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Sustainable Management of Cumulative Environmental and Social Impacts of Geothermal Investments: Turkey as a Case Study

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ABSTRACT

Sustainable use of geothermal resources is key to ensure long-term production schemes are secured and should not focus only on the technical aspects of the production but also on the minimization and mitigation of associated environmental and social impacts. Due to the nature of geothermal power production; i.e. multiple power plant developments using the same reservoir, understanding of environmental and social impacts holistically is of utmost importance. Especially for policy and decision makers, focusing on the bigger picture of potential environmental and social impacts beyond the project level will enhance sustainable management of resources.

With its total installed capacity of approximately 1.3 GW, Turkey is amongst the “1 GW Geothermal Country Club” alongside the U.S., Indonesia, the Philippines and New Zealand. As reported by the Turkish Electricity Transmission Corporation (TEIAS), in 2017, the share of renewable energy in national electricity generation was 45.5% whilst the share of geothermal energy was approximately 1.3%. As of July 2019, of the 47 geothermal power plants (GPPs) currently in operation, 44 GPPs are located on Menderes and Gediz Grabens corresponding to 98.5% of the total capacity in operation.

These two of the most important structural elements in Western Anatolia present abundant geothermal activity and the hottest geothermal resources of Turkey. In addition to the GPPs currently utilizing geothermal waters of the Menderes and Gediz Graben basins, there are also reasonably foreseeable future projects planned in the region with valid licenses from the Turkish authorities, indicating significant potential for further growth in total capacity.

Geothermal power plants have a key role in meeting Turkey’s ever-growing electricity demand in parallel with the increasing population and rising living standards. On the other hand, with the increasing number of geothermal power plants in the same region, Menderes and Gediz grabens in the Turkish case, assessment and management of potential environmental and social impacts holistically becomes utmost importance to ensure sustainable use of resources.

In order to assess the cumulative environmental and social impacts, valued environmental and social components (VECs) that may be potentially affected by cumulative impacts of the existing and reasonably foreseeable projects (at planning / (pre)feasibility / design stage as of assessment time) should be identified. Amongst others, the VECs to be focused on within Menderes and Gediz grabens may include air quality and climate, quality of surface and groundwater resources, biodiversity and critical habitat trigger features, community health and safety, agricultural production and the cultural heritage sites.

Engagement with a wide range of stakeholders including geothermal investors, sectoral associations, scientific institutions, local communities and civil society organizations as well as the governmental authorities as the decision makers would be key to ensure a meaningful assessment of the cumulative impacts.

The mitigation strategies and measures to be developed based on a cumulative impact assessment study would provide guidance on how to manage effectively the impacts along with the existing environmental and social concerns of the local communities. This would help the geothermal investors to safeguard the long-term sustainability of their investments in line with government’s energy policies, yet implementation of the management strategies and measures would require a joint effort by the governmental authorities and the investors.

The aim of this paper is to set forth the framework to assess cumulative environmental and social impacts from geothermal investments using Menderes and Gediz Grabens from Turkey as a case study.

1. INTRODUCTION

Turkey is amongst the “1 GW Geothermal Country Club” alongside the U.S., Indonesia, the Philippines and New Zealand with its total installed capacity of approximately 1.3 GW. In 2017, the share of renewable energy in national electricity generation was 45.5% whilst the share of geothermal energy was approximately 1.3%. As reported by the International Energy Agency (IEA), global geothermal power capacity is expected to rise to just over 17 GW by 2023, with the biggest capacity additions expected in Indonesia, Kenya, Philippines and Turkey.

In Turkey, as of July 2019, 44 geothermal power plants (GPPs) representing 98.5% of the total capacity in operation are located on Menderes and Gediz Grabens in Western Anatolia. All these operational GPPs have already fulfilled their obligations under the national environmental impact assessment legislation. At the project level, some of the GPPs also have in place qualitative assessments of cumulative impacts. At the regional level, considering the future GPP capacity increase foreseen along Menderes and Gediz Grabens, assessment and management of potential environmental and social impacts holistically becomes utmost importance to ensure sustainable use of resources. This effort, however, should not impede the national renewable energy development agenda. On the contrary, it should help elevate the overall environmental and social performance of the GPPs and build up on open and transparent engagement with the stakeholders.

This study presents an initial attempt and effort to highlight the importance of a systematic approach in assessing the potential cumulative impacts of GPPs and set forth a preliminary framework for such assessment considering Menderes and Gediz Grabens.

2. GEOTHERMAL ENERGY POTENTIAL OF TURKEY

Menderes and Gediz Grabens are two of the most important structural elements in Western Anatolia which present abundant geothermal activity and the hottest geothermal resources of Turkey as shown in Figure 1. Menderes Graben extends across Aydin and Denizli Provinces and Gediz Graben extends along Manisa Province.

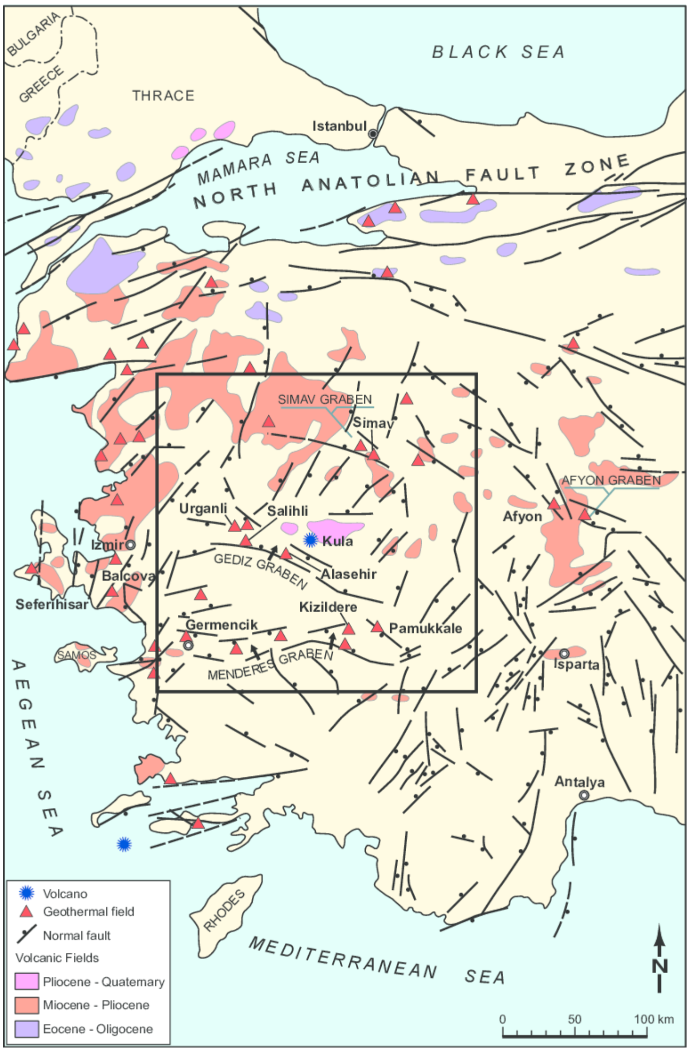

Figure 1: Generalized Geological Map of Western Turkey with Major Fault Zones and Locations of Geothermal Systems (Faulds *et al.*, 2009).

As of July 2019, of the 47 operational geothermal power plants (GPPs), 44 GPPs are located on Menderes and Gediz Grabens corresponding to 98.5% of the total capacity in operation as given in Table 1 (Energy Market Regulatory Authority, Electricity Generation License Database, July 2019).

Table 1: Total Operational Capacity in Turkey (July 2019)

Province	Operation	
	No of GPPs	Total Capacity (MWe)
Aydin-Denizli-Manisa	44	1,263.96
Afyon	1	2.8
Çanakkale	2	15.5
TOTAL	**47**	**1,282.26**

The breakdown of the GPPs located on Menderes and Gediz Grabens that have secured production license and pre-license are given in Table 2 based on data compiled from the electricity generation license database of the Energy Market Regulatory Authority.

Table 2: GPPs Located on Menderes and Gediz Grabens (July 2019)

Province	Production License				Pre-License	
	Operation		Construction/Pre-Construction			
	No of GPPs	Total Capacity (MWe)	No of GPPs	Total Capacity (MWe)	No of GPPs	Total Capacity (MWe)
Gediz Graben						
Manisa	9	200.82	7	276.02	3	66.43
Menderes Graben						
Aydin	29	766.81	1	50	3	114
Denizli	6	296.257	1	3	2	69.9
TOTAL	**44**	**1,263.887**	**9**	**329.02**	**8**	**250.33**

As can be seen from the statistics given above, in addition to the GPPs currently in operation on Menderes and Gediz Grabens, there are also reasonably foreseeable future projects planned in the region with valid licenses from the authorities, indicating significant potential for further growth in total capacity.

3. ASSESSMENT OF CUMULATIVE ENVIRONMENTAL AND SOCIAL IMPACTS

The IFC's Good Practice Handbook on Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets defines cumulative impacts as "impacts that result from the successive, incremental, and/or combined effects of an action, project, or activity when added to other existing, planned, and/or reasonably anticipated future ones" and states that "multiple and successive environmental and social impacts from existing developments, combined with the potential incremental impacts resulting from proposed and/or anticipated future developments, may result in significant cumulative impacts that would not be expected in the case of a stand-alone development" (see Figure 2).

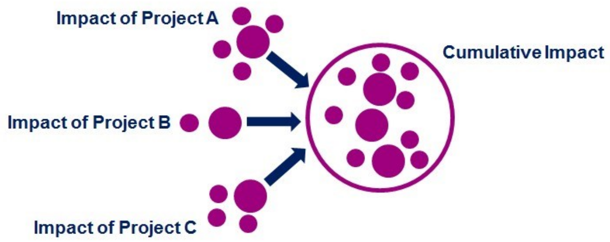

Figure 2: Illustration of Cumulative Impacts.

The need for Cumulative Impact Assessment (CIA) emerges in circumstances where a series of developments, which may or may not be of the same type, is occurring, or being planned within an area where they would impact the same Valued Environmental and Social Components (VECs), which are defined as the environmental and social attributes that are considered to be important in assessing risks.

The good CIA practice suggests that the CIA studies are conducted with a focus on the environmentally or socially important natural resources, ecosystems or human values, which are referred to as VECs and may include the following:

- (i) Physical features, habitats, wildlife populations,
- (ii) Ecosystem services,
- (iii) Natural processes,
- (iv) Social conditions, or
- (v) Cultural aspects.

This approach entails the CIA studies to be looked at "from the VECs point of view" (see Figure 3), instead of a Project-centered perspective as is the case in the Environmental and Social Impact Assessment (ESIA) studies (see Figure 4) and allows assessment of combined, i.e. cumulative, impacts of various projects/activities on each VEC. Any VEC that would be affected by other projects/activities, but not the "Proposed Project", will not be assessed in the scope of the CIA.

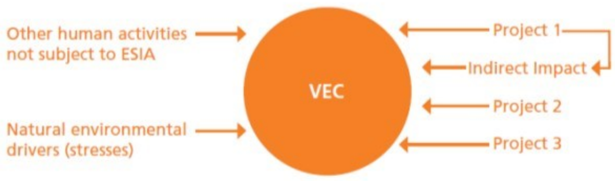

Figure 3: CIA Perspective (VEC-centered).

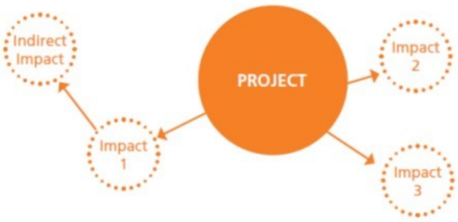

Figure 4: ESIA Perspective (Project-centered).

As defined by the IFC, cumulative impacts can occur:

(i) when there is "spatial crowding" as a result of overlapping impacts from various actions on the same VEC in a limited area (e.g. increased noise levels in a community from industrial developments, existing roads, and a new highway; or landscape fragmentation caused by the installation of several transmission lines in the same area), or

(ii) when there is "temporal crowding" as impacts on a VEC from different actions occur in a shorter period of time than the VEC needs to recover (e.g. impaired health of a fish's downstream migration when subjected to several cascading hydropower plants).

The IFC proposes a six-step approach for conducting Project-initiated CIA studies as illustrated in Figure 5.

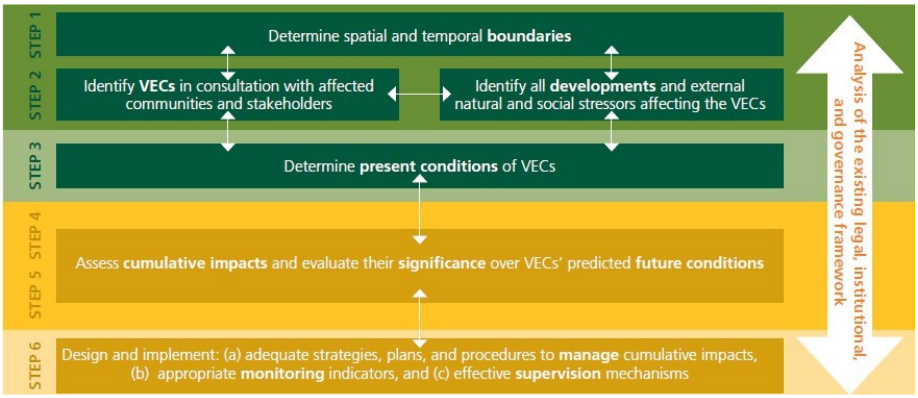

Figure 5: IFC's Six-step CIA Approach.

The CIA study is conducted in a stepwise approach as summarized below:

Step 1 – Scoping Phase I: VECs, Spatial and Temporal Boundaries

Step 2 – Scoping Phase II: Other Developments and Environmental and Social Drivers

Step 3 – Establish Information on Baseline Status of VECs

Step 4 – Assess Cumulative Impacts on VECs

Step 5 – Assess Significance of Predicted Cumulative Impacts

Step 6 – Management of Cumulative Impacts

There are several limitations to the assessment of the cumulative impacts of a Project with other projects over a wide area and over a long period of time. Most of these limitations would apply to many projects of similar scale and duration. The main limitations are:

(i) The available information on future projects is variable and, in many cases, very limited. Therefore, their physical characteristics are uncertain or subject to change. The timing of many future projects is also uncertain and subject to change. Additionally, any planning documentation regarding these projects can be confidential.
(ii) Some of the other projects have not been subject to environmental and social impact assessments (or the assessments are not accessible) yet and the effects of these possible developments have therefore not been documented.
(iii) There are several unknowns associated with the baseline conditions in the CIA study area.
(iv) Cumulative impacts will be influenced by policies and developments outside of the study area.

It should be noted that mitigating the potential negative cumulative impacts are not solely the responsibility of a single Project/Project Owner. Other project owners, relevant local and national authorities should also take responsibility to mitigate the potential impacts identified.

3.1 Identification of VECs and the CIA Study Area Spatial and Temporal Boundaries

Typically for a geothermal power plant project, VECs may include the following environmental and social components:

Environmental/Social Subject	Valued Environmental and Social Components (VECs)
Biodiversity and Natural Resources	Legally Protected Areas
	Key Biodiversity Areas/Important Bird Areas/Important Plant Areas
	Aquatic and Terrestrial Flora/Fauna Species of Conservation Importance
Land Use	Agricultural land availability
Water Resources	Surface and groundwater
Air Emissions	Greenhouse gas emissions
	Air quality at local settlements (e.g. H_2S emissions, odour)
Noise	Noise levels at sensitive receptors at local settlements
Visual Environment	Visual amenity of local communities (visual receptors)
Cultural Heritage	Archaeological sites
	Intangible cultural heritage
Social and Economic Environment	Land and assets
	Economy (e.g. local/regional employment, services sector)
	Quality of Life

The CIA Study Area should be selected to ensure that the spatial extent is sufficiently large to cover both the Project's direct impact area and the boundaries of the identified VECs. The applicable administrative, geographical, topographical, ecological etc. boundaries are to be considered for the determination of the spatial boundaries of the CIA Study Area. On the temporal side, the cumulative assessment should capture the Project lifecycle from land preparation/construction phase throughout operation and closure phases.

3.2 Identification and Classification of Projects within the CIA Study Area

Upon identification of the spatial and temporal boundaries of the CIA Study Area, the existing and future developments and environmental and social drivers within the CIA boundary that would affect the condition of the selected VECs are identified through review of available public databases. The future developments are considered in three categories as given in Figure 6.

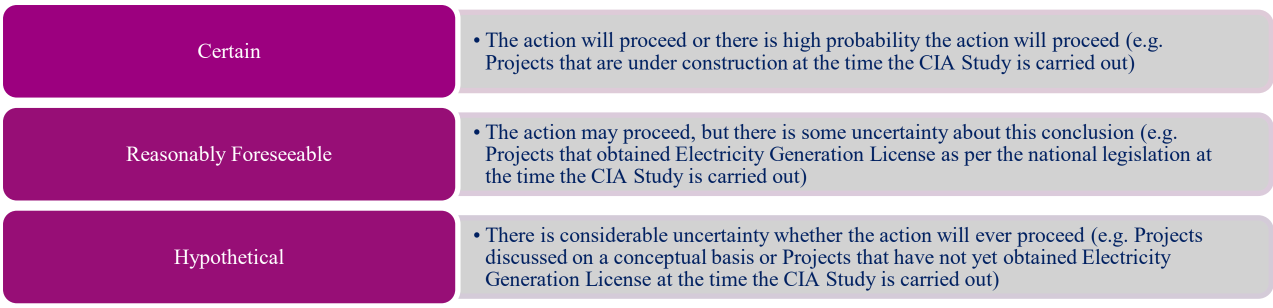

Figure 6: Categorization of Future Developments.

The existing projects together with certain and reasonably foreseeable future projects are considered within the scope of a CIA Study.

3.3 Assessment and Management of Cumulative Impacts

The CIA analysis is future oriented. The impact of a project is not assessed as the difference between the expected future condition of VECs and that of a past baseline condition. It is assessed as the difference between the estimated future condition of VECs in the context of the stresses imposed by all other sources (projects and natural environmental drivers) and the estimated VEC condition in the context of the future baseline plus the development under evaluation.

The estimate of the cumulative project impact, together with the results of environmental and social impact assessment, indicates the need for project-specific mitigation. By contrast, the estimated overall cumulative impact indicates the need for mitigation to be implemented by the various project owners or proponent parties to ensure that their respective contributions to the overall condition of the VECs is coherent and/or compatible with what is mandated or required by government-led national/regional programs and plans, or as a minimum compliant with ambient quality standards for the desired use.

Engagement with a wide range of stakeholders including geothermal investors, sectoral associations, scientific institutions, local communities and civil society organizations as well as the governmental authorities as the decision makers would be key to ensure a meaningful assessment of the cumulative impacts.

The significance of a cumulative impact is evaluated not in terms of the amount of change, but in terms of the potential resulting impact to the vulnerability and/or risk to the sustainability of the VECs assessed. It should be noted that assigning thresholds for every VEC identified may simply be not possible. Therefore, attempt to define limits of acceptable change to a VEC in consultation with both the technical and scientific community and the affected community can be considered.

As the cumulative impacts result from the actions of multiple stakeholders, the responsibility for their management is collective, requiring individual actions to eliminate or minimize individual development’s contributions.

Unlike government agencies, a private sector developer or project sponsor has no control over the actions undertaken by other developers that affect similar VECs, and therefore it is unlikely to have much leverage to influence any mitigation actions by third parties.

3.4 Case of Menderes and Gediz Grabens

In Turkey, the Ministry of Energy and Natural Resources is the governmental institution which has the authority and responsibility for enabling energy and natural resources to be investigated, developed, generated and consumed in duly manner. Decisions regarding the sustainable management of the reservoir in terms of energy production is within the jurisdiction of the Ministry Energy and Natural Resources.

As highlighted above, 98.5% of the total operational capacity in Turkey is located on Menderes and Gediz Grabens. It should be noted that all these operational plants have already fulfilled their obligations under the national environmental impact assessment legislation. This said, to date, the potential cumulative environmental and social impacts stemming from GPPs located on Menderes and Gediz Grabens have not been yet assessed. Although at project level, for some of the GPPs, such qualitative cumulative impact assessments have been reported.

Assessing potential cumulative environmental and social impacts stemming from GPPs located on Menderes and Gediz Grabens should be considered as an opportunity to enhance the environmental and social performance of the project owners and a means to engage and collaborate with the nearby communities and local stakeholders. At the project level, the investors can consider qualitative assessment of potential cumulative impacts which can further feed-in to the decision-making and strategy/policy development processes of the authorities at regional and national level. This should, however, not impede the national renewable energy development agenda. On the contrary, it should help elevate the overall environmental and social performance of the GPPs and build up on open and transparent engagement with the stakeholders.

For Menderes and Gediz Grabens, once the exact locations of the existing and future developments are identified, from impact assessment and management perspective, different localities with concentrated group of projects (using the same reservoir) can be defined. As a starting point, for each locality, the CIA Study Area and specific VECs to that locality can be identified. This approach might also facilitate to define limits of acceptable change to a VEC. A CIA matrix can then be prepared as given in Table 3. In developing the matrix and specifying the VECs, collaboration with the technical/scientific community and local/regional stakeholders is critical including, but not limited to, project developers, governmental authorities, local communities and NGOs.

The mitigation strategies and measures to be developed based on a cumulative impact assessment would provide guidance on how to manage effectively the impacts along with the existing environmental and social concerns of the local communities. This would help the geothermal investors to safeguard the long-term sustainability of their investments in line with government’s energy policies, yet implementation of the management strategies and measures would require a joint effort by the governmental authorities and the investors.

Table 3: Example Matrix for CIA Study

Project	Specific VECs								
	Local Air Quality		GHG Emissions	Land Use	Biodiversity	Visual Impacts			Regional Economy
	Settlement 1	Settlement 2				Settlement 1	Settlement 2	Settlement 3	
Existing Projects									
Project E1									
Project E2									
Project E3									
Future Developments – Certain									
Project C1									
Project C2									
Project C3									
Future Developments – Reasonably Foreseeable									
Project F1									
Project F2									
Project F3									
Cumulative Impact Potential									

4. CONCLUSIONS

Turkey is amongst the "1 GW Geothermal Country Club" alongside the U.S., Indonesia, the Philippines and New Zealand with its total installed capacity of approximately 1.3 GW. In 2017, the share of renewable energy in national electricity generation was 45.5% whilst the share of geothermal energy was approximately 1.3%. As of July 2019, of the 47 geothermal power plants (GPPs) currently in operation, 44 GPPs are located on Menderes and Gediz Grabens corresponding to 98.5% of the total capacity in operation.

All the operational GPPs have already fulfilled their obligations under the national environmental impact assessment legislation. At the regional level, considering the future GPP capacity increases along Menderes and Gediz Grabens, it is of utmost importance to assess the potential cumulative environmental and social impacts stemming from the GPPs. This effort, however, should not impede the national renewable energy development agenda. On the contrary it should help elevate the overall environmental and social performance of the GPPs and build up on open and transparent engagement with the stakeholders.

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