PHYSICAL CLIMATE RISK ASSESEMENT

Garanti BBVA

SUSTAINABILITY TEAM

Table of Contents

Assessment of Climate Change Related Physical Risks **2**

Physical Climate Risk Framework **3**

Hazards *3*

Exposure *3*

Vulnerability *4*

Physical Climate Risks of Garanti BBVA's Portfolios **5**

Operational Assets of Garanti BBVA *5*

Renewable Energy Assets of Garanti BBVA *8*

Summary **10**

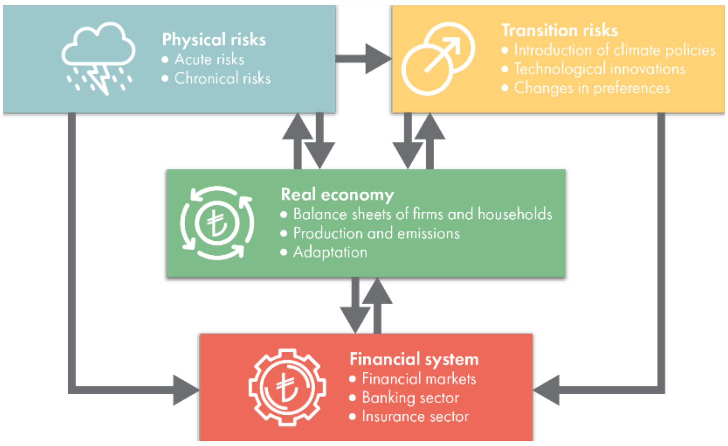
Appendices .... **i**

Operational Assets Risk .... *i*

Renewable Energy Assets Risk .... *ii*

Assessment of Climate Change Related Physical Risks

An emerging question is how the financial sector can respond to the increasing frequency and magnitude of extreme weather events. In particular, banks and credit companies must consider not just the climate risk of the region but also the issuer's sector-specific vulnerabilities. There are two main results of climate change: physical risks and transition risks. Physical risks are the direct results of climate change. They can be either **acute physical risks** (with a fast onset time such as extreme precipitation) or **gradual/chronical physical risks** (with a slow onset time such as sea level rise).



Acute or chronic, managing the physical risks of climate change requires an understanding of which assets are exposed to climate hazards and how the effects of hazards will change over time. Chronic changes in climate can affect economic output and productivity, while acute changes caused by extreme events can lead to asset damage, operational disruptions, and potential changes to asset value due to the damage. Even though extreme events often attract more attention as their impacts are more chaotic and apparent, the risks from chronic changes, which are already happening slowly, should not be overlooked.[1]

Also, risks from physical climate hazards endanger companies based on the location of their assets. Physical risks become business risks when manufacturing facilities, data centers, and other operating facilities are damaged or disrupted, for example.[2]

On the other hand, different from the physical risks, transition risks are the risks emerging during the transition from high carbon to a low carbon emission economy. This transition creates extra economic load for companies through higher costs of production, changes in customer preferences, changes in the used technologies, etc. So, the framework for physical and transition risks has completely different

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[1] *UNEP. (2018). Navigating a New Climate PART 2: Physical risks and opportunities. UN Environment Programme.*

[2] *Preudhomme, N. A. (2022, 06 18). Understanding Industry Relative Exposure to Physical Impacts of Climate Change. https://427mt.com/: https://427mt.com/2021/06/07/understanding-industry-relative-exposure-to-physical-impacts-of-climate-change/*

approaches. Having a context-specific plan to adapt to physical climate risks in existing and/or new operations for banks, insurance companies, and crediting companies is a must.

Physical Climate Risk Framework

According to the IPCC's[3] Fifth Assessment Report (AR5)[4]:

Risk is defined as the potential for consequences where something of value is at stake. Within the AR5 framework, the level of risk in any geographic location is determined as Risk is a function of vulnerability, exposure, and hazard.

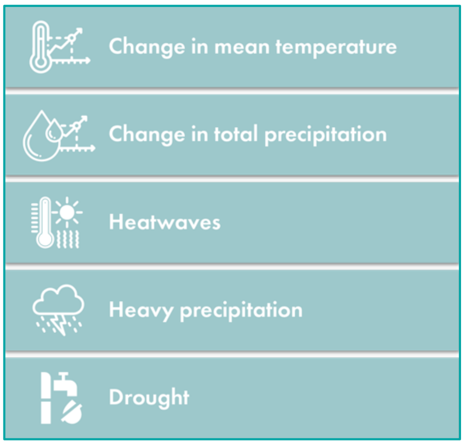
Hazards are climate-related physical events, trends, or their physical impacts that may cause loss of life, injury, other health impacts, loss to property, infrastructure, services, ecosystems, or resources.

Exposure is the presence of people, livelihoods, infrastructure, services, and ecosystems that could be affected by the hazard.

Vulnerability is the sensitivity and adaptive capacity of the affected system to the hazard. Vulnerability varies by sector or sub-sector and location.

Hazards

What determines risk is, under various future climate change scenarios, the magnitude and direction of change in climate and climate-related hazards. In this study, future changes in climate are obtained from global climate models and are applied to index-based climate-related hazards, which are shown in the figure on the right. The data drawn from modeling studies and observations, is provided for future time horizons and Representative Concentration Pathways (RCPs)[5] of interest.



Exposure

Portfolios located in various geographies have different exposures based on the hazard. The exposure of the portfolio is a matrix of investment sectors, sub-sectors, and their associated locations. The level of portfolios can range from point-location

[3] *Intergovernmental Panel on Climate Change*

[4] *IPCC. (2014). IPCC Fifth Assessment Report: Climate Change 2014. Geneva: Intergovernmental Panel on Climate Change.*

[5] *Representative Concentration Pathways represent possible future greenhouse gas emissions and atmospheric concentration scenarios. Four RCPs were used in the IPCC's Fifth Assessment Report.*

data for individual investments to country-level data. Climate-related hazards and risks will differ substantially across different levels and geographies. For example, the Ege, Akdeniz and Karadeniz Regions are regions with significant numbers of projects that also stand out with the highest operational risk scores. However, in terms of wildfire hazard, Ege and Akdeniz stand out as regions with the highest risk. Meanwhile, for heavy precipitation, Karadeniz Region is among the most exposed.

Vulnerability

Within a sector, there are significant differences in average exposure depending on the region/location, as physical climate risk highly varies by location.[6] But also, sensitivity analysis for assessing the physical risks should consider the special and different needs of every single sector because every sector has its own special dynamics. For example, hydroelectric power plants are highly sensitive to changes in temperature and precipitation patterns. Higher precipitation increases the river flows and water levels behind the dam where higher temperatures cause higher evaporation rates and reduce the water storage etc.[7, 8, 9] As a result, hydroelectric power plants' sensitivity to temperature and precipitation pattern changes is higher. Wind power sensitivity, on the other hand, is determined by wind speed, air temperature, and extreme events. Turbines cannot operate in extremely high or extremely low wind speeds, resulting in a reduction in power generation. Changes in the temperature patterns affect the output, and extremes can damage the infrastructure.[7, 8] A rise in temperature reduces cell efficiency and thus energy output in solar power plants. Precipitation's effects on solar power are complicated where it can increase the output by cleaning the dust from the panels and reduce it by causing less solar radiation due to cloudy weather conditions. Extreme events can damage the systems.[7, 8] For geothermal power, temperature and extremes are the keys. Temperature increase changes the power output by changing the temperature difference, and extremes can damage the infrastructure.[9] Sensitivities for the banks own operations are mostly affected by the extreme weather events like heavy precipitation, flooding, heatwave then the gradual/slower changes like the changes in temperature and precipitation patterns.[10]

Every studied sector and sub-sectors' own needs and processes are considered during the assessment of the sectoral sensitivities. International methodologies are examined and combined with expert knowledge.

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[6] *Preudhomme, N. A. (2022, 06 18). Understanding Industry Relative Exposure to Physical Impacts of Climate Change. https://427mt.com/: https://427mt.com/2021/06/07/understanding-industry-relative-exposure-to-physical-impacts-of-climate-change/*

[7] *ADB. (2012). Climate Risk and Adaptation in the Electric Power Sector. Manila, Philippines: Asian Development Bank.*

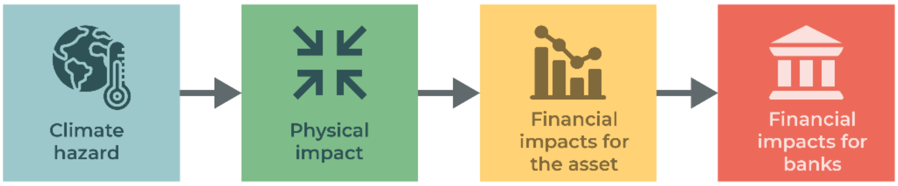
[8] *US Department of Energy. (2013). US Energy Sector Vulnerabilities to Climate Change and Extreme Weather.*

[9] *IDB. (2019). Disaster and Climate Change Risk Assessment Methodology for IDB Projects. Inter-American Development Bank.*

[10] *EBRD-GCECA. (n.d.). Advancing TCFD Guidance on Physical Climate Risks and Opportunities. London, UK: European Bank for Reconstruction and Development.*

Physical Climate Risks of Garanti BBVA's Portfolios

The assessment of climate change related physical risks for Garanti-BBVA's portfolio has the following characteristics. Analyses were completed with three different future time horizons and two different main sectors under two global climate scenarios.



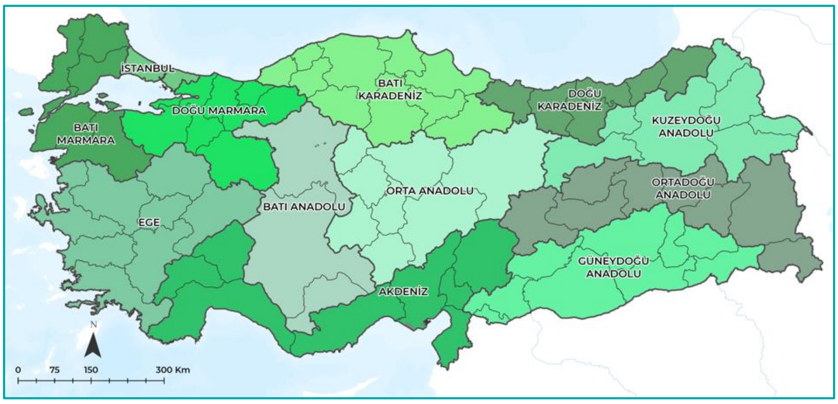
The climate change impacts were examined for the scenarios RCP2.6 and RCP8.5, which are the lowest and highest CO_2 emissions scenarios covered in the IPCC's AR5 reports. RCP2.6 represents a scenario that is likely below 2°C above pre-industrial temperatures[11] and is thereby in line with the goals of the Paris Agreement. RCP8.5 is a high emissions scenario and refers to the "without climate policy" scenario.

MPI-ESM (Max Planck Institute-Earth System Model) global climate model was used with two spatial resolutions (coarse and high) and short-term (2023-2042), medium-term (2043-2062) and long-term (2081-2100) time horizons. The physical climate risk assessment was conducted for the renewable energy sector sub-sectors Hydroelectric Energy Power Plants (HEPP), Wind Energy Power Plants (WPP) and Solar Energy Power Plants (SEPP) and Garanti BBVA's own operations.

The physical climate risk scores were calculated by aggregating the hazard, exposure, and vulnerability components. The results of the risk assessment are shown in the following sections by the assets of Garanti BBVA.

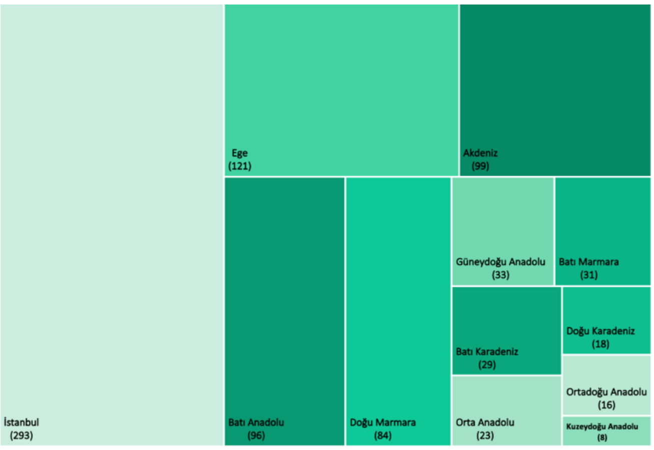
Operational Assets of Garanti BBVA

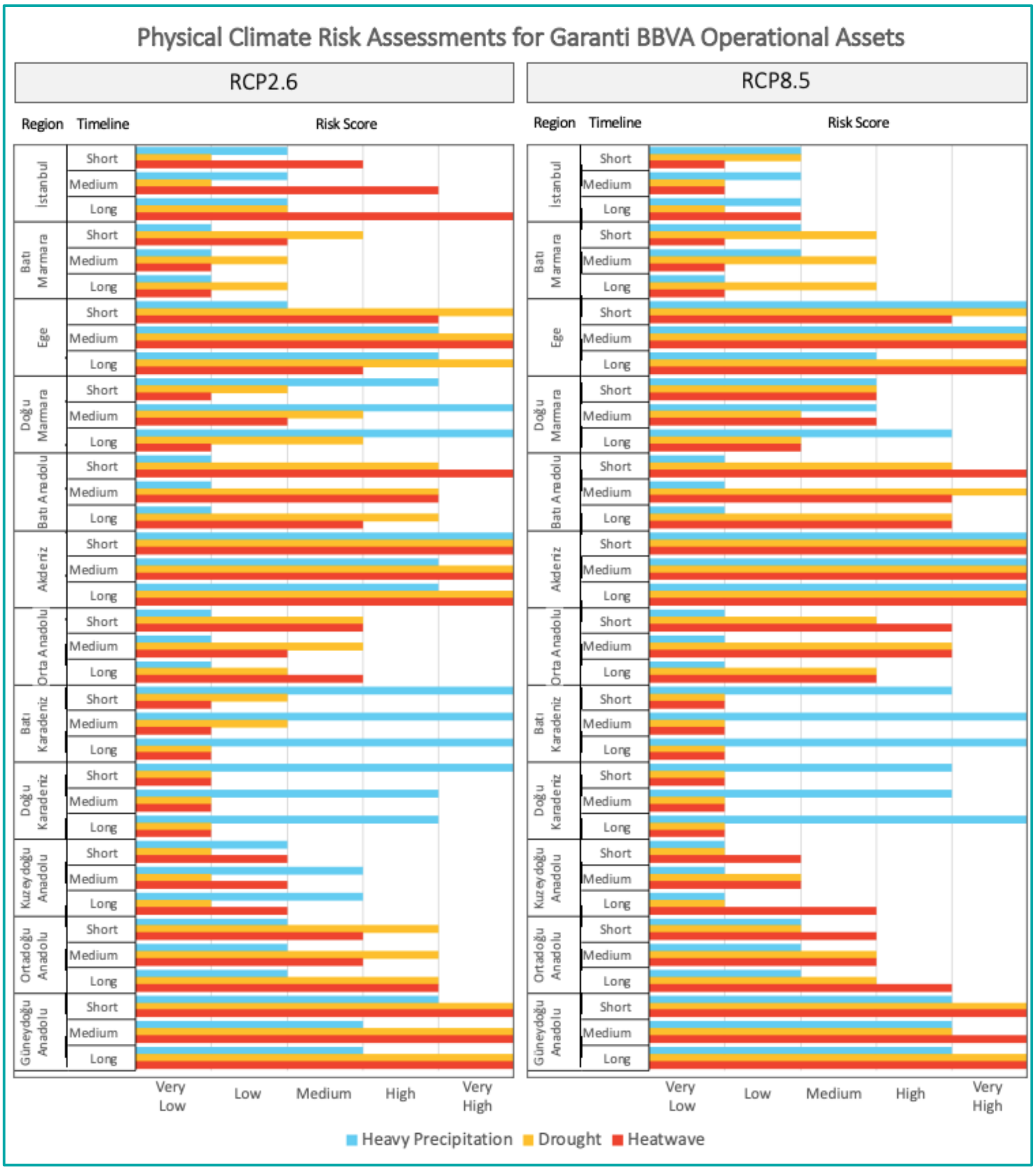
Garanti BBVA's own operational assets (bank branches and headquarters, etc.) were studied under two global climate scenarios: RCP2.6 with coarse resolution and RCP8.5 with high resolution. Drought, heavy precipitation, and heatwave hazards were analyzed for the NUTS Level-1 Geographical Regions of Türkiye as shown on the right.



[11] *IPCC, (2014a). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri, and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp., https://doi.org/10.1256/004316502320517344.*

There are a total of 851 physical assets of Garanti BBVA's own operations. The most bank branches in Türkiye are in İstanbul Region (293), followed by Ege Region (121) and Akdeniz Region (99). The figure below shows the number of branches in each region and their comparative sizes to each other. The bank branches were also classified by their size (from 0-200 m^2 to 1800+ m^2) and were used as the exposure component's indicator. Physical climate risk scores according to climate scenarios of RCP2.6 (left panel) and RCP8.5 (right panel) for the NUTS Level-1 geographical regions of Türkiye and future time horizons are summarized in the figure below. In the figure, risk scores for heavy precipitation hazard in blue, drought hazard in yellow and heatwave hazard in red are shown.

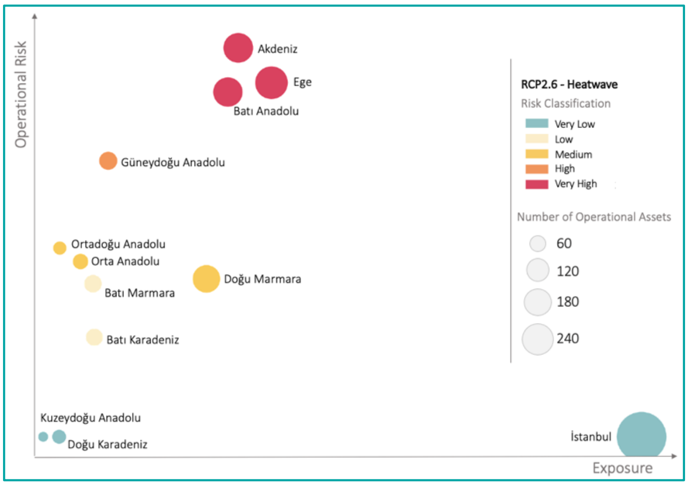




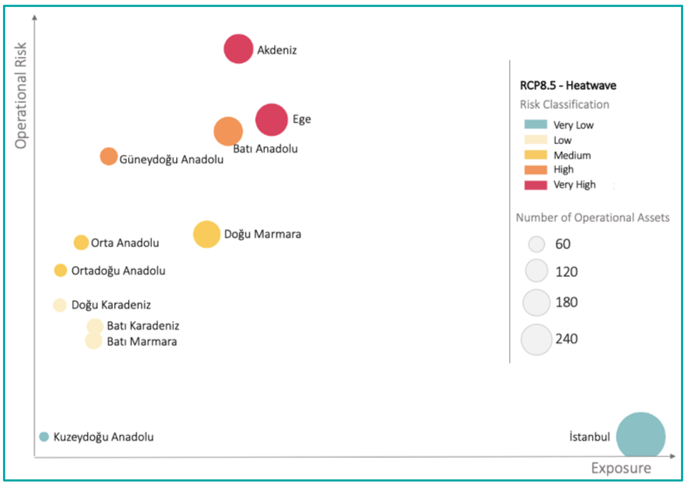
For both spatial resolutions, Batı Karadeniz and Doğu Karadeniz Regions have high or very high heavy precipitation hazard risk for all time horizons, where drought and heatwave risk scores are very low. For all time horizons, the Güneydoğu, Anadolu, and Akdeniz Regions have high or very high-risk scores for drought and heatwave hazard. However, unlike Karadeniz regions there is also a medium to very high heavy precipitation risk for those regions, all along with the drought and heatwave. Due to the heavy precipitation hazard, Güneydoğu Anadolu has a medium to high-risk score, while Akdeniz has a high to very high-risk score.

Also, Ege has a very high-risk score for drought and incrementally increasing heavy precipitation and heatwaves for the RCP2.6 scenario over the time horizons. On the other hand, for the same region, heavy precipitation and drought are very high, and the frequency of heatwaves is increasing over time for the RCP8.5 scenario. Istanbul Region has interesting results in terms of a constantly increasing risk score for the heatwave. Also, Ortadoğu Anadolu has a constant risk score for heavy precipitation but increasing results for drought and heatwave hazards.

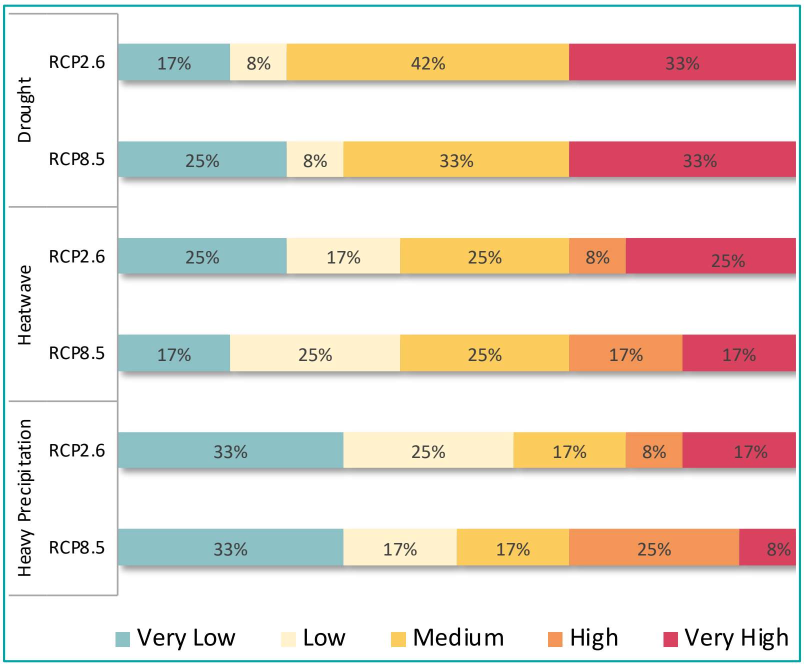
The figure shows the heatwave hazard risk of all the regions for RCP2.6 (top) and RCP8.5 (bottom) climate scenarios. The size of the circles shows the number of operational assets, and the color of the circles shows the risk scores. In the figure, exposure is indicated on the x-axis while the y-axis represents the operational risk score.



Aside from Istanbul, where exposure is high, but risk is low; the regional pattern of the heatwave risk scores goes up with increasing exposure and number of assets for both climate scenarios. However, Doğu Marmara and Güneydoğu Anadolu show an exception. Doğu Marmara has high exposure but low risk, whereas Güneydoğu Anadolu has lower exposure but higher risk.



The figure on the right shows the risk distribution of Garanti BBVA operational assets for the short-term time horizon (2023-2042). With the differences between RCP2.6 and RCP8.5 scenarios are very small, both scenarios show similar patterns.



As a result, drought risk is the emerging risk with high priority, followed by heatwave risk. Besides the drought hazard, where 75% (RCP2.6) and 66% (RCP8.5) of assets are in the medium and very high-risk category, the heatwave risk score is reaching 59% for both scenarios. The heavy precipitation hazard risk (from medium to very high risk) is between 42% and 50% according to RCP2.6 and RCP8.5 scenarios. In light of these results, Garanti BBVA would benefit from a deliberate adaptation plan regarding the regional differences and different impacts of hazards.

Renewable Energy Assets of Garanti BBVA

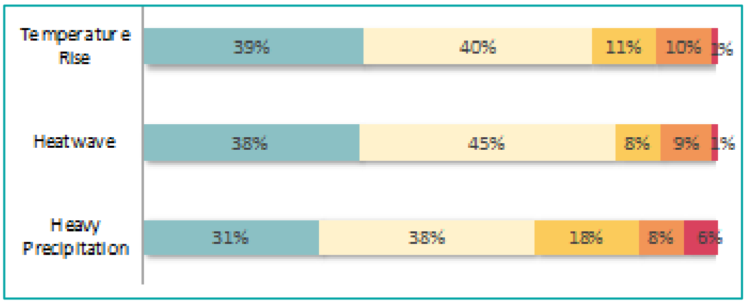
Garanti BBVA's renewable energy sector sub-sectors, Hydroelectric Energy Power Plants (HEPP), Wind Energy Power Plants (WEPP) and Solar Energy Power Plants (SEPP), were studied with only high resolution RCP8.5 scenario. Drought, heavy precipitation, heatwave hazards, and changes in mean temperature and total precipitation were analyzed under the RCP8.5 scenario for the district-level of Türkiye.

The renewable energy projects and their credit values were used as exposure components in this study. There are a total of 166 power plant projects supported by Garanti BBVA since 2007. According to this, the most invested power plant in the energy sector is WEPP (101), followed by HEPP (46) and SEPP (19). The figure on the right, shows the number of projects in each sub-sector and their comparative sizes to each other among all the projects in renewable energy sector.

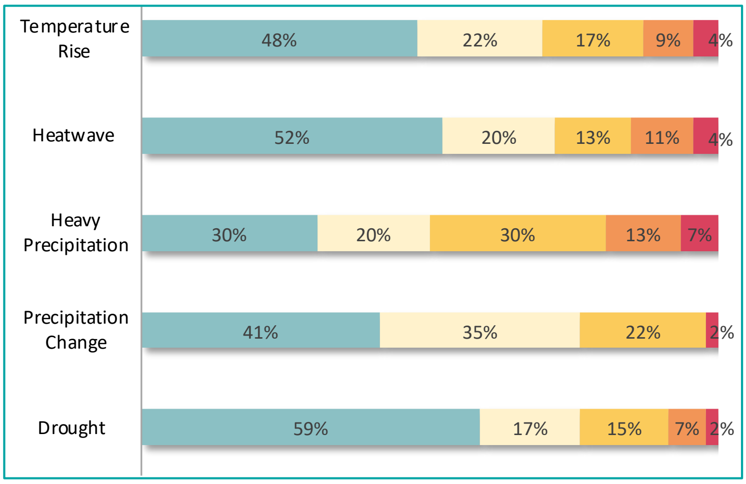
The majority of the WEPPs are located in the cities of İzmir (21), Manisa (20), and Balıkesir (15). Most of those projects are clustered in Ege and İç Anadolu Regions. For the HEPPs cities with the highest number of projects are in Sivas (5) and Adana (5), followed by Sinop (4). Most of those projects are clustered in Karadeniz and Doğu Anadolu Regions. SEPPs with the higher number of projects are in Konya (4), Burdur (3) and Kırıkkale (2) cities. Most of those projects are clustered in Ege and İç Anadolu Regions.

In the following figures, the risk distributions of renewable energy assets are given for selected hazards according to each energy asset type of Garanti BBVA for the short-term time horizon (2023-2042) with RCP8.5 climate scenarios.

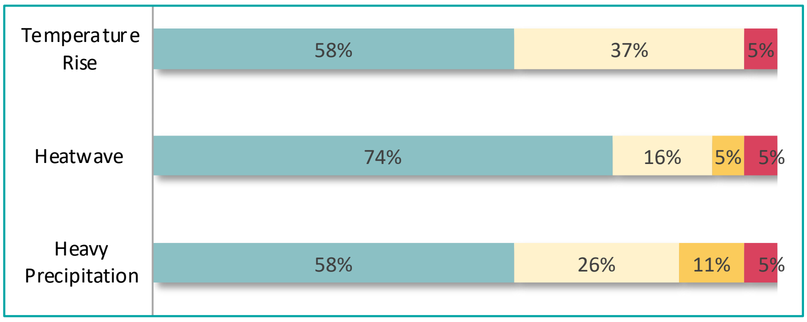
The risk distribution of **WEPP** projects (101) for temperature rise, heatwave, and heavy precipitation hazards is depicted in the figure on the right. As seen in the figure, generally very low and low risk scores dominate the results. For all hazard types, the very low to low-risk score is above 69%, which indicates almost 70% of all the WEPP projects of Garanti BBVA have low risk. 6% of the WEPP projects are in the very high-risk class for heavy precipitation hazard risk, which means a good and fast adaptation plan for those projects should be a high priority.



The figure on the right shows the risk distribution of **HEPP** projects (46) for temperature rise, heat waves, heavy precipitation, drought, and precipitation change hazards. As is known, HEPPs are highly susceptible to changes in precipitation patterns and heavy precipitation, which is also clear in the figure. The very low and low percentage is above 70% for temperature rise, heatwave, drought, and precipitation change, but only 50% for heavy precipitation. The results show half of the projects are in the medium to very high-risk range when the very high-risk percentage is 7%.



The figure on the right shows the risk distribution of **SEPP** projects (19) for temperature rise, heatwaves, and heavy precipitation hazards. As seen, very low and low risk scores dominate this figure. For all hazards, the total risk percentage of very low and low risk is above 84%, which indicates almost all the SEPP projects of Garanti BBVA have very low or low risk.



For the projects that fall under the high-very high-risk range, implementation of adaptation plans for existing operations is a high priority. In the meantime, for the new and upcoming operations, an elaborative planning stage and well-thought adaptation plans could be highly beneficial for Garanti BBVA.

Summary

The physical climate risk assessment for Garanti BBVA shows clear and important results. For Garanti BBVA's own operational assets some regions have very low to medium risk scores; however, some regions, like Akdeniz, Güneydoğu Anadolu and Karadeniz regions, have high to very high risks for different hazards for both spatial resolutions. Drought and heatwave risks are higher in the Akdeniz and Güneydoğu Anadolu Regions, while heavy precipitation risks are more likely in the Karadeniz region. The differences between the RCP2.6 and RCP8.5 climate scenarios are very small. Both scenarios show similar patterns for Garanti BBVA's own operational assets. Drought risk is the emerging risk with high priority, followed by the heatwave risk.

The renewable energy assets of Garanti BBVA risk assessment for the short-term time horizon shows more than 70% of the WEPPs and 84% of SEPPs have either a low or very low risk score. Due to the sensitivity of HEPPs to heavy precipitation, this number is 50% for the HEPPs. Also, projects with higher credit values are mostly in the very low or low risk score. Medium and long-term results are like the short-term results. In this report, only the short-term risk results are given because the timeline for implementation of relevant adaptation measures is less than 5 years for Garanti BBVA. Based on the physical climate risk assessment, Garanti BBVA set up a plan to adapt to the identified physical climate risks in existing and new operations. For the existing operations, which fall under the high to very high-risk range, implementation of adaptation plans is a high priority. In the meantime, for the new and upcoming operations, having a risk assessment before starting the operations and having adaptation plans could be highly beneficial for Garanti BBVA.

Regional analyses are coarser due to the fact that the regional risk scores are only significant in terms of region comparisons and give the average or percentile value of the whole region. If a region with a relatively low risk score is examined within itself, it is divided into smaller areas with the highest and lowest risk levels. Detailed asset level analysis will benefit investments and credits by revealing regional changes in risk and providing asset-specific risk scores rather than the regional average.

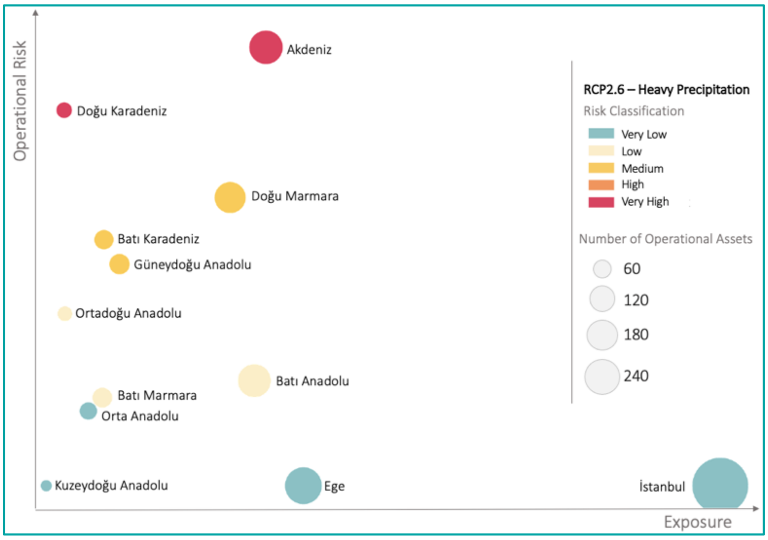
This study offers a multifaceted view of physical risk exposure by sector and location, which can be tailored to the needs of specific risk assessments and implemented on a broader portfolio risk.

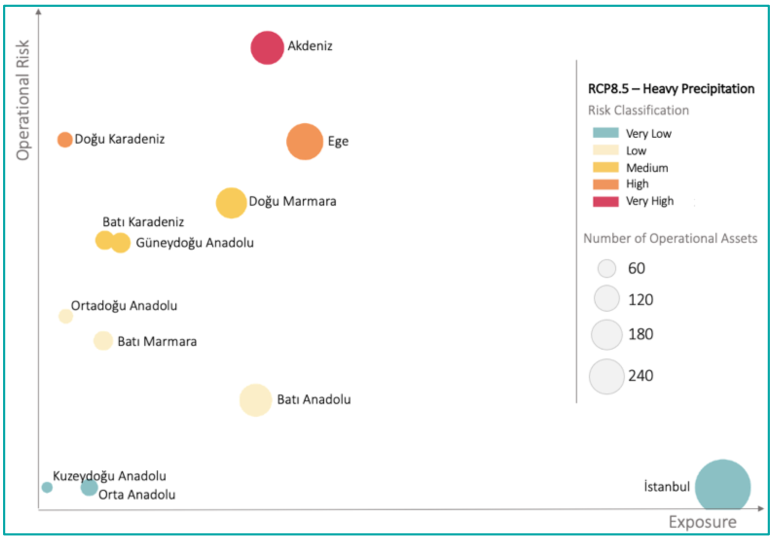
Appendices

Operational Assets Risk

	Short-term Risk					
	Heavy Precipitation		Drought		Heatwaves	
Operational Assets	**RCP2.6**	**RCP8.5**	**RCP2.6**	**RCP8.5**	**RCP2.6**	**RCP8.5**
Akdeniz	100	100	100	96	100	100
Batı Anadolu	24	20	89	92	89	79
Batı Karadeniz	56	56	30	22	26	28
Batı Marmara	20	33	49	48	39	25
Doğu Karadeniz	86	79	0	0	0	34
Doğu Marmara	66	65	58	49	41	52
Ege	0	79	99	100	91	82
Güneydoğu Anadolu	51	56	98	94	71	72
Kuzeydoğu Anadolu	0	0	0	0	0	0
Orta Anadolu	17	0	50	51	45	50
Ortadoğu Anadolu	39	39	48	41	49	43
İstanbul	0	0	45	0	0	0

The figure shows the heavy precipitation hazard risk of all the regions for RCP2.6 (left) and RCP8.5 (right). As already seen in the heatwave risk plot, Istanbul Region has high exposure but low risk. Apart from that regional pattern of the heavy precipitation risk is increasing with ascending exposure and number of assets for both climate scenarios. This situation differs for Doğu Karadeniz region where the exposure is low, but risk is very high according to climate related hazard.





Renewable Energy Assets Risk

Hazard	Risk Short-term	Risk Medium-term	Risk Long-term	WEPP Projects	
Temperature rise	100	100	100	PROJECT 168	İzmir - Çeşme
Heat waves	100	100	100		
Heavy precipitation	67	58	59		
Temperature rise	72	87	73	PROJECT 55	Manisa - Soma
Heat waves	69	66	65		
Heavy precipitation	95	100	89		
Temperature rise	71	94	65	PROJECT 42	Balıkesir - Bandırma
Heat waves	0	0	47		
Heavy precipitation	100	95	100		
Temperature rise	26	75	41	PROJECT 130	Balıkesir - Kepsut
Heat waves	39	37	37		
Heavy precipitation	72	74	75		
Temperature rise	16	0	0	PROJECT 56	Tekirdağ - Muratlı
Heat waves	30	25	28		
Heavy precipitation	40	39	38		