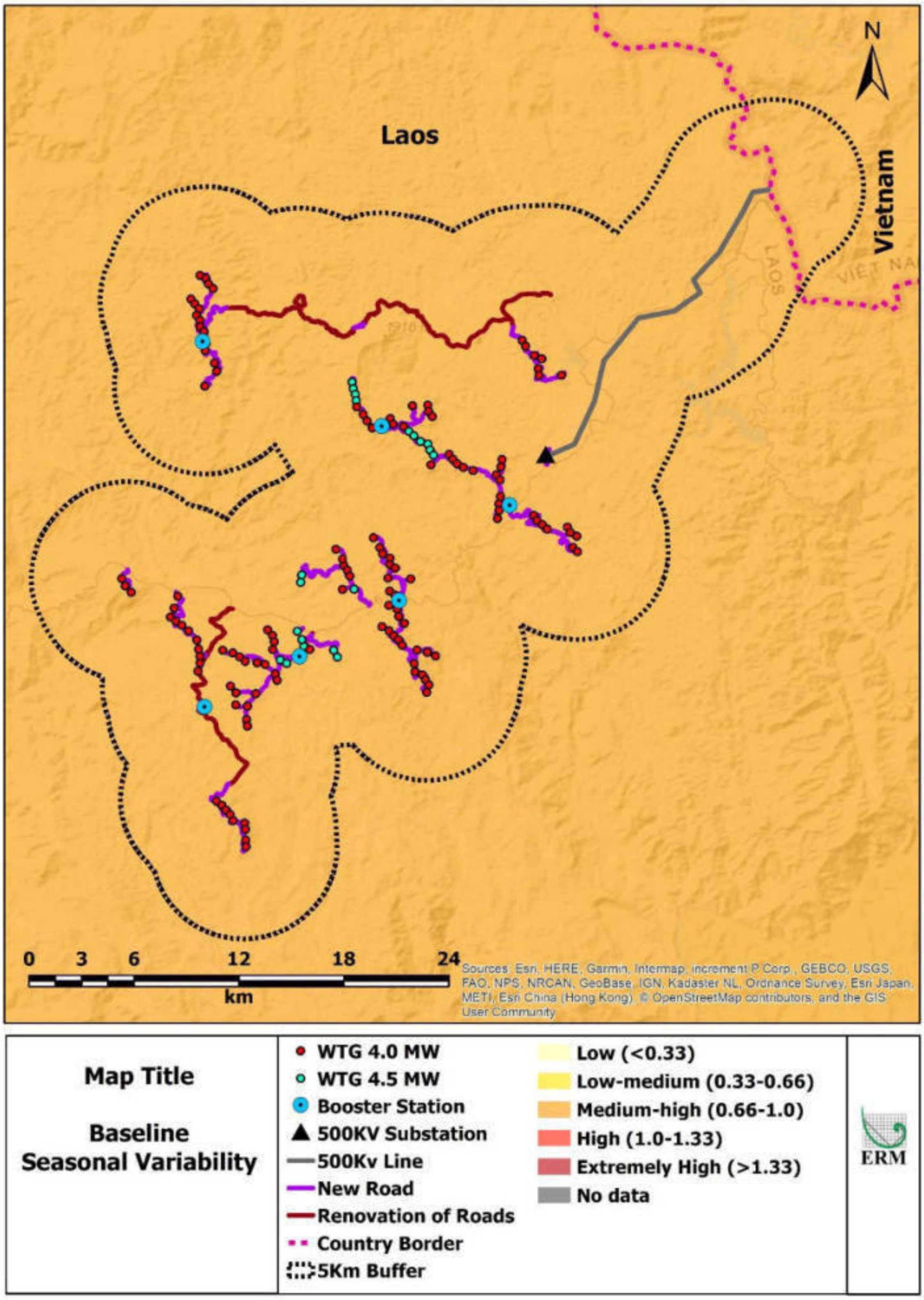
The above evaluation indicated that the area is exposed to 'Low' water stress which is likely to be due to low water usage within study area. A review of satellite imagery (Google Earth) indicated that the area under consideration is mostly covered by forest with sparse rural development and agriculture in neighbouring areas. Hence, no intensive water usage is expected in this region. Therefore, considering the Low water usage in the study area, seasonal variability is not likely to have significant impact on overall availability of water. In addition, the wind project is likely to require relatively large quantities of water only during construction phase, and not during its operations. Therefore, overall hazard towards availability of water is considered to be '**Low**' under baseline conditions.

Figure 8.66: Baseline Water Stress



Source: WRI-Aqueduct Water Risk Atlas

Figure 8.67: Baseline Seasonal Variability



Source: WRI-Aqueduct Water Risk Atlas

- **Climate Change**

Climate change projections for average annual rainfall indicated increasing trend under all climate change scenarios except under RCP 8.5 in 2030. Rainfall under RCP 8.5 in 2030 timeframe indicated a slight decrease (-0.06%). However, projections for evaporation indicated a slightly higher increase as compared to annual rainfall under all climate change scenario. Higher, evaporative losses are likely to be due to increase in average and maximum temperature, and longer warm spells. As a result, net annual rainfall i.e. difference between annual rainfall and evaporation indicated deceasing trend as presented in ***Table 8.91.***

Table 8.91: Climate Change Projections for Annual Rainfall and Evaporation

Parameter	RCP 4.5		RCP 8.5	
	2030	**2050**	**2030**	**2050**
Annual Rainfall	1.6	2.7	-0.06	2.9
Annual Evaporation	1.9	3.2	1.6	3.5
Net Annual Rainfall	-7.0	-9.1	-37.8	-8.7

Climate change projections for water supply under RCP 4.5 and RCP 8.5 scenario during 2030 and 2040` timeframes as presented in ***Figure 8.68*** to ***Figure 8.71*** indicate no significant change. Whereas, as presented in ***Figure 8.72*** to ***Figure 8.75***. Climate change projections for water demand under all climate change scenarios indicate likely increase by 1.2 x from the baseline. Increased water demand with no significant increase in water supply (renewable water) is likely to result in increased water stress in future.

However, climate change projections for water stress under RCP 4.5 and RCP 8.5 scenarios during 2030 and 2040 timeframes indicate water stress to remain 'Low' as presented in ***Figure 8.76*** to ***Figure 8.79***. Therefore, the hazard due to water stress is evaluated to be 'Low'. The Low water stress under the increased water usage scenario may be attributed to initial Low water usage against the available water under baseline conditions.

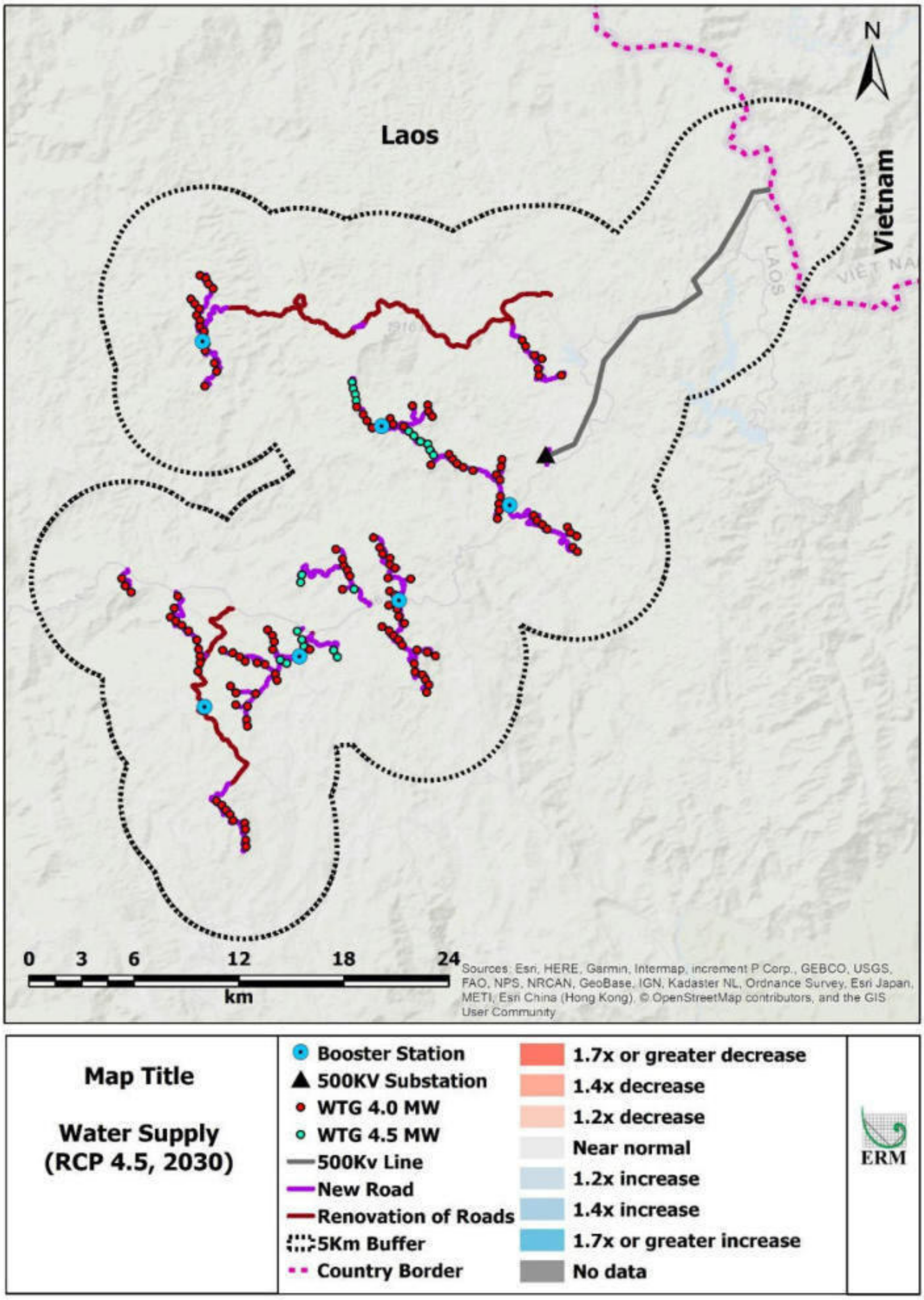
Seasonal variability on the other hand is projected to increase from 'High' to 'Extreme-High' as presented in ***Figure 8.80*** to ***Figure 8.82*** under RCP 4.5 and RCP 8.5 scenarios through 2040. Accordingly, hazard due to seasonal variability is considered to be '***High'***.

However, as discussed earlier as indicated by the land use pattern in the region, and Low water usage as indicated by Low water stress, seasonal variability is not likely to have significant impact on availability of water in general. In addition, the water requirement of the project during operational phases is likely to be significantly lower than during the construction phase. Hence, the hazard due to availability of water is considered to remain 'Low' under all climate change scenarios (***Table 8.92***).

Table 8.92: Summary for Hazard Due to Water Availability under Baseline and Climate Change Scenarios

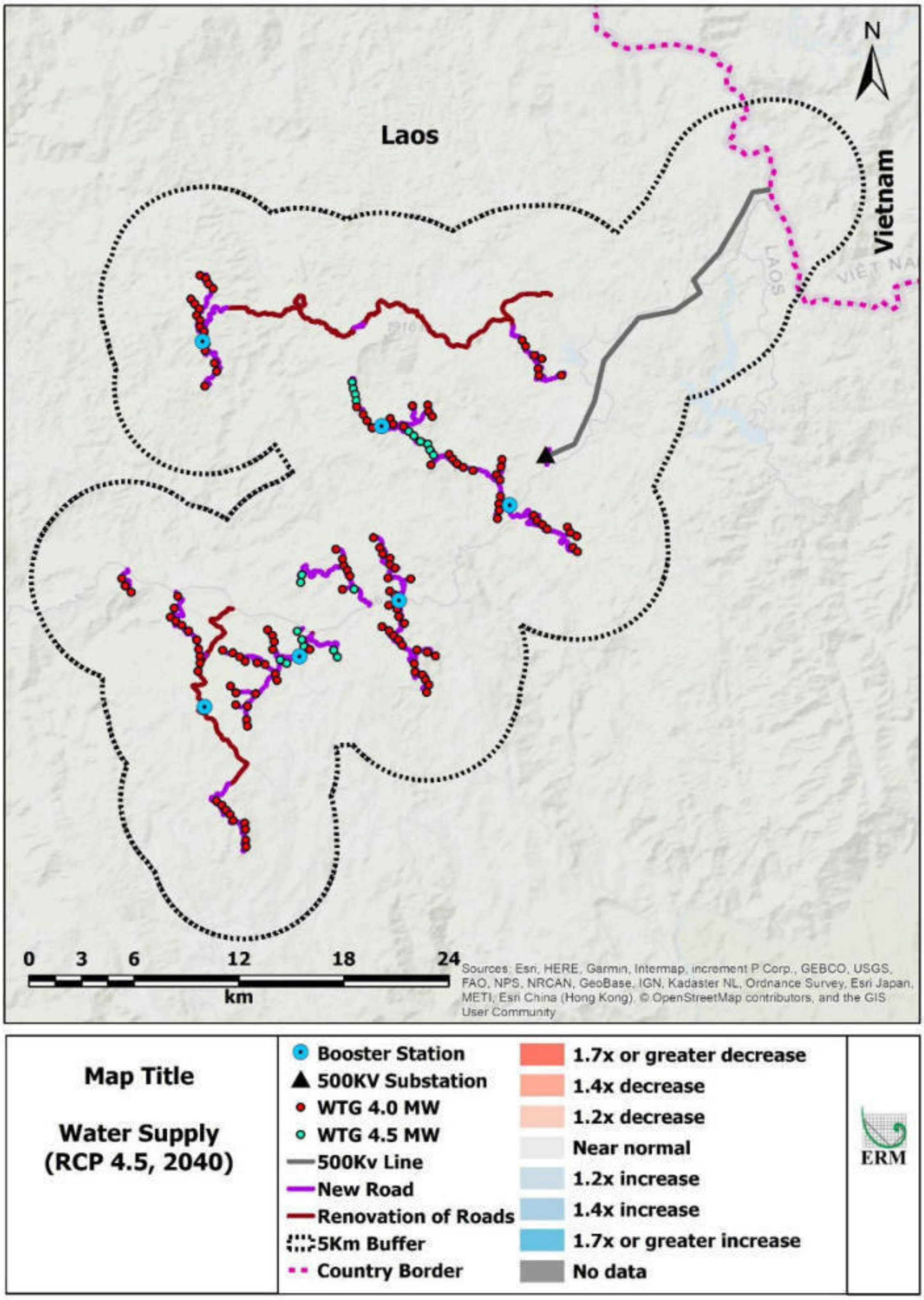
Baseline	RCP 4.5		RCP 8.5	
	2030	2050	2030	2050
Low	Low	Low	Low	Low

Figure 8.68: Water Supply RCP 4.5/2030



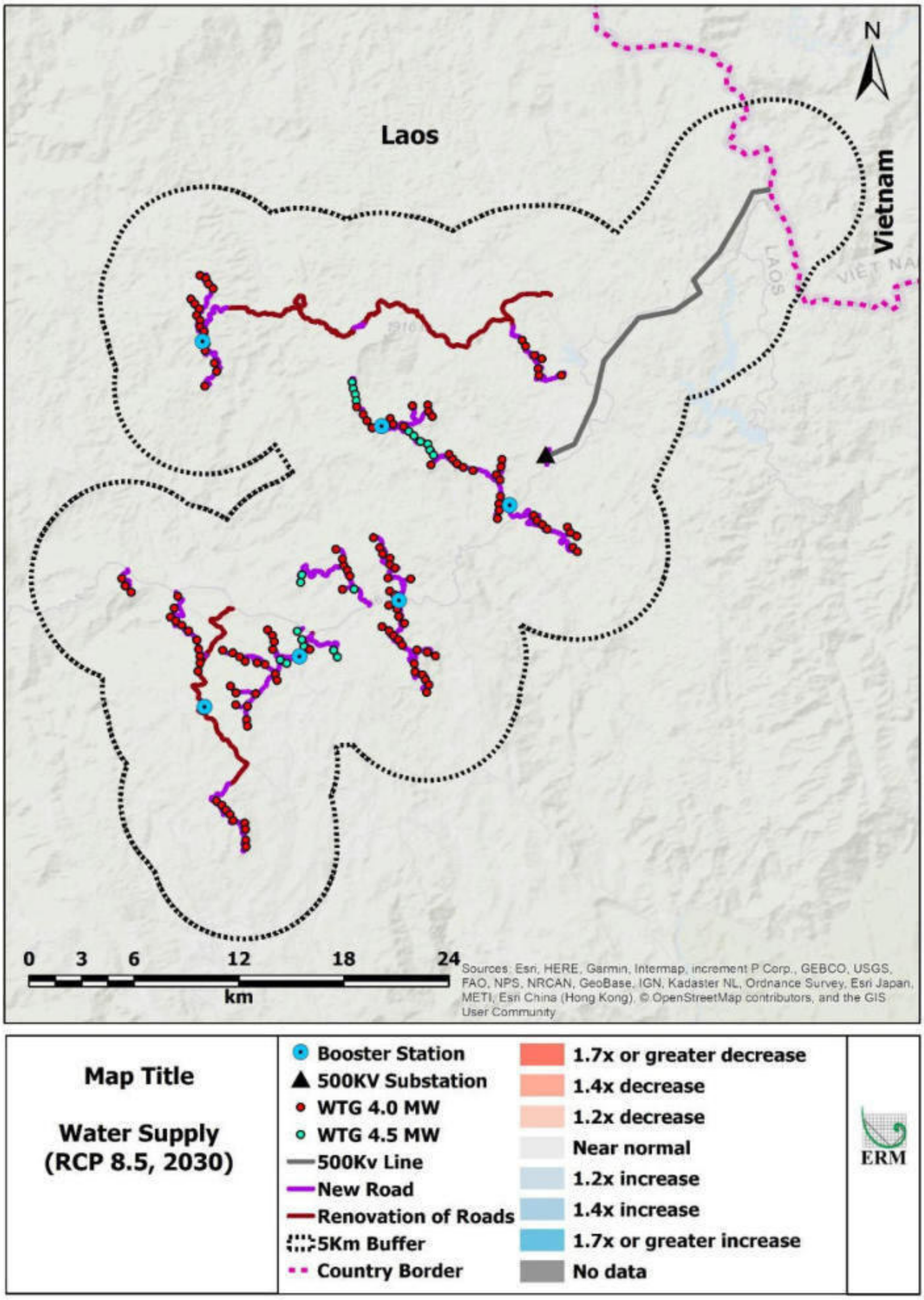
Source: WRI-Aqueduct Water Risk Atlas

Figure 8.69: Water Supply RCP 4.5/2040



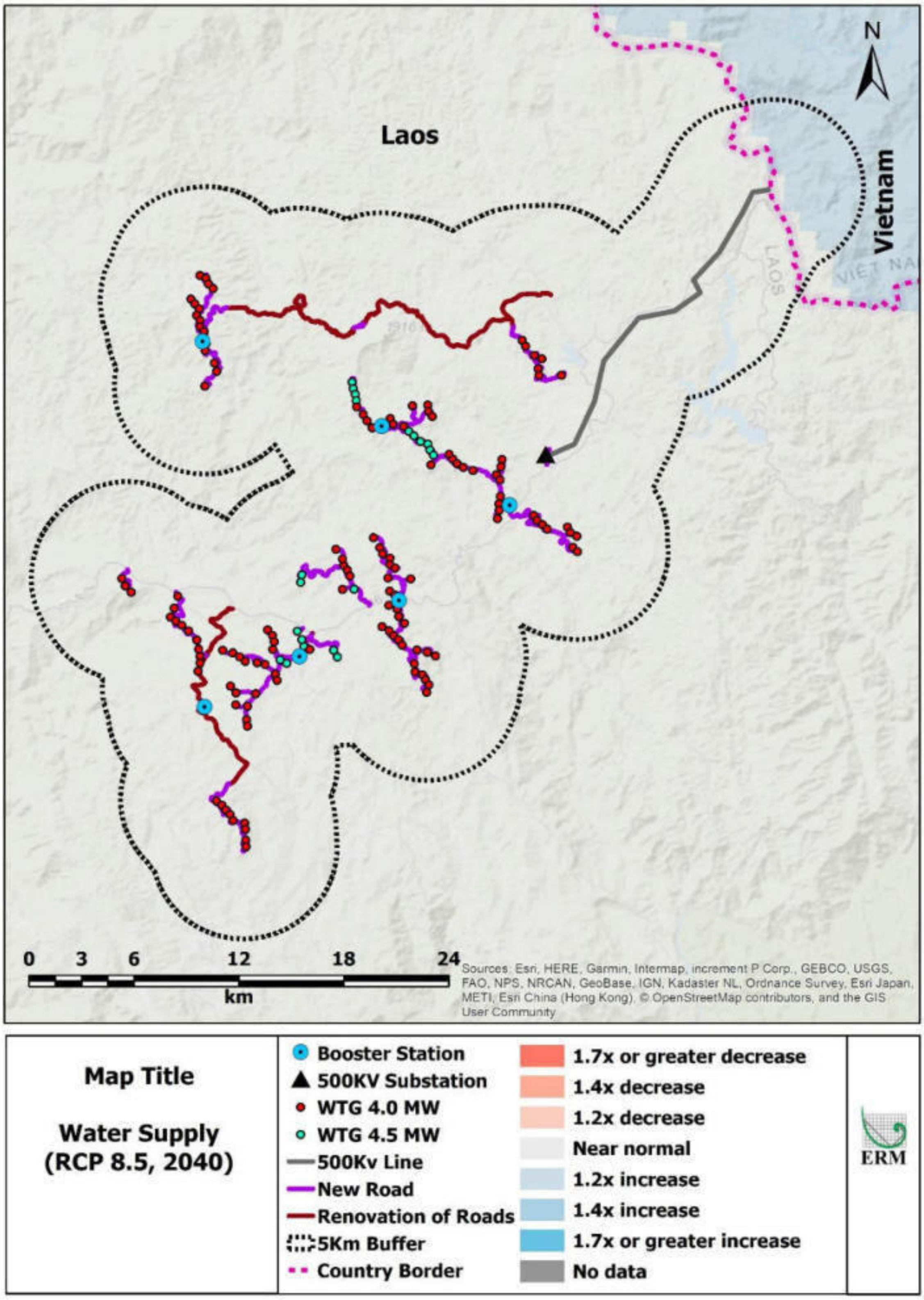
Source: WRI-Aqueduct Water Risk Atlas

Figure 8.70: Water Supply RCP 8.5/2030



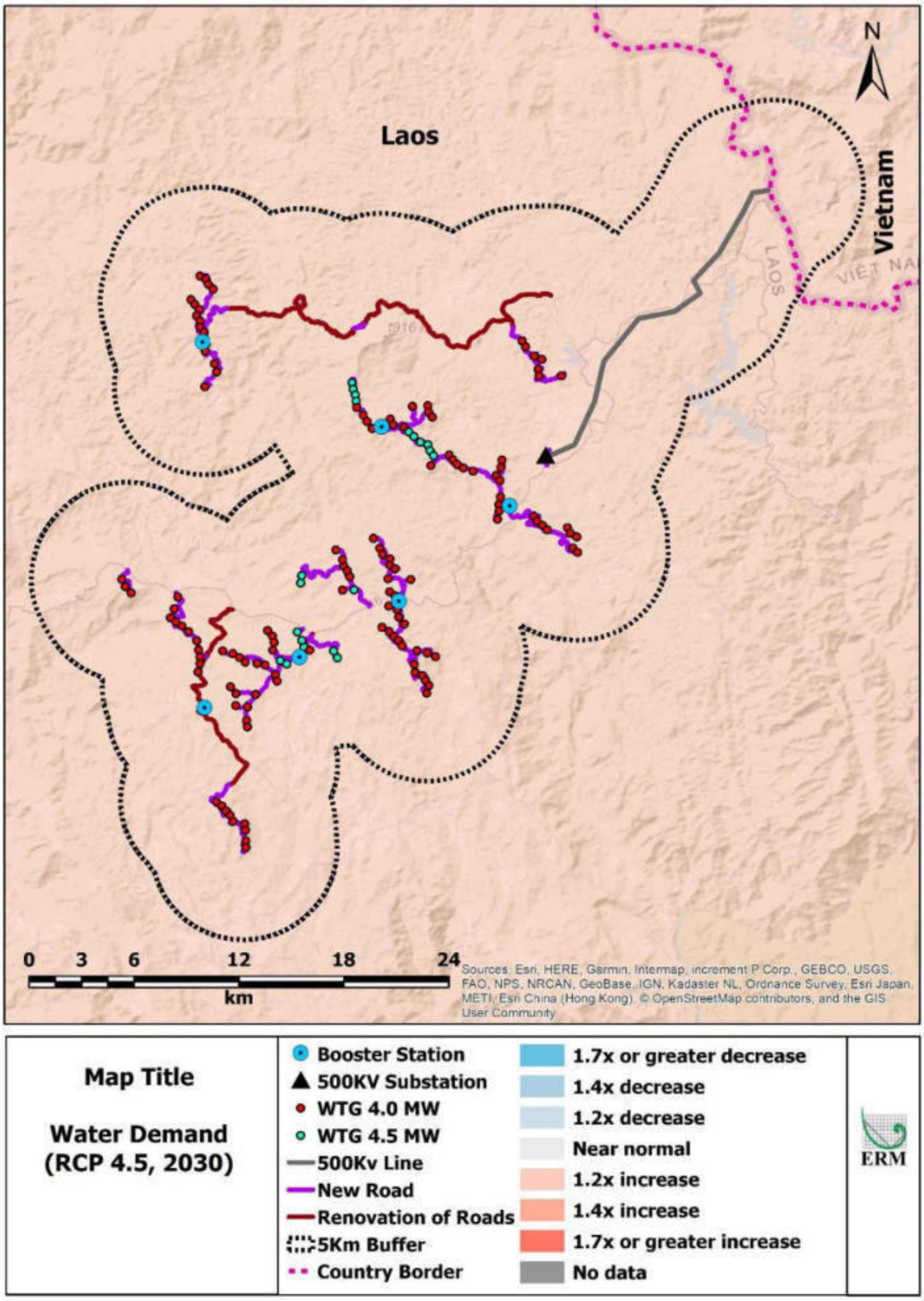
Source: WRI-Aqueduct Water Risk Atlas

Figure 8.71: Water Supply RCP 8.5/2040



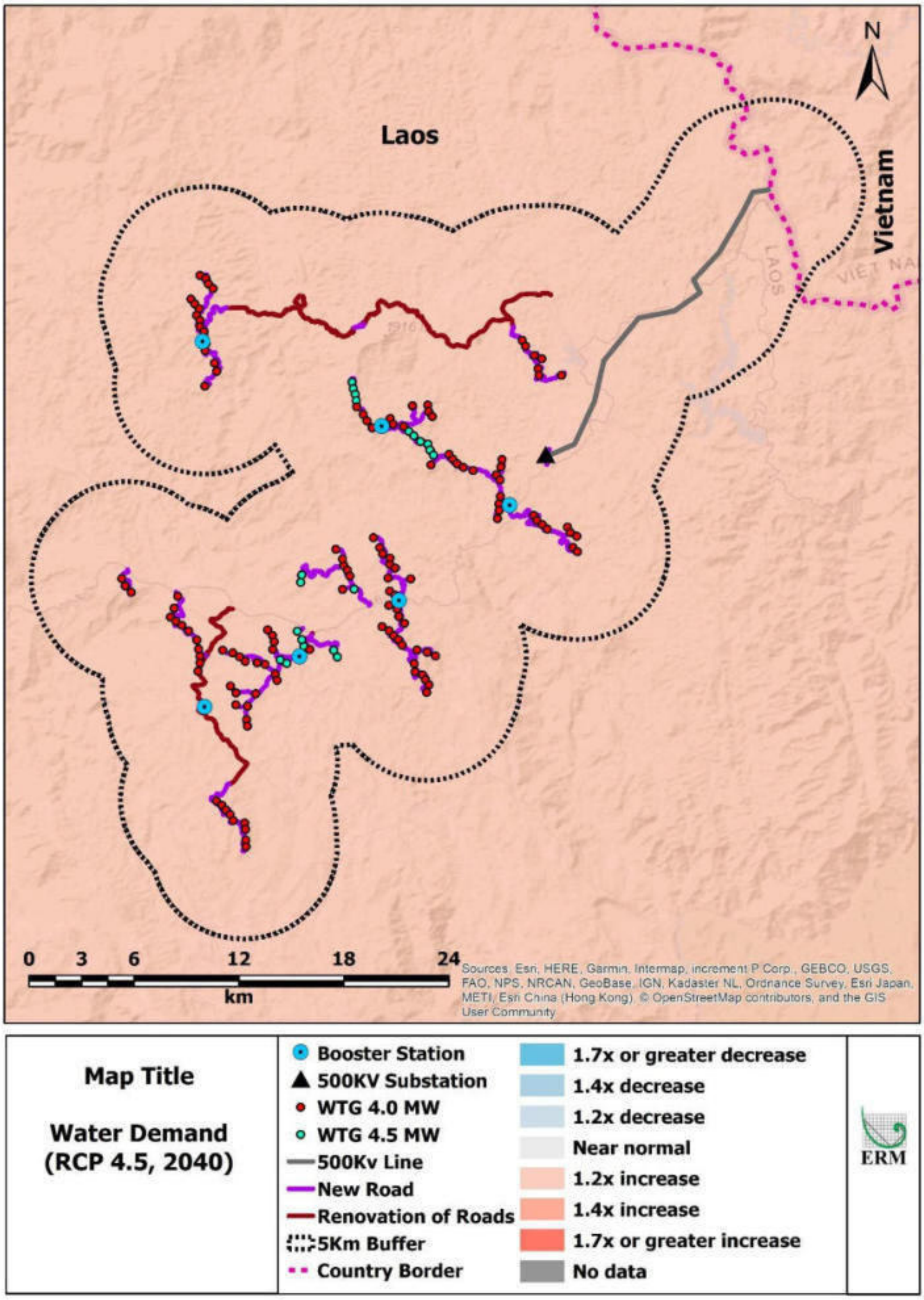
Source: WRI-Aqueduct Water Risk Atlas

Figure 8.72: Water Demand RCP 4.5/2030



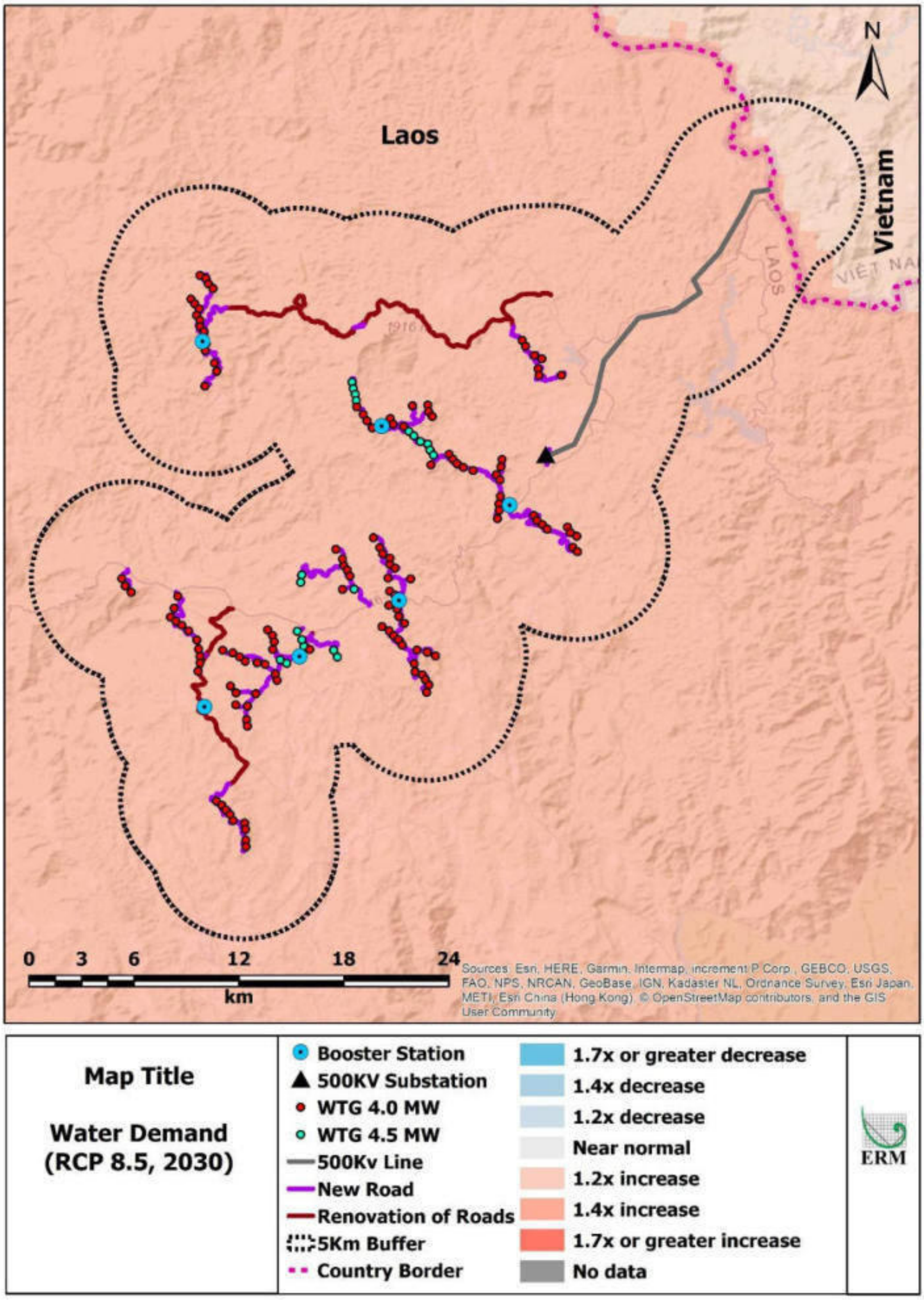
Source: WRI-Aqueduct Water Risk Atlas

Figure 8.73: Water Demand RCP 4.5/2040



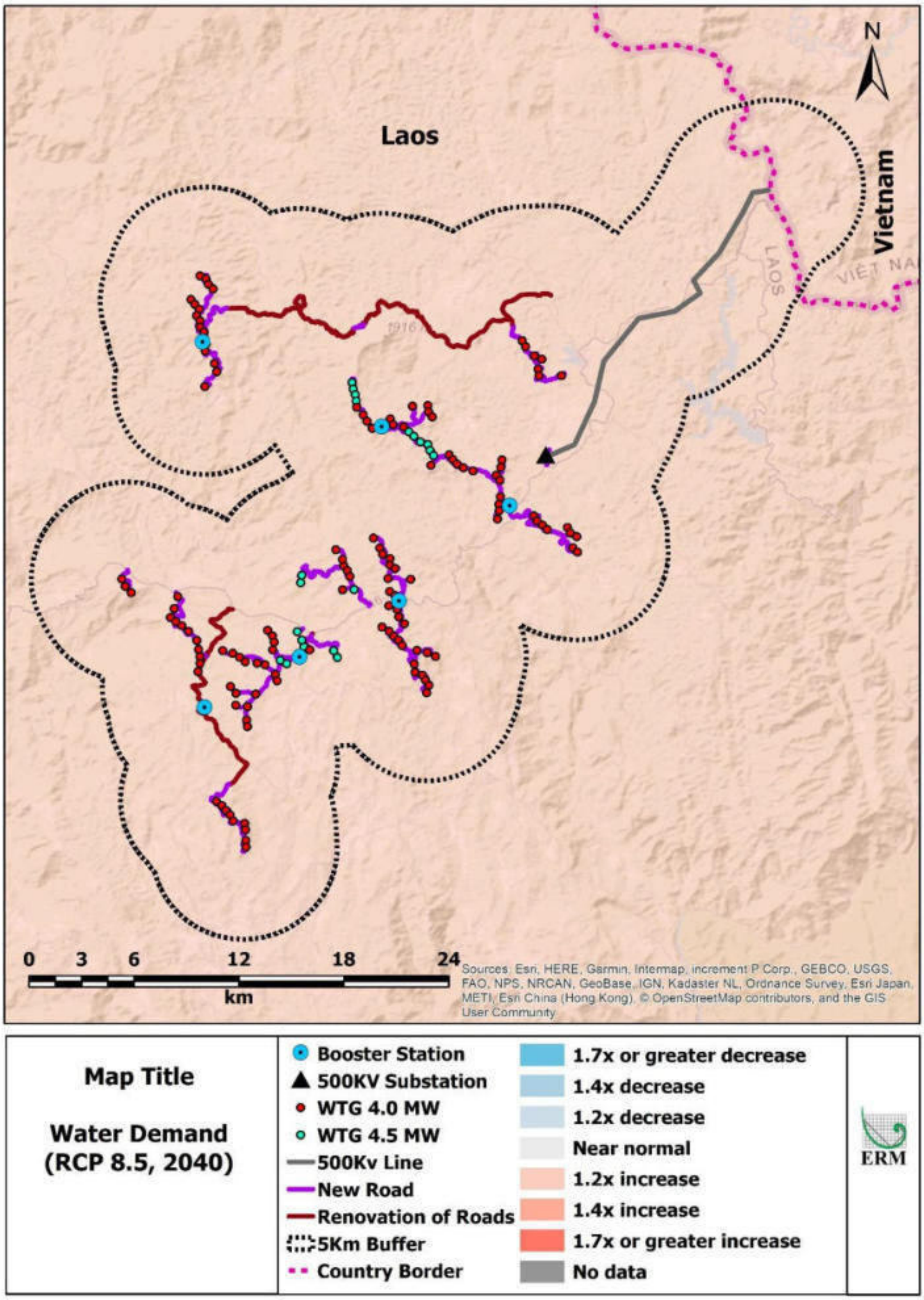
Source: WRI-Aqueduct Water Risk Atlas

Figure 8.74: Water Demand RCP 8.5/2030



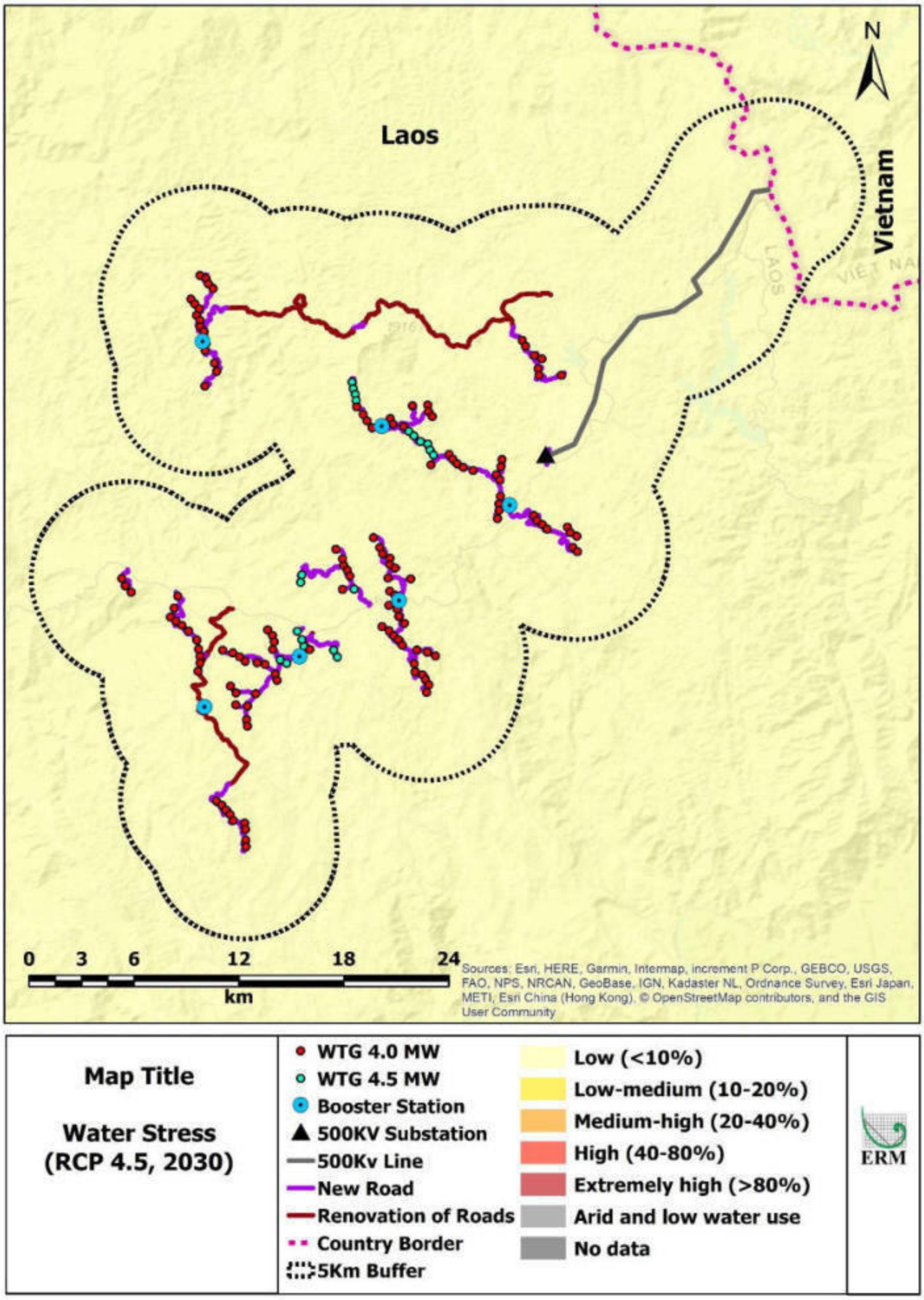
Source: WRI-Aqueduct Water Risk Atlas

Figure 8.75: Water Demand RCP 8.5/2040



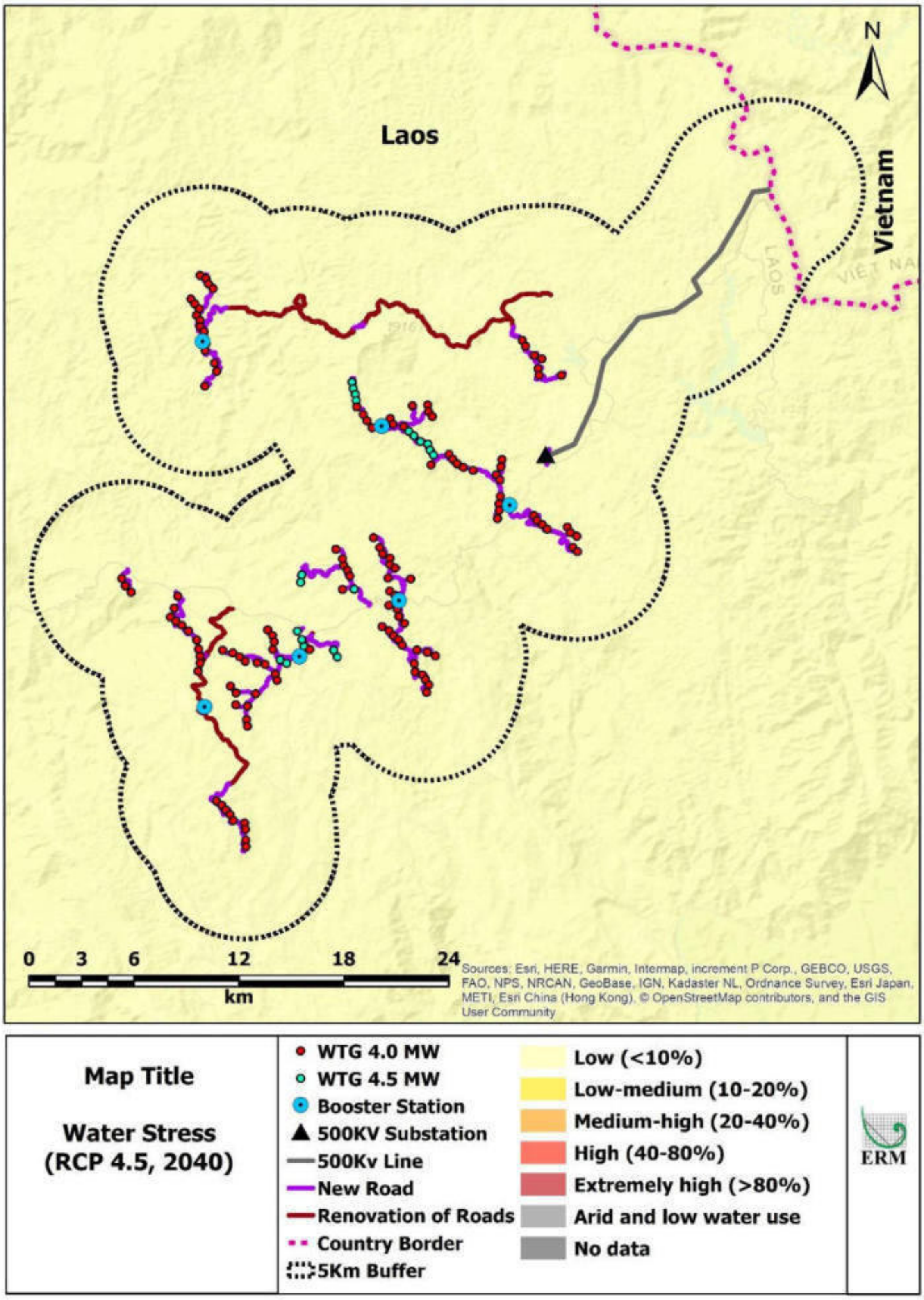
Source: WRI-Aqueduct Water Risk Atlas

Figure 8.76: Water Stress RCP 4.5/2030



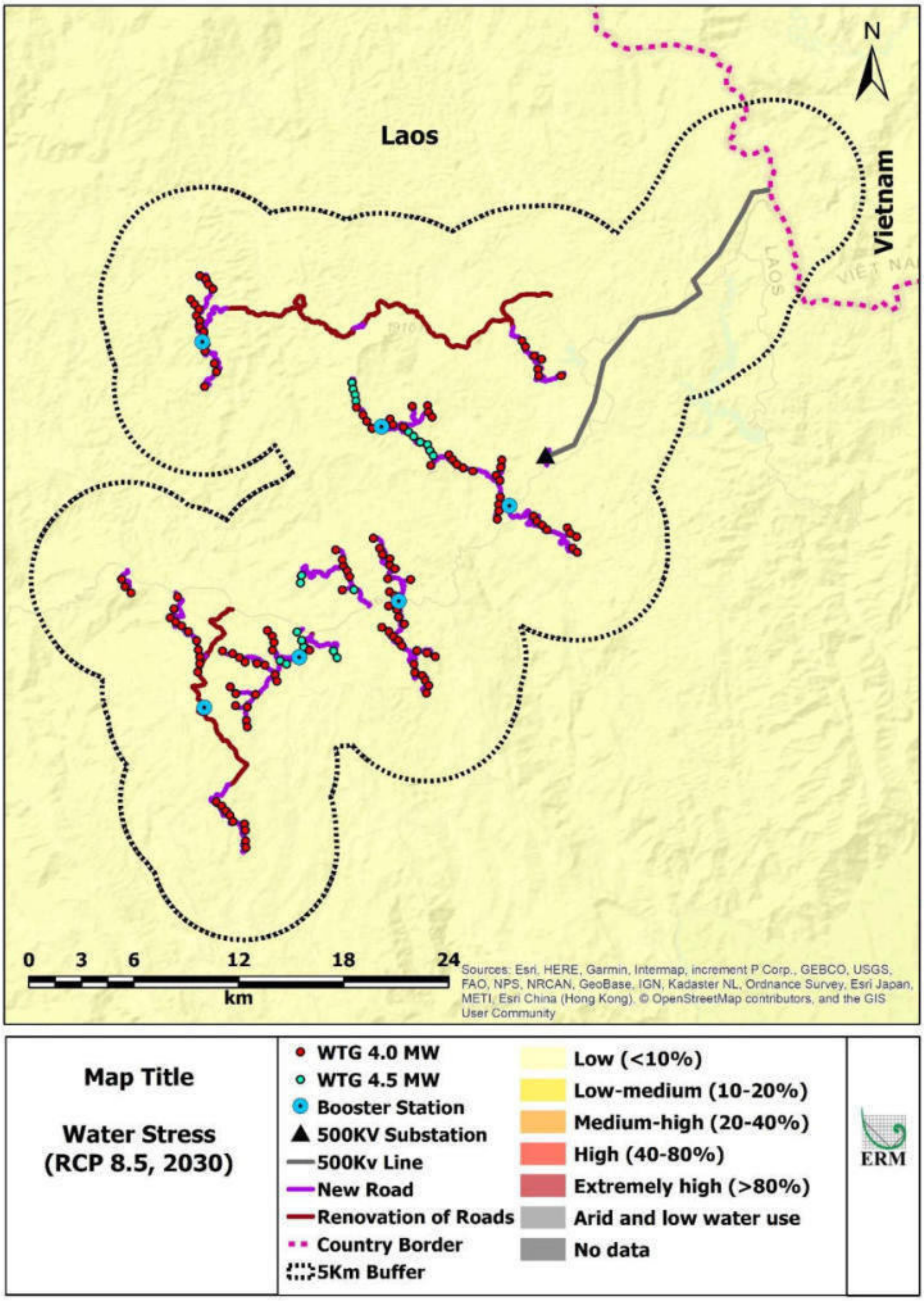
Source: WRI-Aqueduct Water Risk Atlas

Figure 8.77: Water Stress RCP 4.5/2040



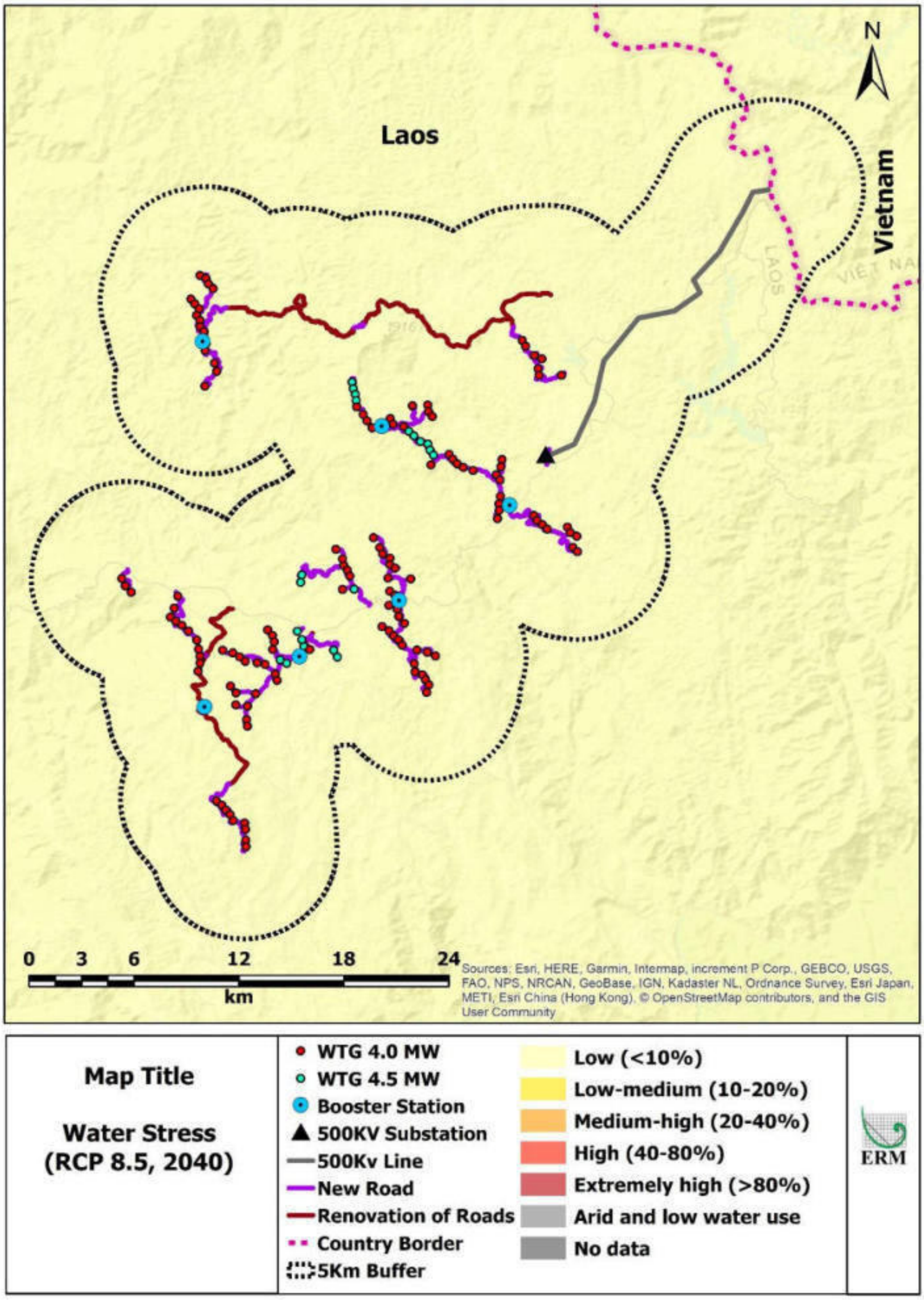
Source: WRI-Aqueduct Water Risk Atlas

Figure 8.78: Water Stress RCP 8.5/2030



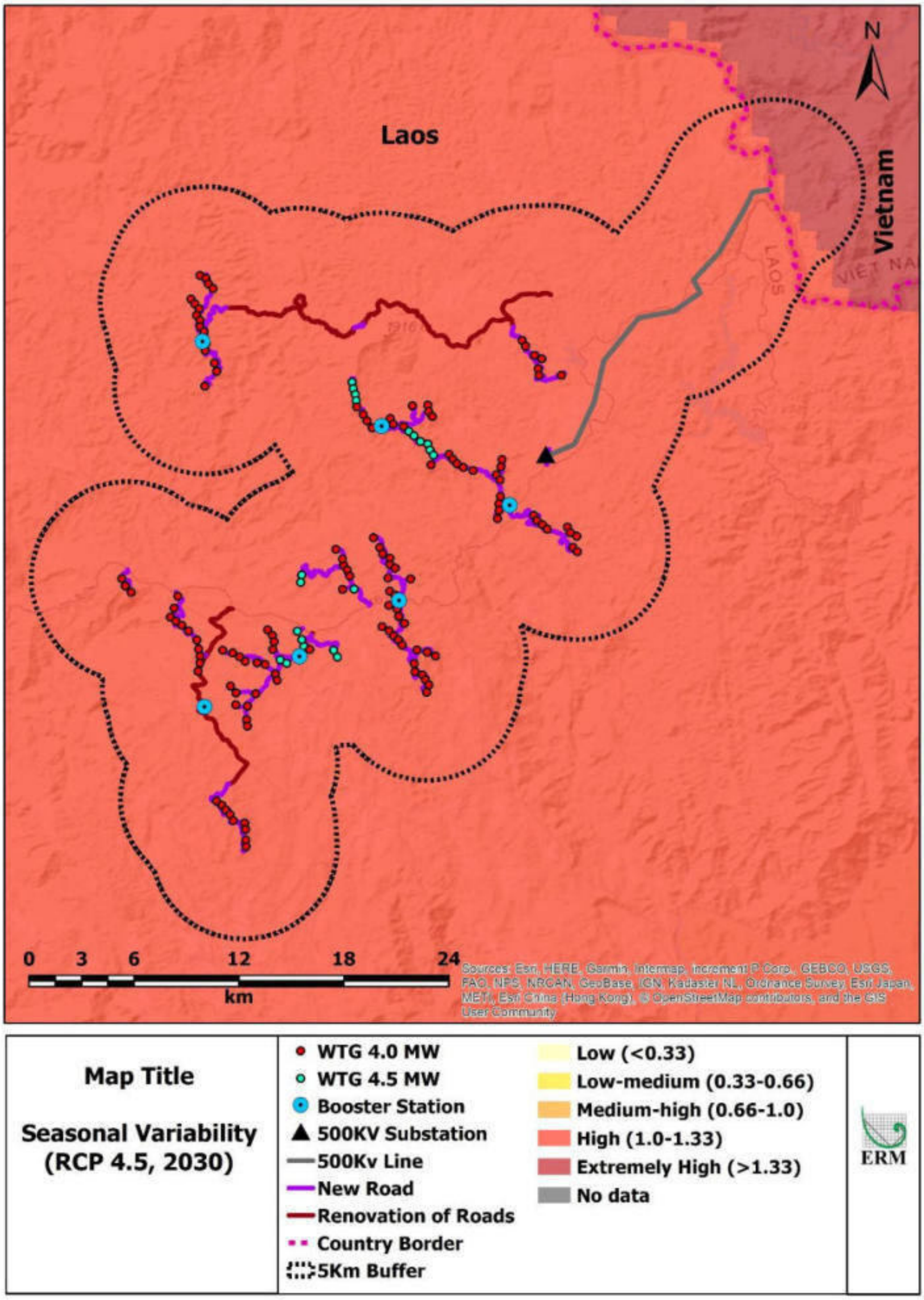
Source: WRI-Aqueduct Water Risk Atlas

Figure 8.79: Water Stress RCP 8.5/2040



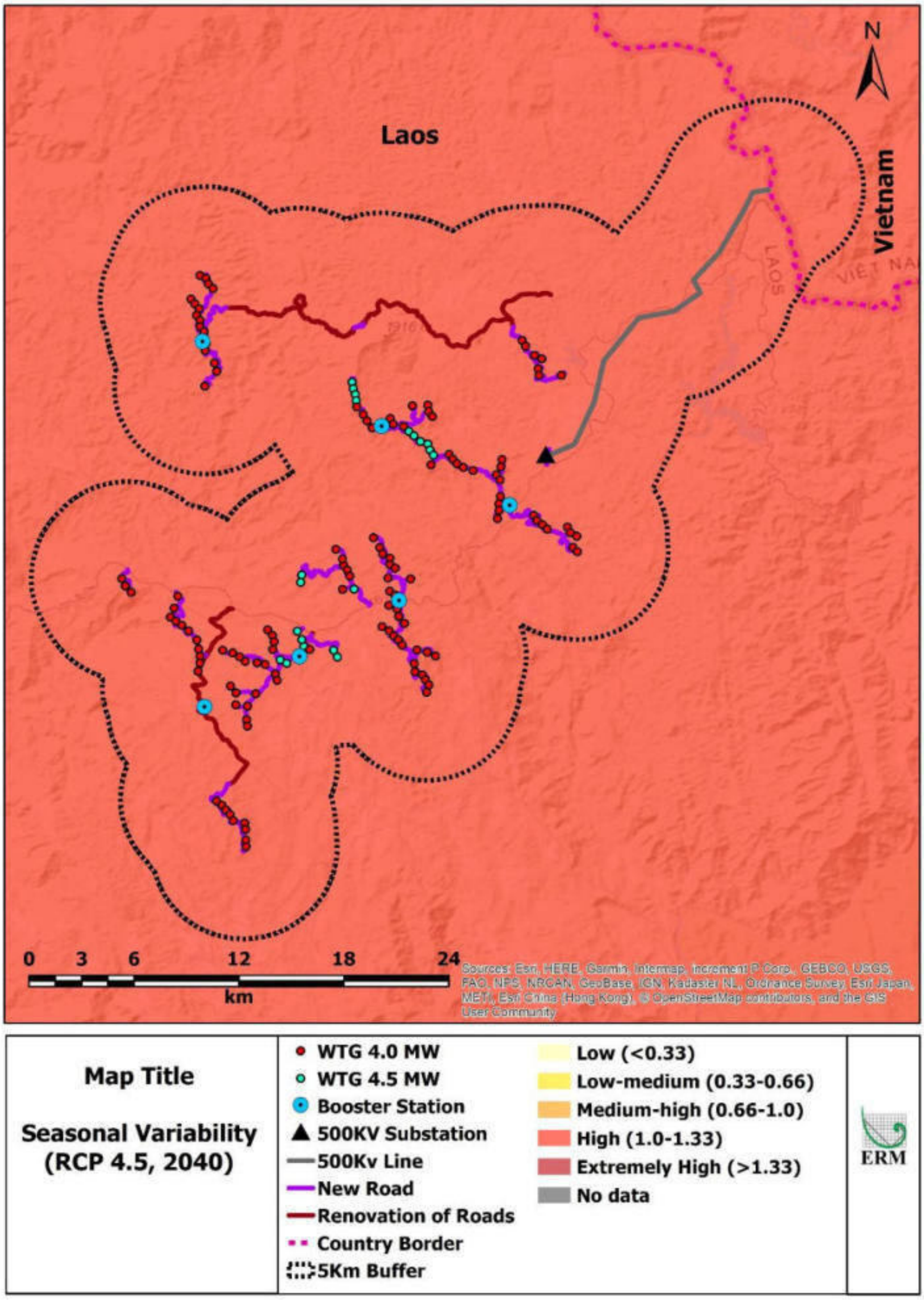
Source: WRI-Aqueduct Water Risk Atlas

Figure 8.80: Seasonal Variability RCP 4.5/2030



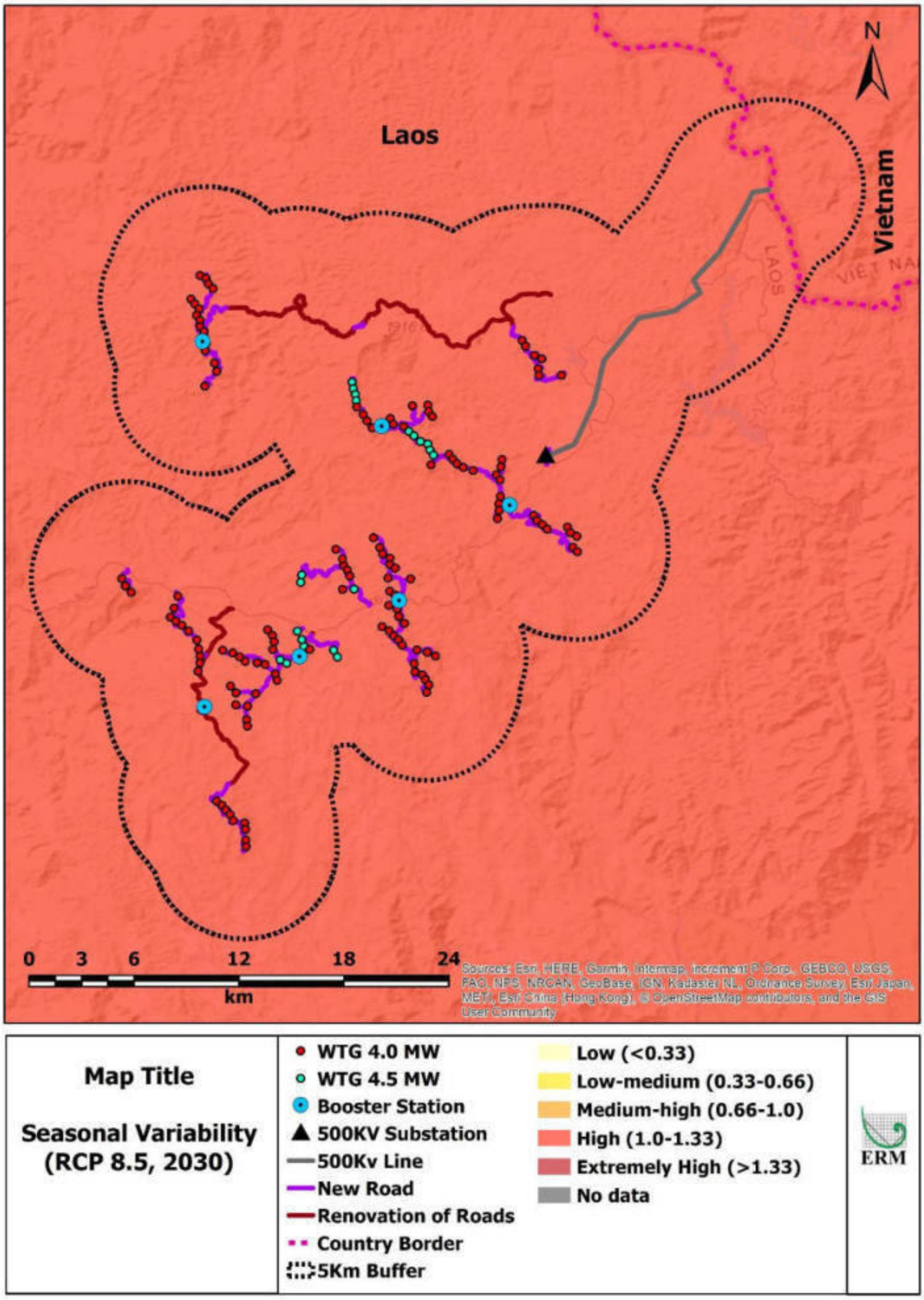
Source: WRI-Aqueduct Water Risk Atlas

Figure 8.1: Seasonal Variability RCP 4.5/2040



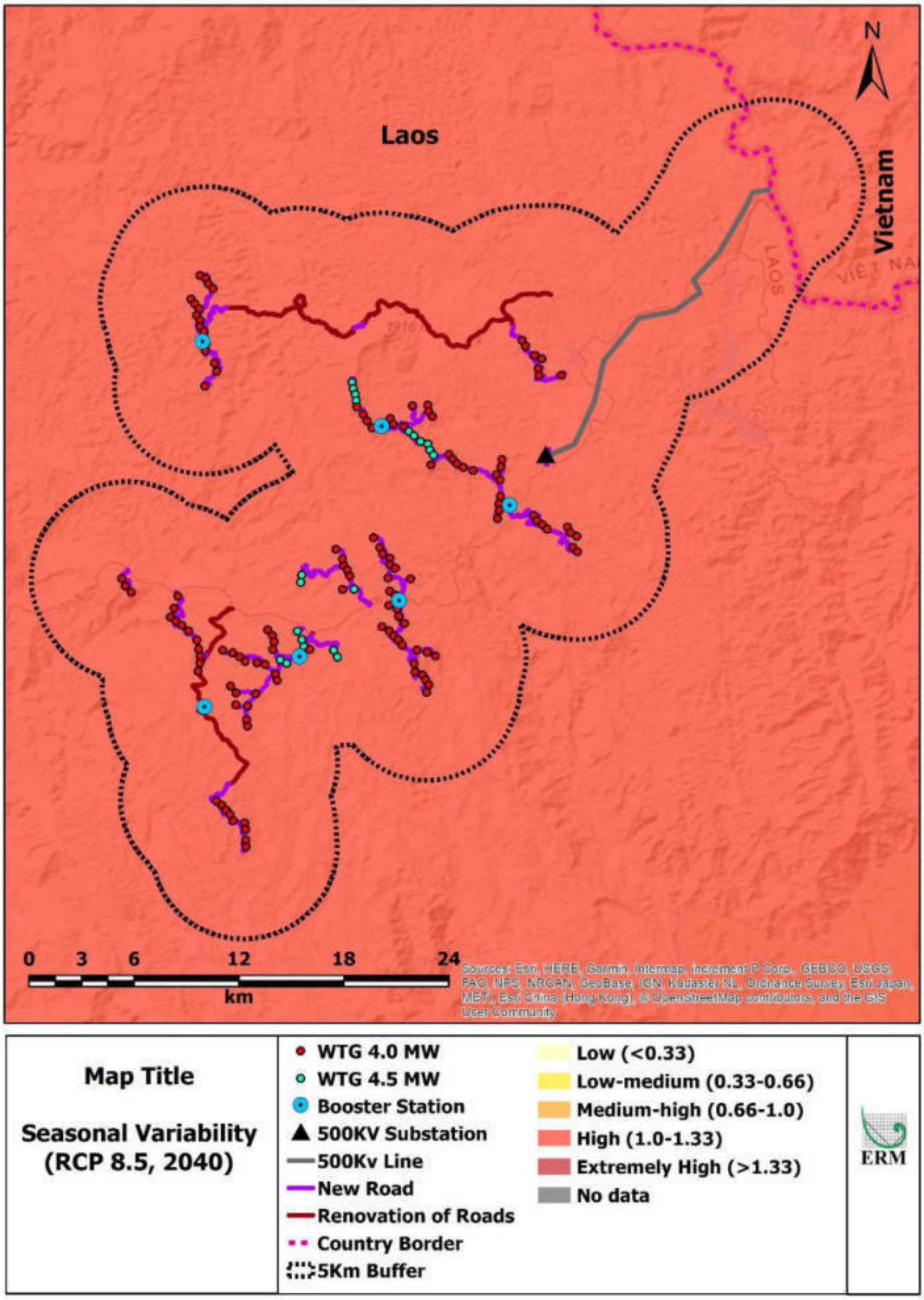
Source: WRI-Aqueduct Water Risk Atlas

Figure 8.81: Seasonal Variability RCP 8.5/2030



Source: WRI-Aqueduct Water Risk Atlas

Figure 8.82: Seasonal Variability RCP 8.5/2040



Source: WRI-Aqueduct Water Risk Atlas

Riverine Floods

Floods are defined as logging of excess water resulting in submergence of dry lands. Floods can be categorized as inland and coastal in nature. Inland flooding may be caused due to heavy rainfall, resulting in high run-off leading to water accumulation in low lying areas, or overtopping of water bodies such as rivers, streams, lakes, ponds and tanks.

Floods are likely to result in wide spread local as well as regional level destruction. This can be caused due to submergence, washing away and damage to infrastructure, buildings, structures, sewerage systems, damage to power transmission and power generation, loss of agricultural land and crops, contamination of fresh water sources, propagation of water borne diseases and loss of life.

- **Baseline**

Sekong and Attapeu province are reported to be among the most flood vulnerable provinces in Laos PDR[155]. However, a review of flood hazard data based on likelihood of damaging and life threatening floods (floods with depth of inundation >0.5 m) (***Figure 8.83***) indicated the flood hazard to be Very Low in Sanxay District in Attapue, and Dak Cheung District in Sekong province where the project is located.

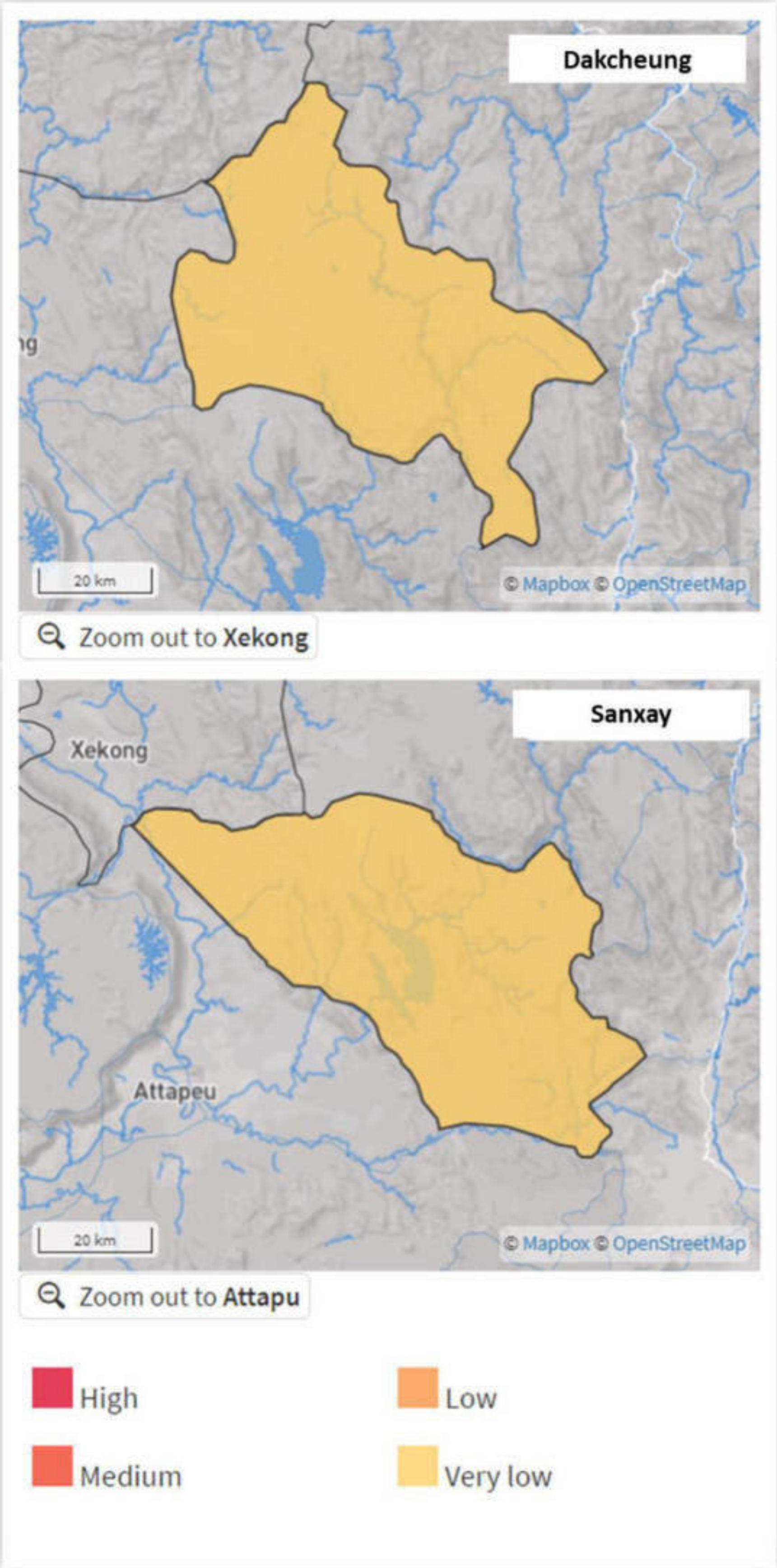
Furthermore, a review of flood hazard map(s) representing the depth of inundation under a flood with 100 year return period (***Figure 8.84***) indicated no inundation in project area.

A review of satellite imagery in and around the study area does not show any rivers flowing through the study area, except Nam Pagnou River, in eastern parts of the project area. The 500 kv transmission line is proposed to cross over the Nam Pagnou River. No other major assets are observed to be located in areas near to the Nam Pagnou River. The wind turbines are also observed to be located on the ridges. Hence, river floods are not likely to impact project assets.

Accordingly, considering the site setting (locations of assets), absence of major rivers, and no reported inundation within study area, riverine floods are not likely to have impact on the project. Hence, no hazard due to riverine flood is considered.

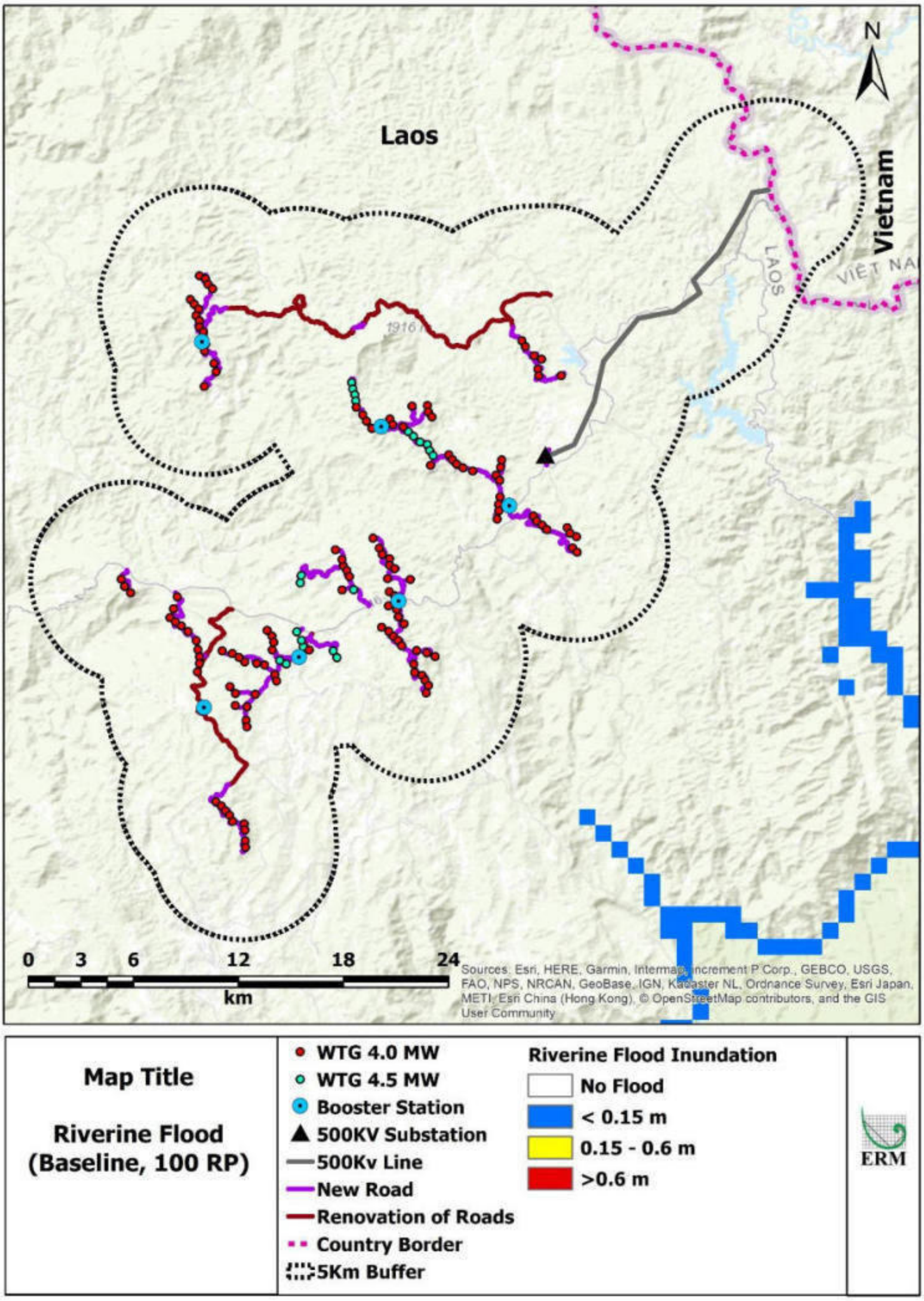
155 https://www.adpc.net/igo/category/ID416/doc/2013-ptk8Nb-ADPC-Publication_LNAReportWEB_(2).pdf

Figure 8.83: Baseline Riverine Flood Hazard



Source: Think Hazard

Figure 8.84: Baseline Riverine Flood Hazard



Source: WRI-Aqueduct Flood Tool

- **Climate Change**

Climate change projections for extreme precipitation (rainfall) indices of 1 day maximum rainfall, 5 day maximum rainfall, and number of days with heavy rainfall (>10mm) indicated increasing trend under all climate change scenarios, except RCP 4.5 in 2030. Extreme precipitation under RCP 4.5 indicated slight decrease in 2030. The increase in extreme precipitation is observed to be intensified with time and radiative forcing (RCP). Accordingly, highest increase in extreme precipitation is projected to be in 2050 under RCP 8.5 scenario.

Similarly, precipitation during cyclones originating in north-east Pacific Ocean is projected to increase by up to 19.4% by 2050 under RCP 8.5 scenario. Therefore, any change in topography during development of project and increased intensity of precipitation may lead to localised surface flooding, mountain floods, or flash floods in future.

Table 8.93: Climate Change Projections for Extreme Precipitation

Parameter	Absolute Values					Percentage Change (%)			
	Baseline	RCP 4.5		RCP 8.5		RCP 4.5		RCP 8..5	
		2030	2050	2030	2050	2030	2050	2030	2050
1-Day (mm)	67.1	-0.9	3.7	0.5	6.0	-1.5	5.6	0.8	9.1
5-Day (mm)	169.8	-6.9	6.9	1.7	11.9	-4.1	4.06	1.0	7.1
>10 mm (Days)	35	-0.3	1.21	0.6	2.1	-0.9	3.4	1.6	5.8
Cyclonic Precipitation* (mm)	N.D.	N.D.	N.D.	N.D.	N.D.	10.1	14.8	11.1	19.4

(: Changes in cyclonic precipitation are based on the studies conducted by Kunston et. Al.(2020)[156] providing projections for basin wise occurrences in cyclones and associated variables such as wind speed, frequency, and precipitation. For the purpose of this assessment a linear relationship is assumed between global average temperature rise and occurrences of cyclone. Accordingly, the projections for cyclones were adjusted from projections for 2°C scenario.).*

As discussed earlier, considering the absence of major rivers in the study area, and Site setting, riverine floods are not likely to impact the project components. Moreover, review of flood hazard maps (inundation under 100 year return period flood) for climate change scenarios indicated no flooding within the study area. Hence, no hazard due to riverine floods is considered.

Table 8.94: Summary of Riverine Flood Hazard under Baseline and Climate Change Scenario

Baseline	RCP 4.5		RCP 8.5	
	2030	2050	2030	2050
No Hazard	No Hazard	No Hazard	No Hazard	No Hazard

156 https://journals.ametsoc.org/view/journals/bams/101/3/bams-d-18-0194.1.xml

Landslides

As per United States Geological Survey (USGS), a landslide is defined as the movement of a mass of rock, debris, or earth down a slope. Several factors are responsible for occurrence of landslides. Some of these are poor mechanical stability, heavy rainfall events, geological formation, earthquake, vibration (mechanical) and slope, and could be influenced largely by human activities at a local level. Some of the human activities which are likely to cause or aggravate landslides are deforestation, cultivation, construction, vibration from heavy machinery and traffic, blasting and mining activities, and large and unstable earthwork/ excavation.

It should be noted that the global data bases in general do not capture landslide events due to human activities, and these datasets are limited to the landslides occurred due to two major reasons: earthquakes and precipitation. However, earthquakes are not affected by climate change only landslides due to precipitation were evaluated under the present assessment.

For the purpose of present assessment, the landslide hazard was evaluated based on the data for rainfall triggered landslide hazard from World Bank Data Catalog and landslide hazard susceptibility data from NASA.

- Dalia Kirschbaum and Thomas Stanley have developed new map of global landslide susceptibility. The map is part of a broader effort to establish a hazards monitoring system that combines satellite observations of rainfall from the Global Precipitation Measurement (GPM) mission with an assessment of the underlying susceptibility of terrain. Steep slopes are the most important factor that make a landscape susceptible to landslides. Other key factors include deforestation, the presence of roads, the strength of bedrock and soils, and the location of faults. While other scientists have previously developed global and continental landslide susceptibility maps, Kirschbaum and Stanley used improved versions of certain datasets. They used a more robust version of elevation data collected by the Shuttle Radar Topography[157]. The new global landslide susceptibility map is intended for use in disaster planning situational awareness, and for incorporation into global decision support systems[158].

The World Bank Data Catalog provides data landslides hazard due to precipitation. The data is in the form of raster images with land slide hazard classified in four classes: Very low, Low, Medium, and High.

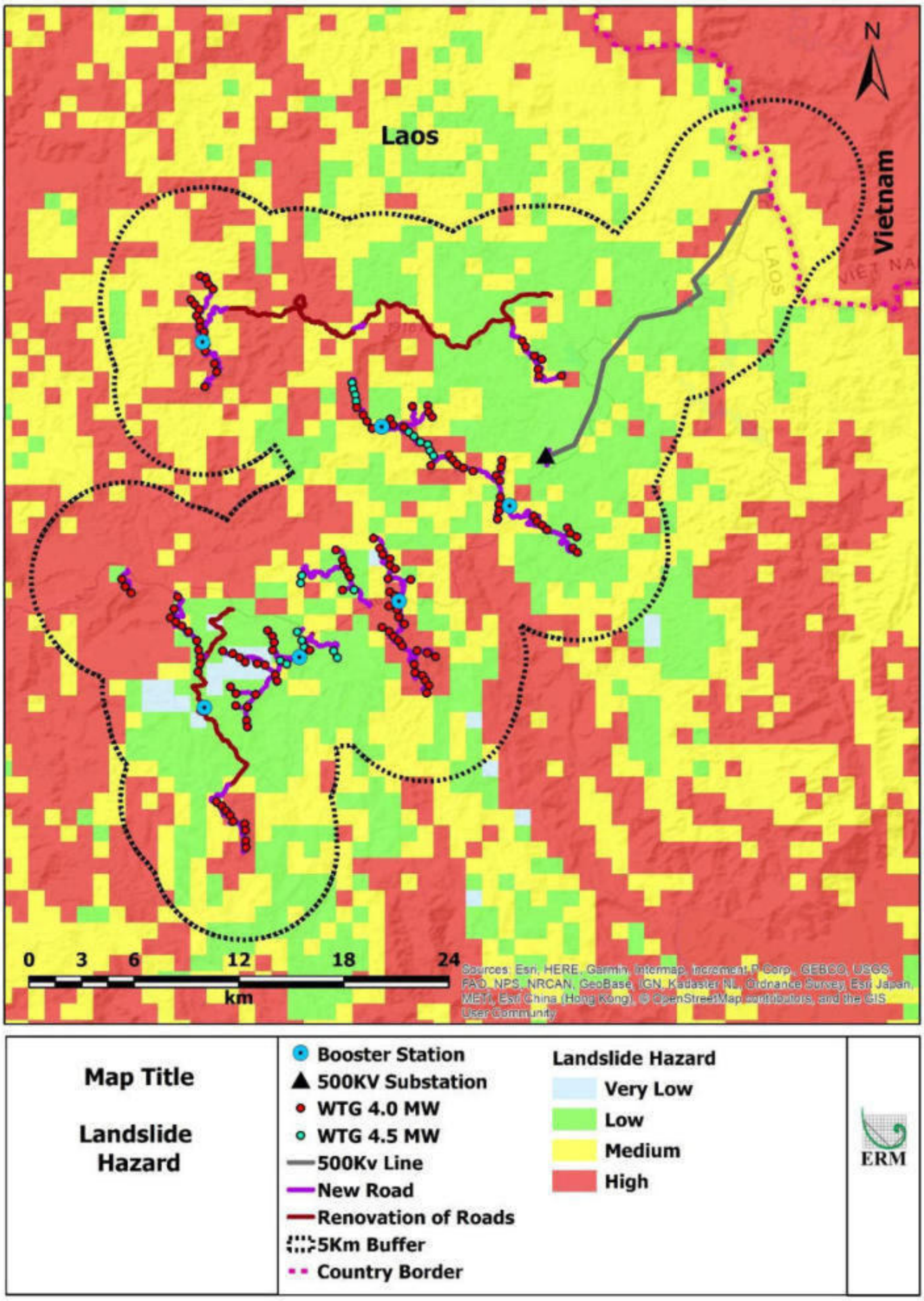
- **Baseline**

Landslide susceptibility within study area is reported to vary between Medium to Very High as presented in ***Figure 8.85***. This indicates that the project area is susceptible to landslides owing to factors such as land cover, soil type, and slope. Moreover, the landslide hazard map as presented in ***Figure 8.86 i***ndicate the hazard due to landslides triggered by precipitation to vary between Low-High within Study area. Accordingly, overall hazard due to landslides triggered by precipitation is considered to be '**High**'.

[157] https://earthobservatory.nasa.gov/images/89937/a-global-view-of-landslide-susceptibility

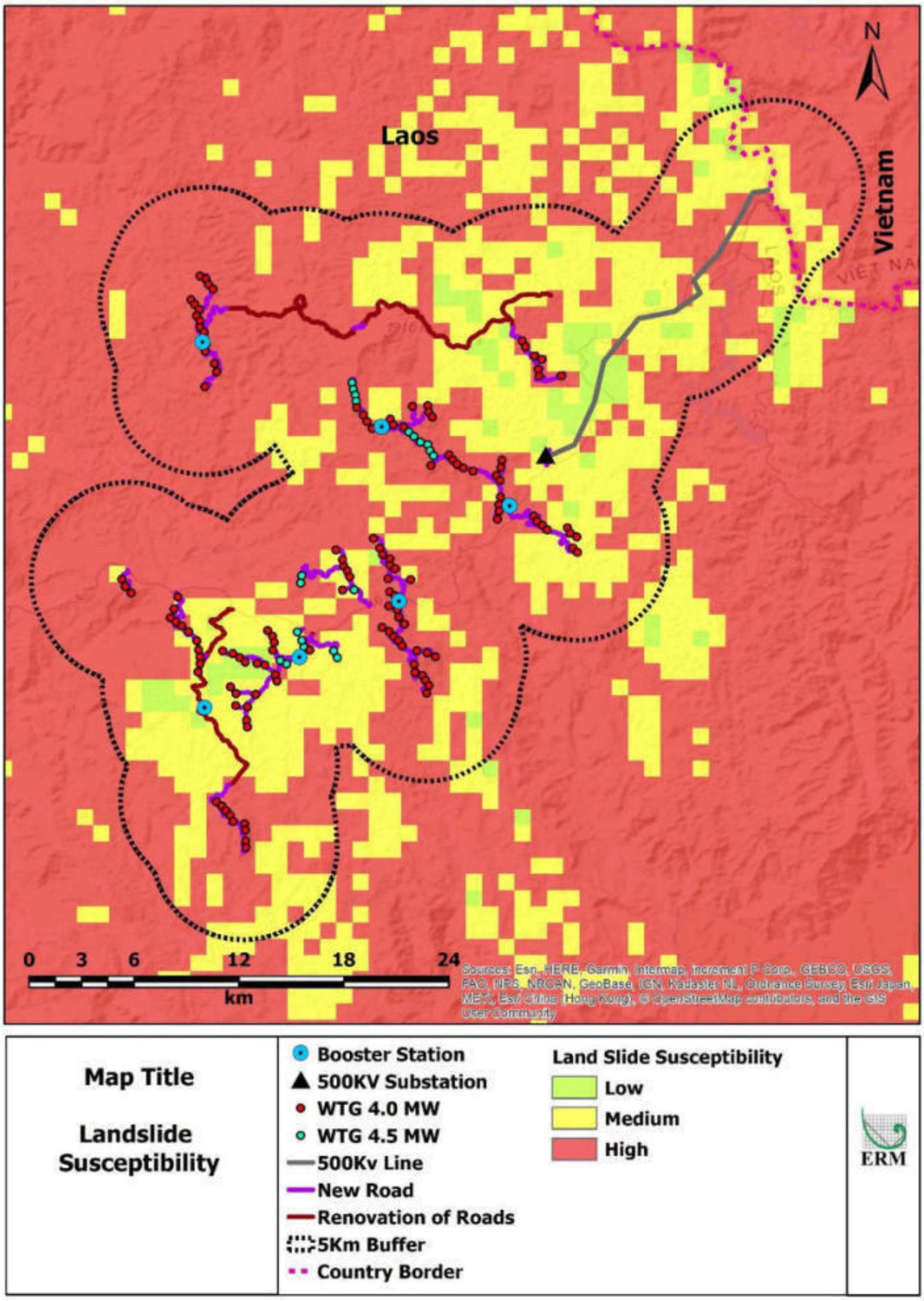
[158] https://link.springer.com/article/10.1007/s11069-017-2757-y

Figure 8.85: Baseline Landslide Hazard



Source: Word Bank Data Catalog

Figure 8.86: Landslide Susceptibility



Source: NASA

- **Climate Change**

As landslides due to rainfall are triggered during extreme precipitation, changes in landslide hazard were evaluated qualitatively based on the projected changes in one day maximum precipitation. Future hazard due to landslides was estimated only for those locations where baseline hazard due to landslides was reported. For other locations, no hazard due to landslides due to precipitation was considered.

Climate change projections for extreme precipitation (rainfall) indices of 1 day maximum rainfall, 5 day maximum rainfall, and number of day with heavy rainfall (>10mm) indicated increasing trend under all climate change scenarios, except RCP 4.5 in 2030. Extreme precipitation under RCP 4.5 indicated slight decrease in 2030. The increase in extreme precipitation is observed to get intensified with time and radiative forcing (RCP). Accordingly, highest increase in extreme precipitation is projected to be in 2050 under RCP 8.5 scenario.

Similarly, precipitation during cyclones originating in north-east Pacific Ocean is projected to increase by up to 19.4% by 2050 under RCP 8.5 scenario. Therefore, any change in topography during development of project and increased intensity of precipitation may lead to localised surface flooding in future.

Table 8.95: Climate Change Projections for Extreme Precipitation

Parameter	Absolute Values					Percentage Change (%)			
	Baseline	RCP 4.5		RCP 8.5		RCP 4.5		RCP 8..5	
		2030	2050	2030	2050	2030	2050	2030	2050
1-Day (mm)	67.1	-0.9	3.7	0.5	6.0	-1.5	5.6	0.8	9.1
5-Day (mm)	169.8	-6.9	6.9	1.7	11.9	-4.1	4.06	1.0	7.1
>10 mm (Days)	35	-0.3	1.21	0.6	2.1	-0.9	3.4	1.6	5.8
Cyclonic Precipitation* (mm)	N.D.	N.D.	N.D.	N.D.	N.D.	10.1	14.8	11.1	19.4

(*: Changes in cyclonic precipitation are based on the studies conducted by Kunston et. al.(2020)[159] providing projections for basin wise occurrences in cyclones and associated variables such as wind speed, frequency, and precipitation. For the purpose of this assessment a linear relationship is assumed between global average temperature rise and occurrences of cyclone. Accordingly, the projections for cyclones were adjusted from projections for 2°C scenario.).

Such increase in extreme precipitation may exacerbate the landslide hazard in future under climate change scenario. Moreover, changes in topography during the project development may locally exacerbate the landslide susceptibility. Hence, the hazard due to landslides triggered by precipitation is considered to remain '**High**' under all climate change scenarios.

Table 8.96: Summary for Landslide Hazard under Baseline and Climate Change Scenario

Baseline	RCP 4.5		RCP 8.5	
	2030	2050	2030	2050
High	High	High	High	High

159 https://journals.ametsoc.org/view/journals/bams/101/3/bams-d-18-0194.1.xml

Extreme Heat

Extreme temperature or extreme heat conditions usually happen gradually and not recognised easily as that of other extreme events such as cyclones, and floods. However, these can pose a significant threat to health and safety, increase energy demand for cooling, and destroy crops.

Typically, heat wave conditions can be characterised by temperatures exceeding 35°C. Moreover, with higher humidity extreme heat like conditions can occur at lower temperatures[160].

For the purpose of this assessment, extreme heat hazard under baseline conditions was evaluated based on the two parameters as given below.

- Occurrences of events with daily maximum temperature greater than 35°C.
- Extreme heat hazard category as evaluated by Think Hazard based on the wet bulb globe temperature.

The Wet Bulb Globe Temperature (WBGT) is a measure of the heat stress in direct sunlight, which takes into account: temperature, humidity, wind speed, sun angle and cloud cover (solar radiation). It differs from the heat index, which takes into consideration temperature and humidity and is calculated for shady areas. The WBGT has an obvious relevance for human health, but it is relevant in all kinds of projects and sectors as heat stress affects personnel and stakeholders, and therefore the design of buildings and infrastructure. In general, the WBGT is a relevant enough proxy to quantify the strain on physical infrastructure (energy, water, transport), such as increased demands for water and electricity, which may also affect decisions related to infrastructure[161,162.] Extreme heat was evaluated based on baseline and projected temperature.

- **Baseline**

Evaluation daily temperature data from NASA Power Viewer, indicated the daily maximum temperature to vary between 13.4-39°C with average maximum temperature of 28.2°C. Average annual temperature is reported to be 22.8°C under the baseline scenario. Moreover, on average the daily maximum temperature is reported to exceed 35°C, 18 times per year.

The extreme heat hazard as evaluated by Think Hazard indicated a Medium hazard in Sanxay District in Attapeu, and Dak Cheung District in Sekong province (Figure 8.87) where the Project is located.

Accordingly, the extreme heat hazard under baseline conditions is evaluated to be '**Medium**'.

The heat hazard was also evaluated to assess the impact of extreme heat conditions on wind turbines. The wind turbines are reported to be designed for operational temperature range of -20 to 45°C and -30 to 40°C.

Considering an environmental lapse rate of ~6.5°C/1000 m, the temperature at the turbine (160 m above ground level or abgl) is expected to be ~1.03°C lower than the near surface temperature discussed above. Accordingly, the maximum temperature at the level of turbine likely to vary between 12.4-38°C, with average maximum temperature of 27.2°C under baseline conditions. Whereas, minimum temperature is estimated to vary between 4.2-24.6°C, with average minimum temperature of 9.6°C.

Accordingly, based on the available information the reported baseline maximum and minimum temperature are reported to be within designed operational temperature ranges of the turbine.

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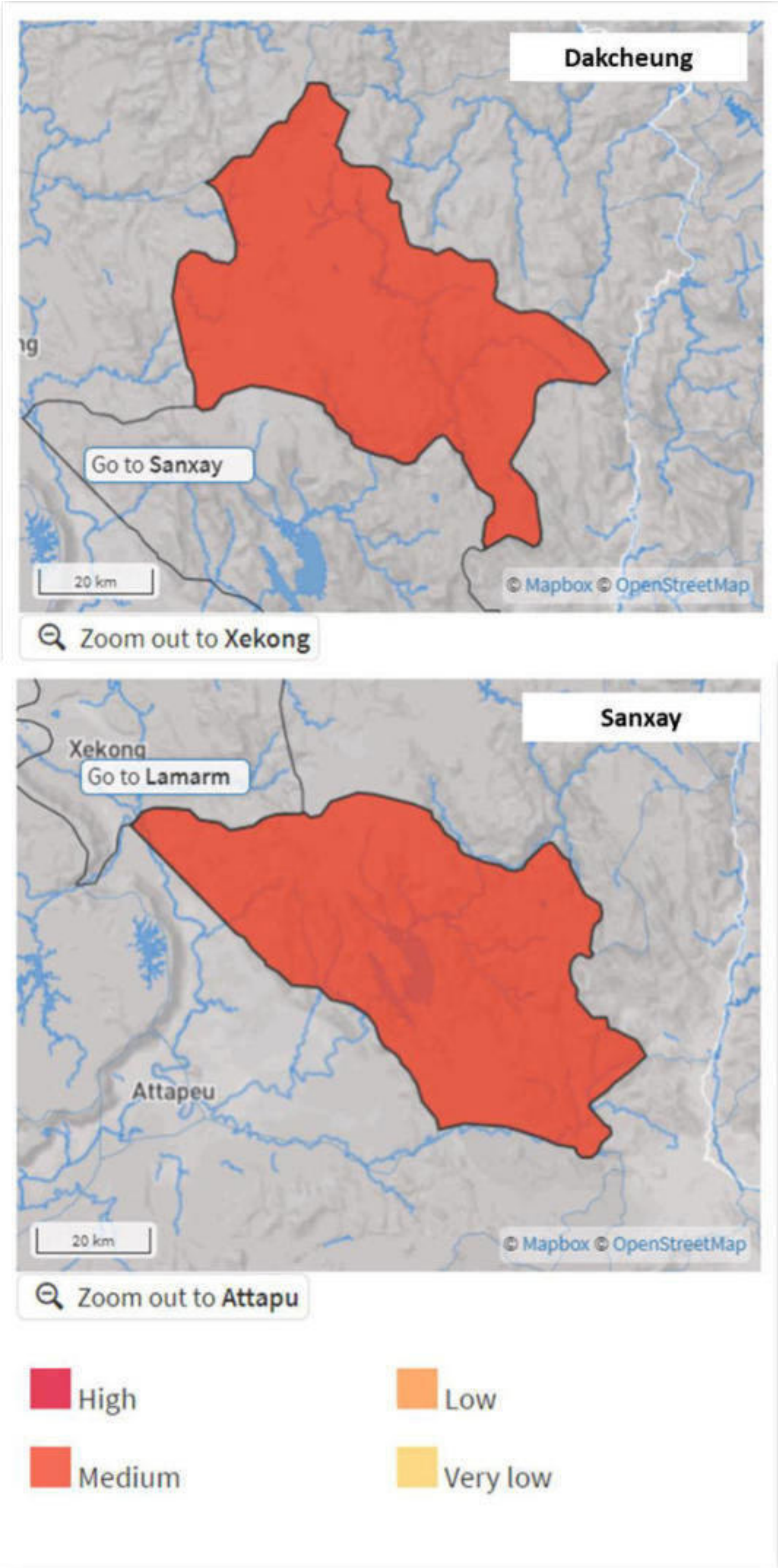
160 https://thinkhazard.org/en/report/5770-bangladesh-chittagong-chittagong/EH

161 https://www.weather.gov/tsa/wbgt#:~:text=The%20WetBulb%20Globe%20Temperature%20(WBGT,is%20calculated%20for%20shady%20areas.

162 https://thinkhazard.org/static/documents/thinkhazard-methodology-report_v2_0.pdf

Figure 8.87: Baseline Extreme Heat Hazard



Source: Think Hazard

- **Climate Change**

Climate change projections for temperature related parameters of average, average maximum, and warm spell duration indicated an increasing trend under all climate change scenarios as presented in ***Table 8.97.***

Table 8.97: Climate Change Projections for Temperature Parameters

Parameter	Baseline	Change from Baseline			
		RCP 4.5		RCP 8.5	
		2030	2050	2030	2050
Average Temperature (°C)	23.9	0.9	1.5	1.0	1.9
Average Maximum Temperature (°C)	27.6	0.9	1.5	1.1	1.9
WSDI (Warm spell duration index) (days)	12	32	62	35	73

Furthermore, the climate change projections for maximum daily temperature indicated an increase trend as presented in ***Table 8.98.***

Table 8.98: Climate Change Projections for Maximum Temperature

RCP 4.5		RCP 8.5	
2030	2050	2030	2050
0.9°C	1.5°C	1°C	1.9°C

Source: World Bank Climate Change Knowledge Portal

Considering the projected increase in average, average maximum temperature, maximum temperature, and WSDI, the heat hazard is likely to increase in the future under all climate change scenarios. Accordingly, the extreme heat hazard under all climate change scenario is considered to be '**High**'.

Table 8.99: Summary of Extreme Heat Hazard under Baseline and Climate Change Scenarios

Baseline	RCP 4.5		RCP 8.5	
	2030	2050	2030	2050
Medium	High	High	High	High

Similar to the baseline scenario, the heat hazard was also evaluated to assess the impact of extreme heat conditions on wind turbine. Considering the projected change in maximum temperature, the maximum temperature at the level of turbine is likely to vary between 13.3-38.9°C, with average maximum temperature of 28.1°C under baseline conditions. This indicates that the maximum temperature is likely to remain within the design operational temperature range of the turbine.

Cyclone and Wind

As per American Meteorological Society, a cyclone is a large scale air mass that rotates around a strong centre of low atmospheric pressure. Tropical cyclones are formed over oceans due to conducive an coinciding conditions such as warm sea surface temperatures, atmospheric instability, high humidity in the lower and middle levels of troposphere, Coriolis force to develop low pressure centre, and low vertical wind shear. Cyclones bring high wind speeds and heavy downpour with them, which are likely to cause disruption to infrastructure, structures, flooding, and other damage to build and natural environment.

For the purpose of this assessment, cyclone hazard was evaluated based the historical cyclone tracks data from International Best Track Archive for Climate Stewardship (IBTrACS) from NOAA. This database provides the cyclone tracks data since 1980 to present.

- **Baseline**

Cyclone hazard was evaluated based on the highest storm category recorded within 100 km distance of Site Area as presented in ***Figure 8.88. Table 8.100***presents the number of storms reported under each category.

Table 8.100: Historical Cyclones Recorded within 100km Distance of the Site Location (1981-Present)

Category of Cyclone	Sustained Wind Speed (km/h)	Count
Tropical Storm	<119	
Category 1	119-153	16
Category 2	154-177	5
Category 3	178-208	1
Category 4	209-251	0
Category 5	>251	0
Total		**22**

Accordingly, considering all but one of the historical occurrences of cyclones is below category 3, the hazard rating due to cyclones is considered to be Medium**'**.

Maximum wind speed recorded at nearest location (Attapeu) located ~50 km west of the Site location indicated the variation of maximum wind speed to be between 1.0 - 23 m/s with an average of 2.4 m/s under baseline. Accordingly, the based on maximum wind speed likely to be experienced in the region, the wind hazard is considered to be '**High**'.

Further, the wind hazard was also evaluated to assess the impact of wind speed on the wind turbine. The wind turbines are reported to be designed for operational wind speed range of 2.5-26 m/s.

The wind speed at the level of wind turbine is estimated based on the relationship presented in equation below

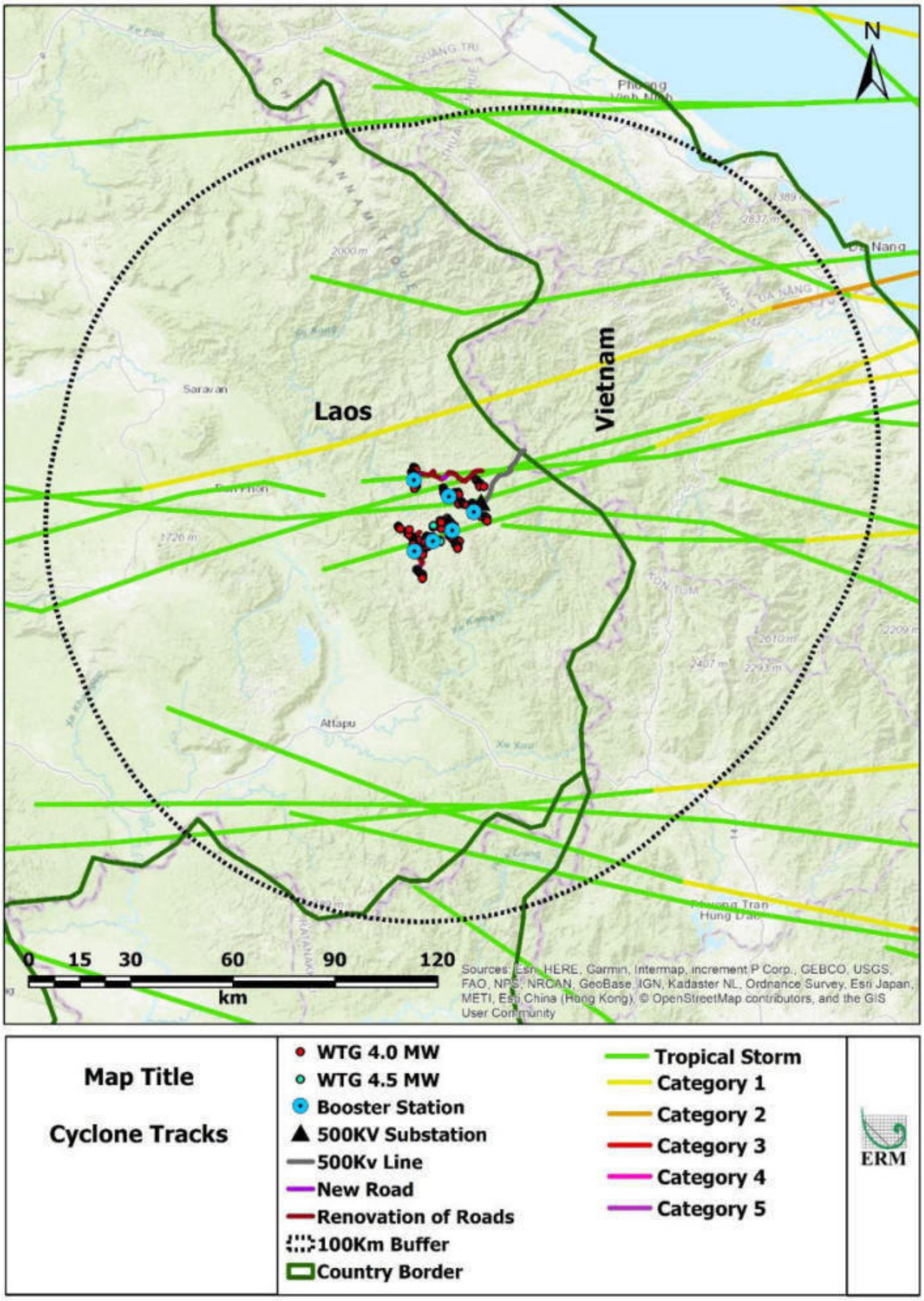
$$\frac{v}{v_o} = \left(\frac{H}{H_0}\right)^{\propto}$$

Where,

$\propto$: coefficient of friction (0.4) for Villages, hamlets and small towns, farming land with many or tall sheltering hedgerows, forest areas and very rough and uneven terrain Landscape

Accordingly, the maximum wind speed at the level of turbine (160 m-abgl) is estimated to be between 3.03-69.7 m/s. This indicates that the power generation may be interrupted during high wind conditions under the baseline scenario.

Figure 8.88: Historical Cyclone Tracks



Source: NOAA-IBTrACS

- **Climate Change**

Tropical cyclones or Typhoons occur in most of the tropical oceans and present significant threat to coastal communities and infrastructure. Every year, about 90 cyclones or Typhoons are reported to occur globally. Further, this number is reported to remained pretty constant since the period of geo stationary satellites (1970s). However, changes in inter-annual and multi-decadal frequency within individual ocean basin are reported to be substantial.

A literature review indicated that the detection of trends in cyclone or Typhoon occurrences (frequency and intensity) is a challenge due to: i) Changes in observation technology, ii) variations in protocol for identification of cyclones or Typhoons in different ocean basins, and iii) limited availability of homogeneous data (30-40 years).

Global reanalysis of tropical cyclone or Typhoons intensity using homogenous satellite data indicated increasing trend in intensity of cyclones, with a suggestive link between cyclone or Typhoons intensity and climate change. However, these observations based on 30 years period, are reported to be insufficient to conclusively provide the evidence for a long-term trend.

Climate change studies suggested likely increase in peak wind intensity and near storm precipitation in future tropical cyclones, and decrease in overall frequency of cyclones. Spatial resolution of some of the earlier models used in AR4 is generally reported to be too coarse to simulate tropical cyclones. The recent advances in downscaling techniques are reported to indicate some level of success in simulating/ reproducing observed tropical cyclone characteristics. However, it should be noted that there exists limitations and high uncertainty in simulation of tropical storms.

IPCC's special report on 1.5°C scenario[163] noted similar remarks stating that the limited period of 30-40 years of observations is not enough to conclusively distinguish anthropogenic induced changes with decadal changes in overall cyclone frequencies. Further studies conducted for detection of Category 4 and 5 cyclones over recent decades indicated increasing trend. However, these changes in frequency are reported to vary from one ocean basin to another. Studies conducted with higher degree of warming indicated a decreasing trend in total number of tropical cyclones while increase in Category 4-5 cyclones.

The recent study by Knuston et. al. (2020)[164] indicated the following likely changes for occurrences of tropical cyclone over North-West Pacific:

- Overall frequency of tropical cyclone by -30 to 20% with median change of -10%,
- Changes in frequency of category 4-5 cyclone between -30 to 40% with median change of -5%.
- Intensity of cyclone indicated change between 2.5 to 10% with median of 5% increase under 2°C scenario by end of the century

Considering the projected in maximum sustained wind speeds the hazard due to cyclone under all climate change scenarios is considered to remain '***High'***.

Climate change projections for maximum wind speed (non-cyclonic) indicated increase in RCP 4.5 climate change scenarios for 2030 and 2050. Also, it is observed the percent change in sustained wind speed and wind will be increase for all climate change scenarios for Ground level.

[163] https://www.ipcc.ch/site/assets/uploads/2018/03/SREX-Chap3_FINAL-1.pdf

[164] Tomas Knuston, Suzana J, Camargo, Jhonny C. L. Chan, Kerry Emanuel, Chang-Hoi Ho, James Kossin, Mrutyunjay Mohapatra, Masaki Satoh, Masato Sugi, Kevin Walsh, and Ligiang Wu (2020. Tropical Cyclones and Climate Change Assessment: Part II: Projected Responses to Anthropogenic Warming. J. Bulletin of American Meteorological Society. 101 (3). 303-322. https://journals.ametsoc.org/view/journals/bams/101/3/bams-d-18-0194.1.xml

Table 8.101: Projected Changes in Maximum Wind Speeds under Climate Change Scenarios at Ground Level

Parameter	Absolute Values					Percentage Change (%)			
	Baseline	RCP 4.5		RCP 8.5		RCP 4.5		RCP 8..5	
		2030	2050	2030	2050	2030	2050	2030	2050
Average Maximum Wind Speed (m/s)	7.3	7.2	7.1	7.4	7.5	-1.9	-3.0	1.6	2.2
Maximum sustained wind at 2^0 Change of Temperature (source: *Knuston et al. (2020)*)	ND	ND	ND	ND	ND	3.0	4.4	3.3	5.8

Accordingly, considering the projected increase in cyclonic (sustained) wind speeds the overall hazard due to wind speeds is considered to remain '**High**'.

Table 8.102: Summary for Cyclone and Wind Hazard under Baseline and Climate Change Scenario

Baseline	RCP 4.5		RCP 8.5	
	2030	2050	2030	2050
High	High	High	High	High

Wild Fire

Wildfires are uncontrolled fires in areas of combustible vegetation. Of the various types of wildfires, forest fires are the most detrimental. The natural causes of wildfires are ascertained to be dry (and hot) climate, lightning, and volcanoes. The most common human causes of wildfire are listed as arson or sabotage, discarded cigarettes, power-line arcs, and sparks from equipment. The key parameters determining the occurrence and spread of wildfires are availability of flammable materials, fuel density, moisture content, ambient temperature, and weather conditions (wind speed).

The impacts of wildfires on the built and natural environment can be significant. In addition, controlling a wild forest fire can be extremely difficult task due to scale, intensity, and accessibility issues. Key impacts of wildfires include economic, environmental and ecological, infrastructural, heritage, and human health.

Wildfire risk was assessed based on the wildfire density data from the UNEP- Global Risk Data Platform, which was available at a resolution of ~2 km. ***Figure 8.89*** presents the average number of fires recorded in the Project area over a period of 1997-2010.

Regional level historical wildfire events are presented in ***Table 8.103.***

Table 8.103: Regional level historical wildfire events

Province	No of Events	Affected	Deaths	Houses Destroyed	Houses Damaged	Losses in Kip
01 Vientiane Mun.	126	347,549	12	145	13,203	2,303,468,583,001
02 Phongsaly	44	55,846	1	30	108	542,809,351,700
03 Luangnamtha	40	60,725	0	1,369	13	17,394,266,400
04 Oudomxay	89	82,007	2	119	656	86,227,761,020
05Bokeo	44	42,651	0	11	106	40,382,531,930
06 Luang Prabang	95	23,327	11	38	112	11,625,514,400
07 Huaphanh	57	350,944	6	28	4,581	4,549,943,990
08 Xayabury	120	35,656	33	1,776	1,286	140,864,951,548
09 Xiengkhuang	45	3,538	6	94	1	7,990,152,000
10 Vientiane	50	75,948	4	92	4,256	2,622,337,860
11 Borikhamxay	76	332,410	5	10,688	796	51,132,082,097
12 Khammuane	126	1,089,765	5	0	1,906	56,241,239,624
13 Savannakhet	67	366,842	4	39	24,165	3,624,720,000
14 Saravane	47	190,917	2	176	78	1,148,560,844
15 Sekong	26	27,224	18	766	4,049	637,776,280,981
16 Champasack	120	338,351	4	16	385	202,024,213,560
17 Attapeu	33	73,146	0	69	222	1,233,024,000
Total	1,205	3,496,846	115	15,456	55,923	4,111,115,514,955

- **Baseline**

One of the factors impacting the occurrences of wildfires is the availability of fuel. In simple words anything that can burn such as trees, grass, and shrubs can be considered as fuel. As these combustible material accumulate, the probability of occurrence of wildfire also increase. In the right conditions this fuel allows fire to burn hotter and spread on larger area, making it difficult to manage, resulting in catastrophic damages[165].

Lao PDR in general is reported to have ~56.2% of the area under the forest cover, followed by grass and shrub land covering ~23.9% and cropland 18.5%. Regional land cover distribution for Kindia, Mamou, Faranah, and Kankan is presented in ***Table 8.104***.

Table 8.104: Regional Land Cover Distribution in Lao

Region	Forest	Cropland	Grass/ Shrub-land
Attapeu	73.9%	17.5%	8.1%
Sekong	80.1%	9.6%	10.%

This indicates that, provided the availability of right weather conditions, the project location may be vulnerable to forest fires (wildfires).

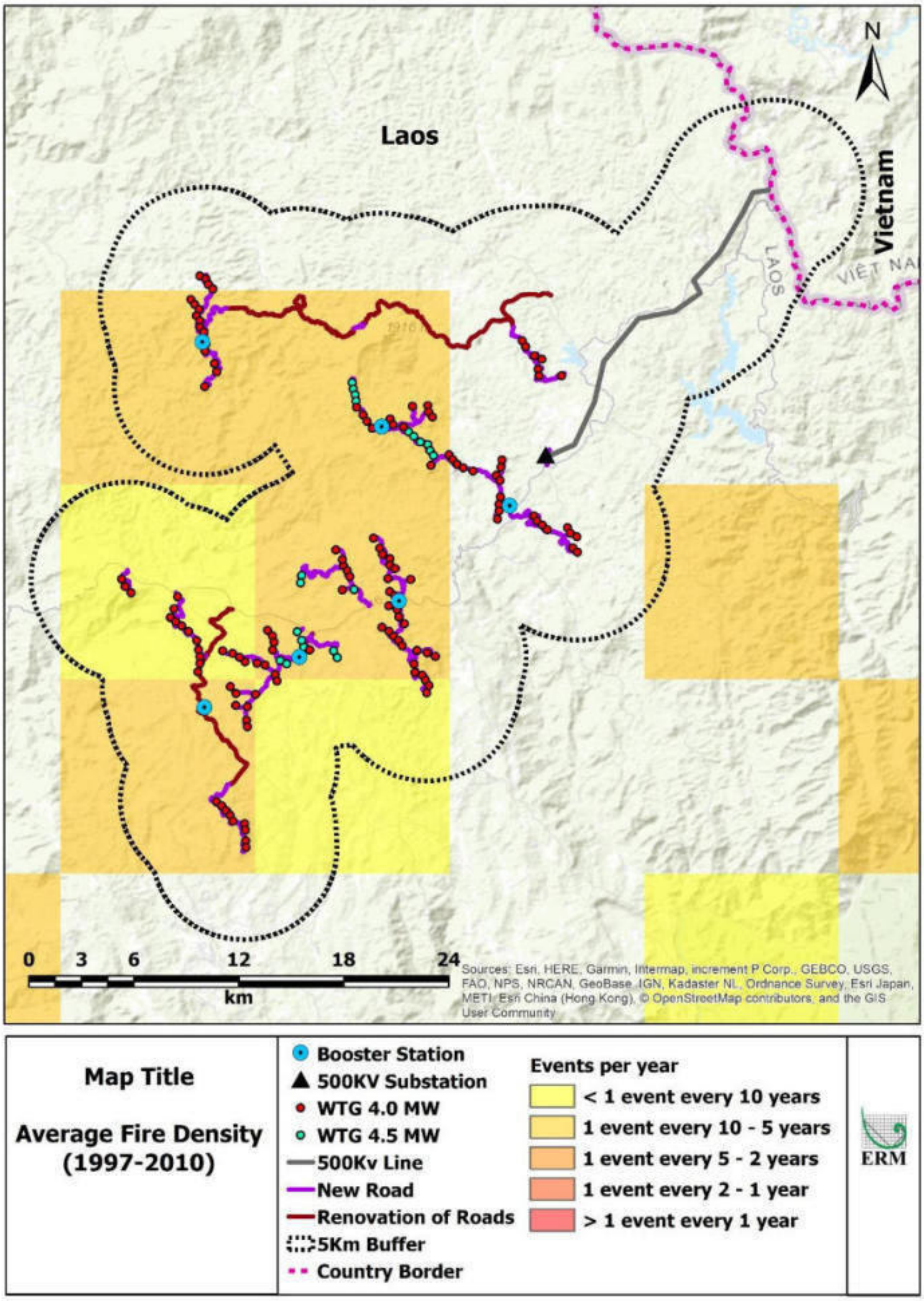
[165] https://www.doi.gov/wildlandfire/fuels

The baseline wildfire hazard was evaluated based on frequency of occurrence, as presented in ***Figure 8.89***. Baseline wildfire hazard was reported to vary 'Low' to 'Medium' at the Project site.

Considering, the fact that a forest fire can be triggered due to multiple reasons including natural (e.g. lightning strikes) or anthropogenic (accidental or intentional burning). Frequency of fire incidences only, may not be a good indicator for climate related physical risk assessment.

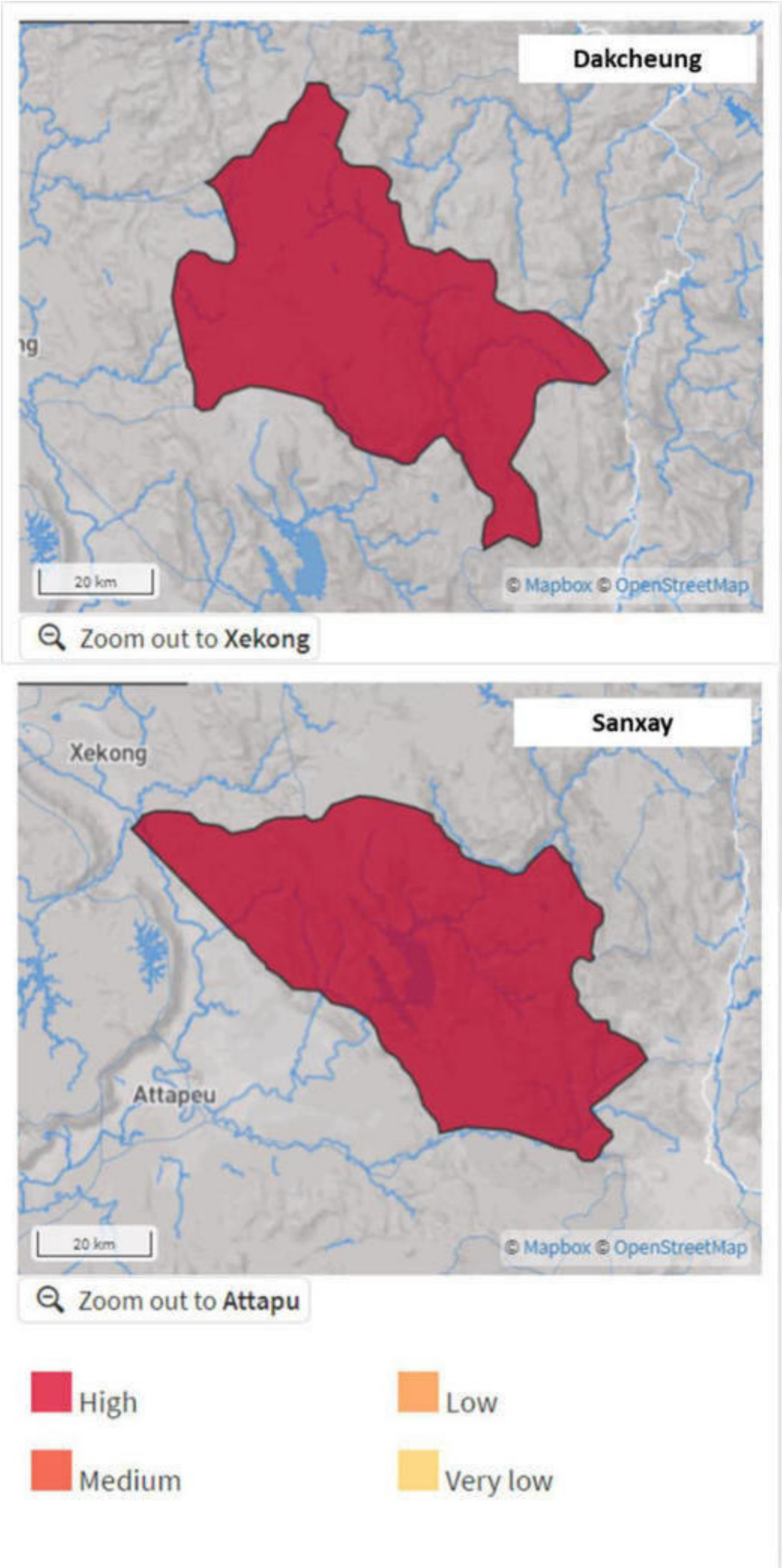
Therefore, for the purpose of this assessment, the wildfire hazard is evaluated based on the frequency of occurrence of weather which can support the significant wildfire as reported by ThinkHazard (***Figure 8.90***). Accordingly, based on prevailing weather supporting the occurrences of wildfire, the wildfire hazard is consider to be '**High**'.

Figure 8.89: Wild Fire Frequency



Source: UNEP- GRID

Figure 8.90: Baseline Wild Fire Hazard



Source: Think Hazard

- **Climate Change**

The climate change projections indicate increased maximum temperature and longer warm spells as presented in ***Table 8.105***. Therefore, the wildfire hazard is considered to remain '**High**' under all climate change scenarios

Table 8.105: Climate Change Projections for Temperature Parameters

Parameter	Baseline	Change from Baseline			
		RCP 4.5		RCP 8.5	
		2030	2050	2030	2050
Average Temperature (°C)	3.9	0.9	1.5	1.0	1.9
Average Maximum Temperature (°C)	27.6	0.9	1.5	1.1	1.9
WSDI (days)	12	32	62	35	73

Table 8.106: Summary of Wildfire Hazard under Baseline and Climate Change Scenario

Baseline	RCP 4.5		RCP 8.5	
	2030	2050	2030	2050
High	High	High	High	High

Lightning and Thunderstorms

Thunderstorms are usually created by heating of the ground surface resulting in upward atmospheric motion that transport moisture along with air. Thunderstorms may lead to high wind conditions with gust speed exceeding 25 m/s, lightning strikes, extreme rainfall and flash floods, and hail showers[166].

As per National Severe Storm Laboratory (NSSL), lightning is a giant spark of electricity in the atmosphere between clouds, the air, or the ground. The process triggers instant release of energy of the order of 1 Gigajoule. Lightning can be caused in three (3) mechanisms; viz within the same thunder cloud, between two (2) thunderclouds or between a thundercloud and ground.

Lighting can cause damage to natural and built environment. Objects struck by lightning experience heat and magnetic forces of great magnitude. It can affect trees, by vaporizing the sap resulting in bursting of bark, damage to tall buildings and structures and several injuries or loss of life.

For the purpose of present assessment, thunderstorms and lightning were evaluated based on the lightning flash data from NASA.

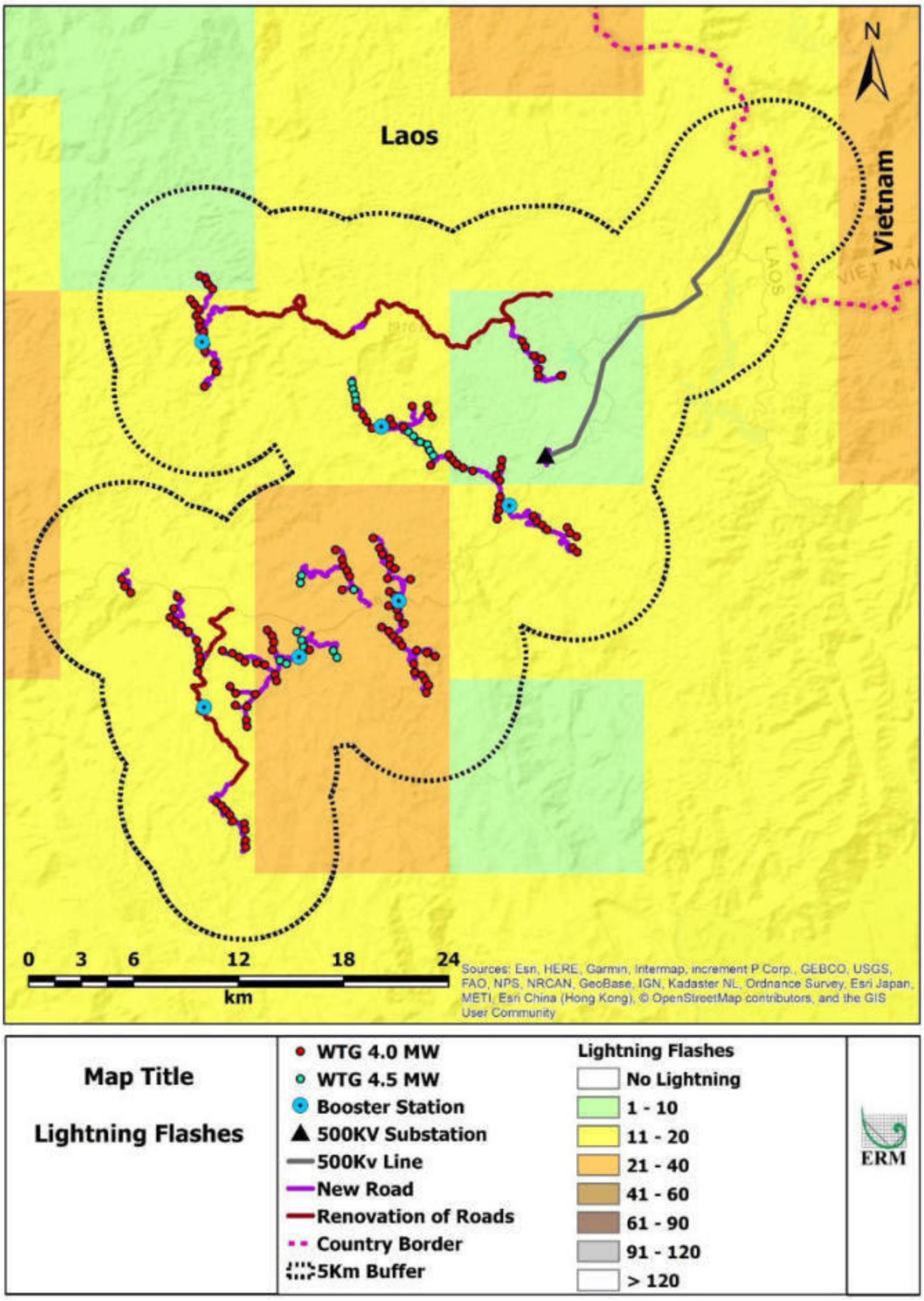
- **Baseline**

A lightning map based on NASA lightning flash data as presented in ***Figure 8.91*** indicates average lightning frequency to vary between less than 10 to up to 60 flashes/km^2/year in the Study Area.

In the absence of standards to categorize the thunderstorm/ lightning hazard, hazard categorization has not been conducted. However, these hazards are evaluated to present the historical events and provide an understanding on different types of hazards likely to be experienced at the study areas.

[166] https://www.nssl.noaa.gov/education/svrwx101/thunderstorms/

Figure 8.91: Lightning Frequency



Sorce: NASA-GHRC

- **Climate Change**

There are no direct projections available for lightning. However, as lightning usually occurs during thunderstorms, any changes in occurrences of thunderstorm are considered as measure for changes in lightning in future.

A literature review indicates that predicting changes in thunderstorm is difficult task, and hence generally changes in frequency of large scale environmental conditions conducive to thunderstorms are used as an indirect measure. One such factor is convective available potential energy (CAPE), which is a measure of maximum kinetic energy obtainable by an air parcel lifted adiabatically from near surface. CAPE is also reported to be important large scale indicator for the potential lightning.

The literature review also indicates tropical and subtropical CAPE extremes increasing sharply with warming across ensembles of global climate models participating in Coupled Model Intercomparison Project 5 (CMIP5). Projections for CAPE available from literature indicated an increase of 250-500J/kg in CAPE by end of century under RCP 8.5 scenario. Such increase in CAPE in future is likely to increase the frequency of days with conditions conducive to the formation of thunder storms by ~25 days/ year.

Hence, increase in thunderstorm and lightning activity can be expected in future under climate change scenarios. In addition, the development of windfarms may further exacerbate the lightning strikes in the area.

8.6.2.3 Existing Controls

Water Availability

- Whenever the project is required to pump water from the stream in the Project area for construction, a water use plan will be required and notified to the local people. This should be coordinated with the State agency of the district and provincial levels.
- Provide clean water for use for consumption to construction workers.

Riverine Floods

- When a rainstorm warning is received, consider suspending operations and transfer personnel to safe location.
- Review meteorological information regularly, and take precautions against possible floods, landslides, mudslides, and other disasters.
- Ensure an Emergency Response Plan is in place covering floods, landslides, wildfires, cyclones, and thunderstorms.

Landslides

- Review meteorological information regularly, and take precautions against possible floods, landslides, mudslides, and other disasters.
- Ensure an Emergency Response Plan is in place covering floods, landslides, wildfires, cyclones, and thunderstorms.
- Avoid undertaking earthwork during heavy rainfall that can cause erosion; perform backfilling and compacting work after completing the construction; replantation in suitable areas where possible.

Extreme Heat

- Ensure designed operation temperature range ~30-40°C

Cyclone and Wind Speed

- Ensure designed operational wind turbines at wind speed ranges between ~24 to 26 m/s.

- Ensure an Emergency Response Plan is in place covering floods, landslides, wildfires, cyclones, and thunderstorms.
- Design to consider wind turbine's impeller lock process for wind speeds.

Wild Fire

- Ensure an Emergency Response Plan is in place covering floods, landslides, wildfires, cyclones, and thunderstorms.

Lightning and Thunderstorms

- Ensure lightning protection grounding of the wind turbine. A metal air termination system is installed at the blade tip. A copper conductor is used to reliability connect the air termination system to the lightening lead on hub.
- Ensure an Emergency Response Plan is in place covering floods, landslides, wildfires, cyclones, and thunderstorms.
- Ensure design according to IEC-61400-24 to achieve Grade I lightning protection to wind turbine the cross-sectional area of blade lighting protection copper conductor should not be less than $50mm^2$.

8.6.2.4 Significance of Risks

Water Availability

- There is no significant risk due to reduced or non-availability of water is expected. However, it may impact the water requirement of domestic usage including drinking and sanitation by the employees and workers at the Site.
- Water availability may impact the water required by the nearby communities for their domestic and agricultural purposes.

Riverine Floods

- No significant risk due to riverine floods is expected.

Landslides

- Landslides may damage physical infrastructure including wind turbines, transmission towers, and substations. This may also result in disruption of operations at the Site.
- Landslides can also pose a significant threat to health and safety of the employees and workers working at the Site.
- Disruption of access routes to and from the Site.

Extreme Heat

- Extreme temperature may result in reduced wind power generation,
- Wind power generation is reported to decline with increase in temperature. Therefore, occurrences of extreme temperature may result in reduced power generation efficiency of the turbines.
- Extreme temperature may also result in damage to electronic components.
- Higher temperatures can also reduce the efficiency of the power transmission
- Extreme temperature may also impact the H&S of the employees due to risk of heat stress. Higher temperature will also result in increased demand for water.

Cyclone and Wind

- Damage to physical assets including wind turbines, transmission towers, and transmission lines due to high wind speeds.
- Suspension of power generation if the wind speeds exceed maximum (cut-off) wind speeds resulting in loss of power generation.
- Threat to the safety of employees, workers working in the open, or at heights (construction or maintenance of wind turbines and transmission lines).

Wild Fire

- Wild fire can result in damage to the physical assets
- It can also pose a significant risk to safety of employees and workers due to fire as well as smoke.

Lightning

- Damage to electrical components due to lightning strike
- Grid failure due to lightning strike
- Damage to electrical components due to lightning strike
- Cost for replacement of assets
- People working in the open during thunder storm may be considered as most vulnerable
- Lightning strikes on human being may result in death or serious injuries

8.6.2.5 Additional Mitigation, Management, and Monitoring Measures

Water Availability

- The water availability related issues should be monitored and tracked closely.
- Implement water saving technologies for domestic water usage within project.

Riverine Floods

- Site to implement identified control/ response measure.
- Monitor flood situation at the Site. If any significant floods events affecting the physical infrastructure, operations, and health and safety are observed in future, detailed studies may be considered for flood mitigation measures.

Landslides

- Implement identified control measure
- Prepare emergency response plan for landslide events

Extreme Heat

- Worker’s resting areas, on-site offices, worker’s quarters should be constructed with heat resisting material to keep the indoor temperature lower.
- A heat stress management plan should be prepared as part of standard operations and safety procedures.
- Train workers to identify the symptoms of heat stress and first aid.
- Make appropriate considerations while designing the cooling systems (if required).

Cyclone and Wind

- Include cyclone and wind as one of the hazard in emergency management plan

Wild Fire

- Include wildfire as one of the hazard in emergency management plan
- Develop and maintain fire lines around the important assets
- Develop and maintain vegetation clearances with respect to prevailing standards and regulations

Lightning

- Include lightning as one of the hazard in emergency management plan

8.6.2.6 Residual Impact Significance

Table 8.107 presents the summary of hazards under various climate change scenarios and implications of the hazard on various project components.

Table 8.107: Hazard Receptor Matrix

Hazard	Hazard Category (Acute or Chronic)	Hazard Level				Summary of Applicable Planned/ Existing Control Measures							Recommendations
		RCP 4.5		RCP 8.5									
		2030	2050	2030	2050		Wind Turbine (WTG)	Transmission line and Towers	Sub stations	Other Buildings	Employees	Communities	
Water Availability	Chronic	Low	Low	Low	Low	■ Prepare water use plan and inform the local people and coordinate with the State agency of district and provincial levels for inspecting whether the water pumping point is appropriate or not[167]. ■ Provide clean water for use for consumption to construction workers[167].	■ No Implications	■ No Implications	■ No Implications	■ No Implications	■ Reduced availability for domestic usage including sanitation and drinking	■ Reduced availability for domestic and agricultural use	■ The water availability related issues should be monitored and tracked closely ■ Implement water saving technologies for domestic water usage within project.
Riverine Floods	Acute	None	None	None	None	■ Consider cutting off outdoor power supply and suspending operations. Ensure personnel transferred to the safe place[167] ■ Review regularly meteorological information, and take precautions against possible floods, landslides, mudslides, and other disasters[168]. ■	■ No Implications	■ No Implications	■ No Implications	■ No Implications	■ No Implications	■ No Implications	■ Implement identified control measures
Landslides	Acute	High	High	High	High	■ Keep an eye on meteorological information, and take	■ Physical damage to	■ Physical damage to	■ Physical damage to	■ Physical damage to	■ Health and Safety	■ Physical damage to	■ Implement identified

[167] Environmental Consultancy Company (2020). 600 MW Monsoon Wind Farm Project Dakcheung District, Sekong Province and Sanxay District, Attapeu Province Environmental and social Impact assessment Report.
[168] Goldwind International for rainstorm and flood emergency disposal plan

Hazard	Hazard Category (Acute or Chronic)	Hazard Level				Summary of Applicable Planned/ Existing Control Measures							Recommendations
		RCP 4.5		RCP 8.5									
		2030	2050	2030	2050		Wind Turbine (WTG)	Transmission line and Towers	Sub stations	Other Buildings	Employees	Communities	
						precautions against possible floods, landslides, mudslides and other disasters[167]. ■ Avoid undertaking earthwork during heavy rainfall that will easily cause erosion; perform backfilling and compacting work after completing the construction; plant the grass on suitable places or leave the places for the plants to grow and become green[167];	assets/ foundations	assets/ foundations ■ Disruption of supply chains	assets/ foundations	assets/ foundations	■ Disruption of access routes	infrastructure and buildings ■ Health and safety	control measure ■ Prepare emergency response plan for landslide events
Extreme Heat	Acute	High	High	High	High	■ Designed operation temperature range ~30-40°C[169]	■ Reduced Efficiency ■ Damage to electronic monitoring/ controlling component ■ Loss of production ■ Costs for replacement of damaged assets	■ Reduced transmission efficiency	■ Overheating of components resulting in damage or reduced efficiency	■ Increase in cooling demand	■ Reduced comfort levels ■ Threat of heat stress/ heat stroke ■ Increased water demand	■ Reduced comfort levels ■ Threat of heat stress/ heat stroke ■ Increased water demand	■ Worker's resting areas, on-site offices, worker's quarters should be constructed with heat resisting material to keep the indoor temperature lower. ■ A heat stress management plan should be prepared as part of standard operations and

[169] Information of the proposed WTG, Technical Document, 600MW Monsoon On-Shore Wind Farm Project.

Hazard	Hazard Category (Acute or Chronic)	Hazard Level				Summary of Applicable Planned/ Existing Control Measures							Recommendations
		RCP 4.5		RCP 8.5									
		2030	2050	2030	2050		Wind Turbine (WTG)	Transmission line and Towers	Sub stations	Other Buildings	Employees	Communities	
													safety procedures. ■ Train workers to identify the symptoms of heat stress and first aid. ■ Make appropriate considerations while designing the cooling systems (if required).
Cyclone and Wind Speed	Acute	High	High	High	High	■ Operate wind turbines at wind speed ranges between ~24 to 26 m/s[169]. ■ Projects in combination with the practical situation of the site of the project and the project office, cyclone early warning information, based on the local meteorological department to detailed ferreting cyclone hazards, to identify the hazards and take appropriate measures, plan, supervision and control[170]. ■ Check the wind turbine's impeller lock situation on site[170].	■ Damage due to high wind speed ■ Suspension of power generation if the upper limit for wind speed exceeds ■ Lost production Cost for replacement of assets	■ Damage, uprooting of transmission towers ■ Short-circuiting in transmission lines Cost for replacement of assets	■ Structural damage due to heavy rainfall Cost for replacement of assets	■ Damage/ collapse of non-permanent structures Cost for replacement of assets	■ High wind speed can lead to threat towards safety of workers working at heights for installation or maintenance of wind turbines, transmission line during high wind conditions. The threat can be in the form of fall or injury to the eyes from the debris (sand/ dust) carried by the winds.	Health and Safety	■ Implement identified control measure ■ Include cyclone and wind as one of the hazard in emergency management plan

[170] Goldwind International typhoon emergency plan

Hazard	Hazard Category (Acute or Chronic)	Hazard Level				Summary of Applicable Planned/ Existing Control Measures							Recommendations
		RCP 4.5		RCP 8.5									
		2030	2050	2030	2050		Wind Turbine (WTG)	Transmission line and Towers	Sub stations	Other Buildings	Employees	Communities	
						■ During the cyclone, people stay in permanent residence and are prohibited from staying in temporary rooms[170] ■ Before the cyclone comes, should pay attention to the safety of the electric field. Important equipment such as computer and air conditioning must be off[167]							
Wildfire	Acute	High	High	High	High	■ No Existing Plans Available	■ Physical damage to assets	■ Physical damage to assets	■ Physical damage to assets	■ Physical damage to assets	■ Health and Safety ■ Disruption of access routes	Physical damage to infrastructure and buildings Health and safety	■ Include wildfire as one of the hazard in emergency management plan ■ Develop and maintain fire lines around the important assets ■ Develop and maintain vegetation clearances with respect to prevailing standards and regulations
Lightning	Acute					■ Check the lightning protection grounding of the wind turbine[171]. ■ A metal air termination system is	■ Damage to electrical components due to lightning strike	■ Grid failure ■ Cost for replacement of assets	■ Damage to electrical components due to lightning strike	■ Damage to electrical components due to lightning strike	■ People working in the open during thunder storm may be considered as most vulnerable	■ People working in the open during thunder storm may be considered as most vulnerable	■ Implement identified control measures ■ Include lightning as

[171] WTG Specifications, 600MW On-Shore Wind Farm Project, Tendering Document

Hazard	Hazard Category (Acute or Chronic)	Hazard Level				Summary of Applicable Planned/ Existing Control Measures							Recommendations
		RCP 4.5		RCP 8.5									
		2030	2050	2030	2050		Wind Turbine (WTG)	Transmission line and Towers	Sub stations	Other Buildings	Employees	Communities	
						installed at blade tip. A copper conductor is used to reliability connect the air termination system to the lightening lead on hub. ■ According to IEC-61400-24 to achieve Grade I lighting protection to wind turbine the cross-sectional area of blade lighting protection copper conductor should not be less than $50mm^2$ ■ If any worker wants to go out, do not carry umbrellas. At the same time, the lightning protection measures.	■ Lost production ■ Cost for replacement of assets		■ Cost for replacement of assets	■ Cost for replacement of damaged good	■ Lightning strikes on human being may result in death or serious injuries	■ Lightning strikes on human being may result in death or serious injuries	one of the hazard in emergency management plan

EP-4 requires to identify potential impacts of project development on exacerbation of climate related risks as presented in ***Table 8.108***.

Table 8.108: Impact of Project on Exacerbation of Climate Related Physical Risks

Hazard	Hazard Category (Acute or Chronic)	Implications
Landslides	Acute and Chronic	■ Change in land use pattern and excavations may further exacerbate the landslide hazard
Lightning	Acute	■ The wind turbine tower may exacerbate the lightning strikes
Wildfire	Acute	■ Any short-circuiting between over-head power lines during high wind conditions (particularly during dry periods) may trigger wildfire.