Balancing Adaptation and Mitigation Pathways for Pakistan

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Summary:

Pakistan has witnessed increased probability and intensity of extreme events. Despite shortcomings in climate policies and data, multiple national policies have been implemented recently focusing on energy generation, conservation, and emission reduction. To analyze the effectiveness of these policies, we develop a national energy model and design three scenarios that help us identify the transition of energy sector. While current policies emphasize renewable integration in electricity generation, the key to reducing emissions lies in transforming all contributing sectors. Additionally, we synthesize how countries like Pakistan need to balance adaptation and mitigation goals to strengthen the case for local policy makers.

Introduction:

Pakistan’s extreme susceptibility to climate change impacts has been witnessed by the higher occurrence and severity of extreme weather events like floods, droughts, cyclones, heavy rainfall, and extremely high temperatures throughout the nation. Despite Pakistan's greenhouse gas emissions accounting for less than one percent globally, the nation grapples with notable implications of climate change, indicating a pressing need for proactive measures and achieving a balance between adaptation and mitigation objectives. Loose policies regarding climate change management contribute to a disjointed approach, while ambiguous details further complicate effective decision-making in Pakistan. The absence of climate-related data for Pakistan poses a barrier to efforts to adapt and mitigate the effects of climate change, hence hindering the nation's development towards a sustainable future. As per Pakistan's 2018 GHG emissions inventory, the estimated total GHG emissions are 489.87 MtCO2e. The energy and agriculture sectors are key contributors to these emissions, with up to 218.94 and 223.45 MtCO2e, respectively, along with industrial operations and waste [1].

In Pakistan, smallholder farmers constitute towards the majority but due to lack of resources and technological interventions being expensive to adopt, they resort to traditional practices. Agriculture is intricately linked with food production, and its emissions encompass not only production-related activities such as crop cultivation, land-use practices, and livestock but also extend to food consumption across the supply chain. On the contrary, Pakistan's energy and power sector is currently challenged by significant inefficiencies, such as demand side management issues, limited access to energy and fiscal burden along with climate and socio-economic risks [2]. In the recent years, Pakistan has shifted towards clean energy adoption along with concentrating on developing additional policies that have ambitious energy- and climate-related objectives that can help move the nation toward a sustainable future. The Alternative Energy Development Board (AEDB) Pakistan approved the Alternative and Renewable Energy (ARE) Policy 2019 which targets 30% energy generation from renewable resources (excluding hydropower) by 2030 [3]. Indicative Generation Capacity Expansion Plan (IGCEP) 2021 was devised by National Transmission and Dispatch Company (NTDC) also clearly mentions the contribution of renewable energy sources including hydropower to be up to 60% by 2030 [4]. With being a Paris Agreement signatory and the updated Nationally Determined Contributions in 2021, Pakistan's climate pledge is a cumulative target of 50% emission reductions by the year 2030, 35% of which is conditional to international support. We set up a national level energy model for Pakistan using the MESSAGEix framework [5] to aid the modeling and reduction of GHG emissions for Pakistan's energy sector and facilitate well-informed policy decisions for the low-emissions transition.

Methodology:

MESSAGEix-Pakistan has single spatial node with model horizon until 2060. To translate the energy supply system of Pakistan into the model, the input data such as technical and economic details of technologies, emission factors, fossil reserves and resources, renewable potentials, energy balances and demands were obtained from International Energy Agency (IEA), International Renewable Energy Agency (IRENA) and National Renewable Energy Laboratory (NREL) databases. For demand projections of the future, we considered the Middle of the Road Shared Socioeconomic Pathway, SSP2.

For MESSAGEix-Pakistan, we developed three distinct scenarios, current policy, NDC-35 and NDC-50, to explore varying trajectories of GHG emissions and renewable energy adoption while assessing the effectiveness of existing legislative policies and Pakistan's NDC pledges. The current policy scenario reflects the current implemented legislative policies, ARE policy 2019 and IGCEP 2021, which cover the electricity sector with targets for

the share of renewables. Conversely, the NDC-50 and NDC 35 scenarios outline an overall 50% and conditional 35% reduction of Pakistan's projected GHG emissions by 2030, respectively.

Insights

Figure 1 illustrates the electricity generation mix for Pakistan for current policy scenario, showcasing the distribution of power generation across various fossil and renewable sources. In the early years, we see a larger percentage of fossil resources make up the generation mix, since they are subsidized and locally abundant but post 2030, hydropower takes up the major share with up to 50% by the end of model horizon. However, to meet the

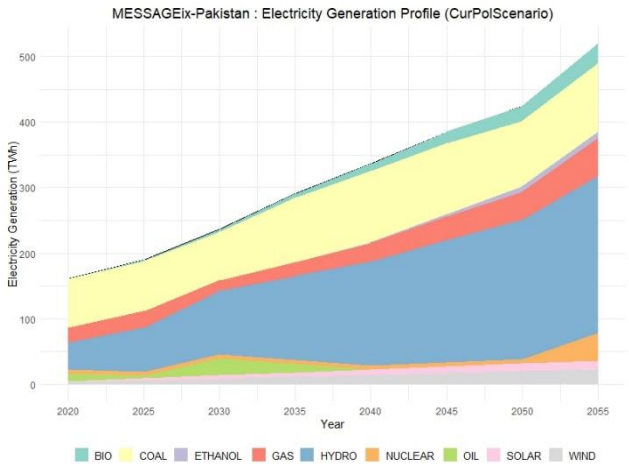

Figure 1. Electricity generation portfolio by source for current policy scenario

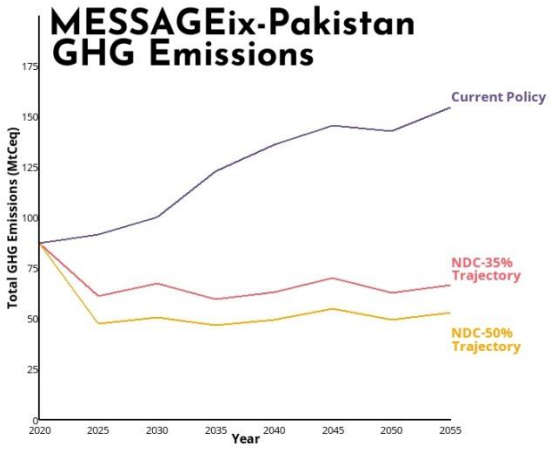

Figure 2. Greenhouse gas emissions trends across three scenarios

increasing energy demands, the model continues to rely on coal and gas alongside renewables, highlighting the ongoing challenge of transitioning to cleaner energy sources. Despite the predominance of renewable sources in the generation mix, Figure 2 indicates a concerning rise in GHG emissions across the energy sector. This trend is not only driven by increasing energy demand but also by emissions stemming from beyond electricity demands, including transportation, thermal and industrial feedstock demands. Interestingly, both NDC-35 and NDC-50 scenarios show lower emission trajectories across the horizon, suggesting the effectiveness of the voluntary contribution listed in Pakistan's NDCs and highlighting the need for climate policy development in sectors other than electricity to reduce emissions.

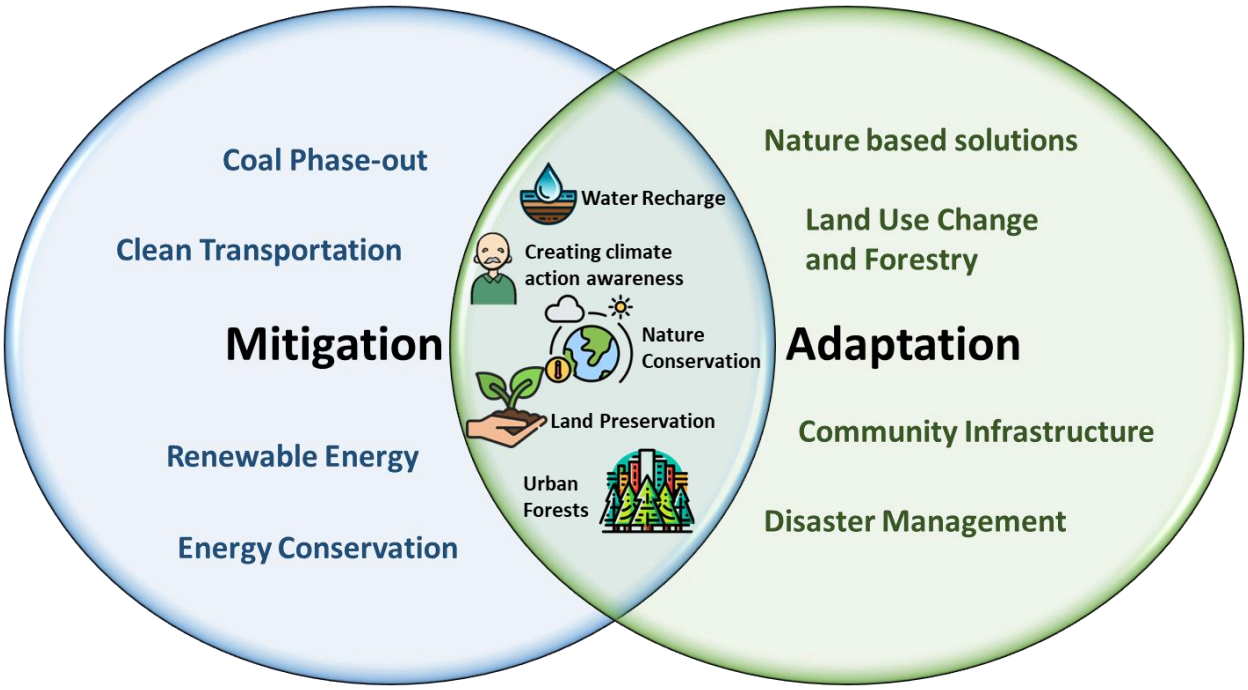

Figure 3. Adaptation vs Mitigation balance across Energy-Water-Land sectors

Figure 3 illustrates the current mitigation strategies and adaptation interventions for Pakistan. However, a thorough analysis of the interplay between adaptation and mitigation for the Water-Energy-Food (WEF) nexus underscores the importance of integrated assessment approaches in optimizing resource allocation, enhancing resilience, and promoting informed decision-making towards sustainable development pathways. Given the results of these scenarios, a long-term strategy for Pakistan is needed to better assess the adaptation versus mitigation portfolio as both are crucial aspects of addressing climate change, but their importance can vary across sectors depending on multiple factors. For example, food and water security are often addressed with tradeoffs where interventions to improve one aspect may inadvertently impact the other. Similarly, a justified transition for Pakistan's agri-food sector is about balancing livelihood protection, preserving land and soil health, reduce surface water usage and minimizing inputs into the food system. Overall, for Pakistan, adaptation is perceived as more immediately important due to several reasons such as higher vulnerability to climate impacts in the form of extreme climate events, heavy dependance on agriculture sector, water scarcity challenges and the lack of economic resources to support large scale mitigation efforts.

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