Fragile Lines: Climate-Security Nexus on Power Transmission Infrastructure

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Abstract

Pakistan ranks top ten countries worst hit by climatic changes, as climate-related events become habitual, these disruptions produce terrain facilitative to theft and vandalism, thereby complicating / intensifying existing challenges and trapping the system in vicious circle of clime-security nexus. This paper explores complicated relationship between climate and physical security within power transmission sector, a crucial lynchpin in energy system. By emphasizing on compounded vulnerabilities arising from climate-induced disruptions and accelerating security threats, the study aims unveiling its nexus in Pakistan Electric Transmission Networks. Employing Barry Buzan's "Five Sectors of Security" frame and triangulation approach, the study carried out detailed investigation of records, collected data physically and performed interviews of key stake holders to get practical insights into climate-security nexus. Findings reveal significant climate-security nexus damaging the power systems, wherein environmental stressors amplify physical security challenges, the complex statistical tests conducted on data set showed strong significant results also positive correlation between the two variables i.e. climatic impacts and physical security incidents on power transmission system, the study also revealed as to how positive feedback (virtuous cycle) and negative feedback (vicious cycle) operate in this nexus. Paper emphasizes and recommends critical need for visionary responses to these interlinked challenges and responses which are required for enhanced reliability / resilience of energy systems, thereby promoting socio-economic stability / sustainability by enhancing National Security posture and safeguarding effective economic balance of power in South Asia.

Keywords: Energy Security, Climate-Security Nexus, Sustainable Growth.

Introduction

Today climate change and its impacts have increased the insecurity of infrastructure in the global world and it has posed a lot of challenges on the energy sector. Pakistan emerges among the top ten countries most exposed to climate change risks and faces more intense disruptions from extreme weather processes that adversely affect the country's energy demands, especially the power transmission networks that are critical to energy security. Thunderstorms, heat, and

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humidity cause physical working degradation of the transmission lines but also diminish structural integrity. Such climate induced vulnerabilities create opportunities for security threats such as theft and acts of sabotage, thus defining a climate-security nexus in Pakistan's power transmission sector. This nexus indicates a very important area of research since the pressures underpinned by environments and security threats are impacting the fragility of Pakistan's energy stability.

Quantitatively and qualitatively with both approaches this research focuses on climate impacts and physical security of electricity transmission systems in operation in Pakistan. The research is guided by two primary questions: How climatic changes influence the physical security threats that pose risks to Pakistan's electricity transmission systems? and What mitigation measures can be employed to make those systems immune both to the climatic and security challenges? In addressing these questions, the study aims to contribute to the strengthening of practical and effective planning and policy architectures that Pakistani policy-makers can employ to address the twin threats of climate and security in the sector. In a country where the provision of secure and reliable electricity transmission is not simply an adjunct to economic prosperity but also to the health of society, it is crucial that such risks are understood to interconnect.

It employs Barry Buzan's Five Sectors of Security developed at the Copenhagen School of Security Studies, which move security beyond military to ecological, economic, as well as societal perimeters. This framework is useful in this regard given that it brings out a multi-dimensional view of how climate threats can cause a conscientious aggravation of physical security risks, especially where infrastructure as fundamental as energy transmission is under consideration. Thus, using Buzan's model, the study can frame the transmission network of Pakistan as not only the technical element, but as the operational facet of societal security. Security threats interlink within this framework with environmental degradation in providing cumulative threats to the nation's energy security, economic sovereignty, and societal cohesion.

However, there is a significant research gap in the existing literature, where no study has provided an extensive assessment of the climate-security relationship in the context of the power transmission sector in Pakistan which is worst-affected in terms of climatic vulnerabilities coupled with the high level of infrastructure security risks. Although there is an increasing body of literature on climate adaptation and infrastructure risk management worldwide, little research has been done that addresses both climatic risks and physical security risks in the Pakistan's power sector. This study thus aids in filling this gap through an analysis of how climate disruptions combine with physical insecurity threats to disrupt energy transmission networks with implications likely to extend to comparable climate exposed areas facing similar threats. That is why the conclusions derived from the presented research are expected to help to analyse the general threats in relation to the mentioned power transmission systems belonging to Pakistan, as well as to introduce the relevant policies improving infrastructure stability in conditions of climatic changes and safety threats.

Literature Review

Climate change has been referred to as a threat multiplier; meaning that, the climate change already poses tremendous risks to infrastructure (Adger et al., 2014; Barnett & O'Neill, 2010). For instance, high temperatures negatively affect the structure of the transmission lines and result in sagging causing system overloading while floods physically destroy the equipment and require reinforcement and major repairs and downtime (Sullivan & Wilhelmi, 2022). The combined frequency of such events exerts substantial stress on infrastructure, largely straining energy systems during the high demand period, not an insignificant phenomenon in countries like Pakistan (Khan et al., 2020; Mahmood et al., 2020). Recent studies claim that infrastructure is even more vulnerable to destruction in the course of storms, which raises the rates of theft and sabotage, when infrastructure is damaged (Schäffer et al., 2021; Zomlot, 2022). This is especially the case considering areas where physical security of energy infrastructure is already a major issue, thus for instance Pakistan where rampant theft of items used in the electrical power transmission like copper and transformers makes the energy network even more vulnerable (Rafiq & Malik, 2017; Ali et al., 2022). It results in a cyclical relationship where climate change increases physical security threats and reductions in these threats enhances climate change. In terms of the climate-security nexus literature has risen in recent years and the scholars have highlighted how climate change impacts increase existing social or structural insecurities (Adger et al., 2014, Floyd & Matthew, 2013, Mastrorillo et al., 2016). In Pakistan, the uncertainties that result from the climate change and physical security threats are likely to exacerbate the vulnerability of energy systems in the country (Khan & Shakir, 2022; Khan et al., 2020).

Climate change remains a big test to the transmission and distribution of electrical power. The communication also anticipated that higher temperatures and shifting rainfall patterns could cause more severe and costly effects on T&D systems (Fant et al., 2020; Burillo, 2018). Yearly climate change costs to society may double by 2100 (Fant et al., 2020). The outcomes indicate that extreme and variable wind regimes are likely to increase, and possibly impact mechanical stress on transmission towers (Manis & Bloodworth, 2017). In Russia, climate changes play the same role as in other countries: wind and lightning storms cause frequent interruptions in the power supply, the increase in these numbers may reach 1.5 times by 2025 (Kondrateva et al., 2020). Costs of expected climate change impacts can be cut down to half through using strategies such as anticipation measures and upgrading infrastructure (Fant et al., 2020; Burillo, 2018). Other threats are man-made threats, such as sabotage, external events which might harm substations' components including transformers, control panels, and transmission lines of the smart grid (Brewer et al., 2015; Sadeghian et al., 2022). Consequently, the effects of such attacks may reach from local disruptions up to chain effects and major blackouts (Bilis et al., 2013).

Scientists have come up with models for risk identification and even for rating the susceptibility of some components of the power system (Brewer et al., 2015). According to Bilis et al., 2013 complex network theory and social network analysis can come in handy in determinations of the structural properties of the electrical power grid thus protecting the more vital components. This is important as interconnected power systems call for more dependence on digital technologies, hence requiring cyber-physical security (Amin, 2010). Power transmission systems need to be safeguarded with an integrated approach that entails physical security, system reliability enhancement and measures that will reduce vulnerability to attacks (Sadeghian et al., 2022; Amin, 2010).

Climate-security connection as a concept has a number of interrelated components and remains a rather promising research area. Climate change poses a threat of increasing the likelihood of conflicts by increasing the impact of other factors that may lead to emergent of conflicts, particularly in societies with weak governance systems (Silander, 2021; Gemenne et al., 2014). climate actions can also increase human security by increasing early warning systems, safety nets, and climate-proof planning. Recent studies also stress the need for a social construction of risks and a more comprehensible approach to climate-security risks (Nadiruzzaman et al., 2023). The nexus covers a wide range of factors that can include security of a country, its infrastructure, geopolitical interest and human security threats (Gemenne et al., 2014).

Theoretical Foundations

Barry Buzan's "Five Sectors of Security" developed within Copenhagen School of Security Studies gives a multi-faceted perspective of security threats. Buzan hinted that, security should go beyond military security and should be conceived five sector military, political, economic, social, and ecological. categorical framing of security thus carries direction of security by acknowledging how the geometries of threat intersect with each other and are often entangled. Of these, environmental security, as one of the important sections in Buzan's model, has received further development following the enhancement of climate change as the world security issue.

In fact, primarily, Buzan's works rely on his explorations of new security threats and his most illuminated works with other scholars such as Ole Wæver and Jaap de Wilde titled "A New Framework for Analysis" published in 1998. In case of Pakistan with respect to power transmission section the frame engulfs the comprehensive assessment lens developed via increased vulnerabilities that emerges because of climate change physical security threats interface. Such climate occurrences nurture instant effects on transmission lines and substations, often leading to power blackouts and long system disruptions with other features such as physical security threats pressuring the energy transmission industry.

External factors erode the physical character of the transmission structure, while internal factors also exploit a similar vulnerability and consequently cause additional damage to the system. In this context, frame by Buzan can again assist in defining transmission sector not just as technical apparatus, but as a question of security in human terms. In this context there is high relevance of Buzan's concept of societal security which in its original idea aims at protection against disruption of societal stability and identity. Dependence on energy infrastructures to climate and physical security risks threats the social cohesion through sowing instability and insecurity. It presents a multidimensional exposition of security threats. Buzan alluded that, security should advance beyond the conventional military sphere and should be analyzed across five sectors military, political, economic, societal, and environmental. Such a framing extends direction of security through recognition of how different geometries of threats interrelate with each other and frequently cut across. The economic losses associated with repairing climate-damaged structure and addressing physical security infringements depositing fresh strain on state exchequer farther weaken the capability of the state to react effectively against these interconnected threats.

Materials and Methods

Design: This study adopts a triangulation approach. The data collected for study involved semi structured interviews, literature review and scanning of the records. In addition, the quantitative data for number of disruptions observed on the system by both the variables i.e., climatic impacts and the physical security incidents observed at transmission system were collected for four years to identify trends and patterns.

Data collection: National Disaster Management Authority (NDMA), Provincial Disaster Management Authority (PDMA), Baluchistan Irrigation Department, South Asian Terrorism portal and Official NEPRA reports was used as secondary data with an effort to conduct and record opinions of authorities through recorded interviews. The UN reports issued officially at website were taken as authentic documents.

Analysis: Interviews from key stake holders and authorities were performed with narrative analysis. The data of physical security incidents was plotted on the map and analyzed with respect to climatic patterns of the area to see either the relationship between the two components. The quantitative data was tested by complex statistical tests using statisty .app tool to know the significance and correlation between the variables.

The study focused only at transmission sector and Generation, Distribution, Renewable energy, Clean Energy sources remained untouched as to limit the study in certain boundaries. In order to view system in holistic approach future endeavours in the unexplored arenas will be fruitful.

The conception remains to developing connections between the climatic impacts, energy sector and the physical security measures.

Results

The data was grouped into three groups North, Centre and Southern zones and the total disruptions on the systems were noted down in domain of both the variables. Quantitative analysis of the data set showed following properties;

Table 1: Total Count of the disruptions observed against the two variables

Region	**Year**	**Physical Security Disruptions**	**Climatic Impacts Disruptions**	**Total Disruptions**
North	2020	96	13	109
	2021	127	33	160
	2022	163	51	214
	2023	213	69	282
Centre	2020	65	12	77
	2021	88	27	115
	2022	116	46	162
	2023	152	73	225
South	2020	145	41	186
	2021	192	74	266
	2022	258	92	350
	2023	349	119	468
Total	2020	306	66	372
	2021	407	134	541
	2022	537	189	726
	2023	714	261	975

Table 2: Descriptive statistics for the two variables

	Disruptions due Physical Security Reasons	Disruptions due Environmental Reasons	Total Disruptions
Mean	245.5	81.25	326.75
Median	177.5	67.5	245.5
Mode	65	12	77
Std. Deviation	179.85	66.96	245.79
Variance	32346.1	4483.27	60414.5
Minimum	65	12	77
Maximum	714	261	975
Range	649	249	898
Median absolute deviation	81	30.5	115.5
Skew	1.49	1.57	1.53
Kurtosis	1.92	2.5	2.16

Figure 1: Comparison chart between the two variables calculated for all three zones

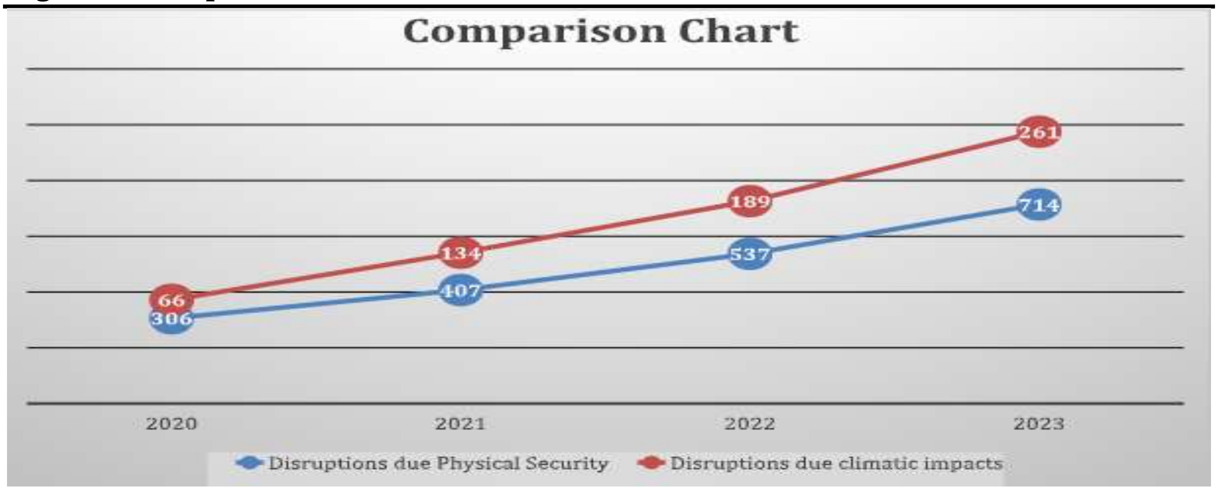


Table 3: Descriptive statistics

	n	Mean	Std. Deviation
Disruptions due Physical Security Reasons	16	245.5	179.85
Disruptions due Environmental Reasons	16	81.25	66.96
Total Disruptions	16	326.75	245.79

Table 4: Repeated Measures ANOVA

	Type III Sum of Squares	df	Mean Squares	F	p	η^2
Treatment	500532.67	2	250266.33	29.99	<.001	0.67
Residual	250368.67	30	8345.62			

Table 5: ANOVA

	Sum of Squares	df	Mean Squares	F	p
Factor	500532.67	2	250266.33	7.72	.001
Residual	1458658	45	32414.62		
Total	1959190.67	47			

Table 6: Effect size

η^2	η_p^2	Cohens f^2
0.26	0.26	0.34

According to Cohen (1988) limits for size of effect are .01 (small effect), .06 (medium effect), and .14 (large effect). Cohen, J. (1988). Statistical Power Analysis for the Behavioural Sciences. Hoboken: Taylor and Francis.

Table 7: Welch's ANOVA

	F	df1	df2	p
Welch-Test	11.85	2	23.58	<.001

Tabe 8: Correlation

Number	Valid cases 16	
	r	p
Disruptions due Physical Security Reasons and Disruptions due Environmental Reasons	0.98	<.001

Table 9: Covariance

	Disruptions due Physical Security Reasons	Disruptions due Environmental Reasons
Disruptions due Physical Security Reasons	32346.13	11792.53
Disruptions due Environmental Reasons	11792.53	4483.27

Results of Quantitative Analysis

Detailed interviews with Chief Security Officer (CSO), Chief Engineer (CE) and Chief Environment Officer (CEO) highlighted the link of climate change and security challenges regarding the aforementioned issues in Pakistan's energy transmission sector. CSO pointed out how extreme rainfall events complicate security vulnerabilities by displacing original populations, many times leaving them without livelihoods. This, along with the economic rigors brought about by environmental disasters, has seen a conspicuous rise in theft and sabotage incidents that target transmission lines and grid stations. CE further highlighted these issues, underlining that theft causes very specialized damage, not only extremely expensive to repair but also adding extended downtime for crucial energy structure. He further reiterated that, while the fiscal loss is considerable, the functioning implications of such losses have spiralling effects that bring in insecurity in the energy sector and overall socio-economic domains. While redirecting how climate change increases the physical stress on the structure, quoted those increased impacts weaken structural foundations which further are utilized by small thieves and net result is disruption of power. The CEO drew attention to such environmental factors, which create a vicious circle: the more the climate stresses the system, the more vulnerable the latter becomes to criminal exertion. The team inclusively agreed that, without robust measures for the mitigation of such threats from climate and physical security, critical downfalls would continue to characterize the energy sector. They urged for an integrated approach that encompassed adaptable designs of climate, improved community involvement with the aim of helping to reduce incidences of crime, as well as state-of-the-art security that was in place. The CSO emphasized more specifically that disruption of energy structure depends on a solution that addresses root causes.

During the Fifth UN Security Council deliberation on climate-security risks and responses held in the summer of 2020, UN Assistant Secretary-General Miroslav Jença highlighted “failure to consider the growing impacts of climate change will undermine our efforts at conflict prevention, peace-making and sustaining peace, and risk trapping vulnerable countries in a vicious cycle of climate disaster and conflict”. In an interview with The New York Times’ Thomas Friedman on June 7th 2014, USAs President Barrack Obama said “Instability brought on by climate change, is what creates an environment for terrorism”. While talking about fragile states he said “When people are hungry, when people are displaced, when there are a lot of young people, particularly young men, who are drifting without prospects for the future, the fertility of the soil for terrorism ends up being significant”. Further while answering a question by the host, he augmented that “Climate change can lead to wars by fostering conflict over resources”. He further added that it is not just the actual disasters that might arise, it is the accumulating stresses that are placed on a lot of different countries and the possibility of war, conflict, refugees, displacement that arise from a changing climate.

Figure 2: Violent incidents of killings in Pakistan (Source, South Asia Terrorism Portal)

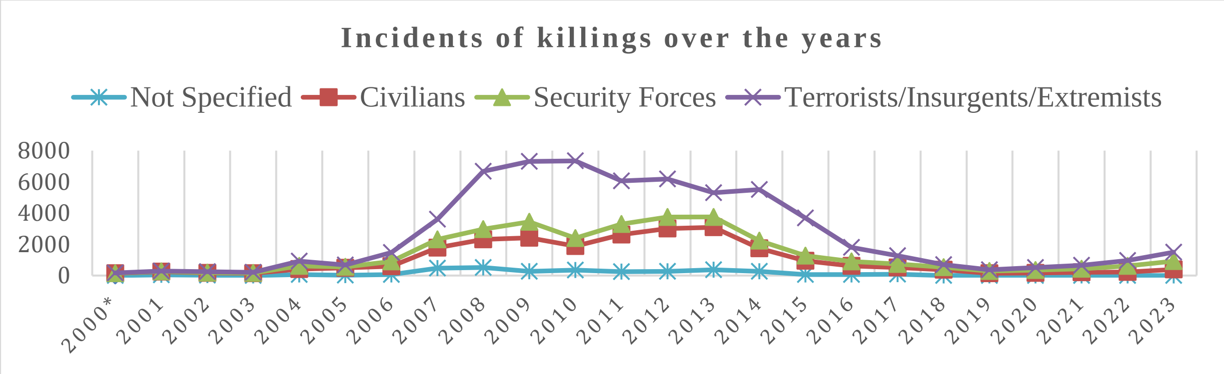


Figure 3: Plot chart hotspot areas of security incidents (Source, South Asia Terrorism Portal)

While Pakistan is facing multi-dimensional challenges at present, the interplay between climate change and security in Pakistan is posing complex challenges as environmental stressors interact with multiple factors causing vulnerabilities, threatening national stability and various security challenges, including terrorism and extremism. These challenges pose threats to the country's stability, governance, and overall security environment. In past decade, state made intensified efforts to combat terrorism and extremism, directing significant resources towards this cause despite limitations. There was a clear prioritization of addressing issue of extremism and terrorism across all state institutions. However, it is important to recognize that this approach can be likened to treating the symptoms rather than addressing the root cause. There is a need to understand nexus of climatic changes and its implications on national security, without understanding root causes we will not be able to efficiently and effectively counter the threats to National Security of Pakistan.

Climatic changes act as catalysts, triggering effects such as poverty, oppression, internal population displacement, resource scarcity, crime, and inter-provincial enmity. As in resource scarce conditions, indicators of social identity, such as gender, religion, ethnicity, or socio-economic factors, become more pronounced. The fragile areas already hit by climatic impacts receive more security threats to transmission sector as compared to other areas of the country.

Figure 4: Theft of materials in fragile locations, weak structures collapse with climatic impacts

Figure 5: Impact of Sabotage in fragile locations resulting in disruption first climatic hit

It was observed that the areas having the hotspot issues of security incidents as depicted in figure 2 are the same areas having disruptions to the transmission systems due physical security threats and the data also showed the same area effected by climatic impacts of the floods, high temperatures, droughts and seismic activities. The research already reveled that, climatic impacts on the societies trigger the crimes and violent activities hence the relationship with respect to increased disruptions in the areas hit by climatic impacts observed larger physical security disruptions as well and the transmission infrastructure underwent greater impact in those vulnerable areas.

Figure 6. Areas hit by frequent floods (Right) (Source, NDMA, OCHA, United Nations Sep 2022 report Al-Jazeera) and Areas receiving Heavy Rainfall (Left) (Source OCHA, United Nations Report, BBC)

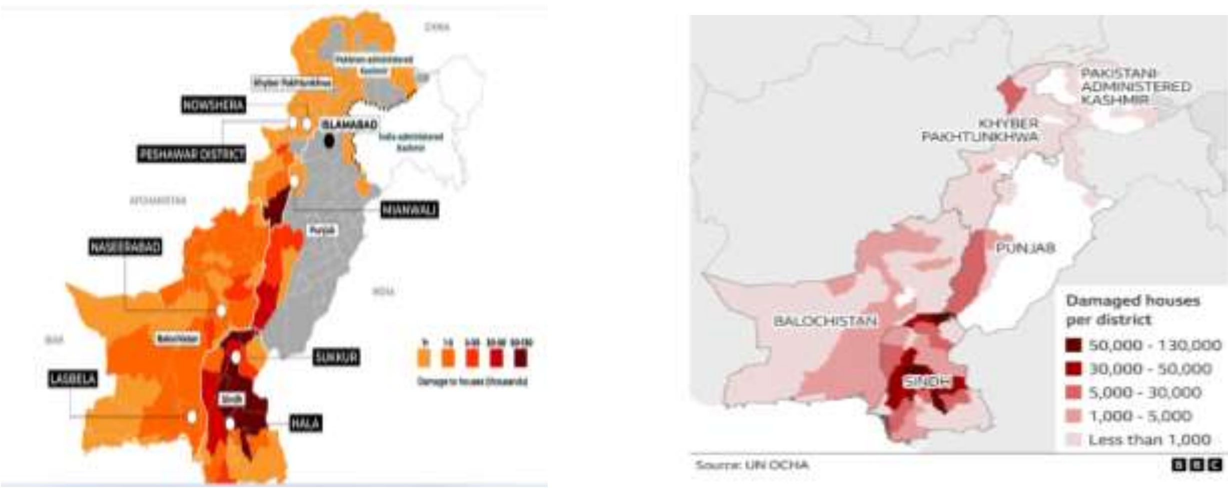
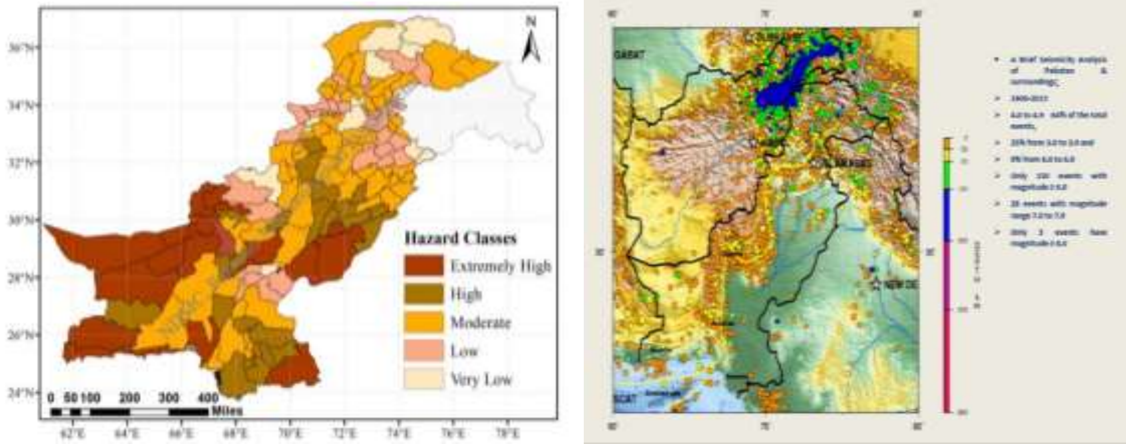


Figure 7: Pakistan Drought Map (Right) and High seismic zones of Pakistan (Left) (Source, Pakistan Meteorological Department)



As per European Commission Disaster Risk Management Knowledge Centre December 2023 crisis report Pakistan stands in severity class high risk with 94.4M people effected, 20.6M people in need and about 1.2K people killed and 3.33M displaced. The risk profile of the country showed risk class high and more alarming results as ranked 20 in risk profile with World Bank low income graded country, graded 4 in hazards and exposures with natural and human hazards . with ranking of 37 in vulnerability major categorization in socio-economic and vulnerable groups. The lack of coping capacity showed ranking of 37 in the world categorisation of both institutional capacity and infrastructure capacity. Till now the climate change policy issued by the Government seems to lack implementation mechanisms both at Governmental and Grassroot levels as per the analysis.

These entries illustrate how extreme weather events can influence the likelihood of security-related incidents. The effects of climate can create vulnerabilities in infrastructure that are exploited for theft or sabotage, demonstrating the interconnectedness of climatic impacts and security threats.

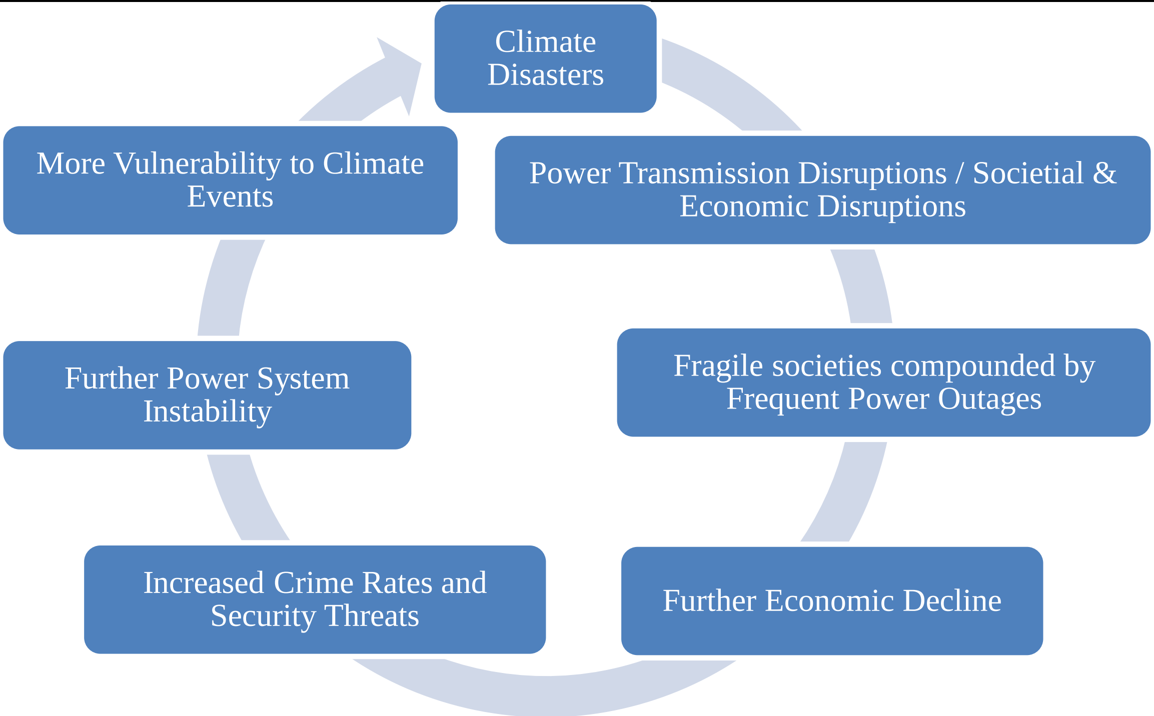
Table 3 and 4 as annex to this paper clearly define the interaction and feedback loops in the climate security nexus with respect to power transmission systems of Pakistan. The vulnerabilities caused by the climatic changes affect the societal and economic dimensions of already suppressed communities which in turn increases the crimes in the area. The fragile energy system which is already under stress due same climatic impacts gets compounding impacts and if the system collapses it further aggravates the situation in the area thus creating a positive relationship and positive loop. The regular maintenance or the improved societal or economic conditions impact the energy infrastructure by better materials and low crime rates increasing the economic activities in the area and improving human lives thus creating negative loop and negative relationship in the system dynamics.

While analyzing these events it was found that the climatic disruptions on the societies if not the root causes of these security related threats is certainly a contributing factor and as termed by the UN it is exacerbating the existing threats. The power sector which was taken as referent object suffered the compounding effects of these threats and as a result the power had direct impact on the societies which create an interaction and feedback loop in case of climate security nexus studies in Pakistan environment. These effects were seen enhanced in southern regions instead of central or northern regions. As southern regions are more prone to the impacts of climatic events in Pakistan and housing the majority of the population living below the poverty line. The same regions are also affected by floods and catastrophic rains each year which adds to the vulnerabilities of both the segments under study.

Negative Feedback (Vicious Cycle): Climatic impacts (e.g., floods, storms) → Impact on Power Transmission Disruptions / Societies (Displacement, houses / factories damage, livestock / agriculture impacted) → Fragile societies compounded by Frequent Power Outages → Further Economic Decline (business closures, unemployment) → Increased Crime Rates and Security Threats (theft of power infrastructure, sabotages, vandalism) → Further Power System Instability (compromised transmission lines) → More Vulnerability to Climate Events (weakened power system can't cope with future climate impacts).

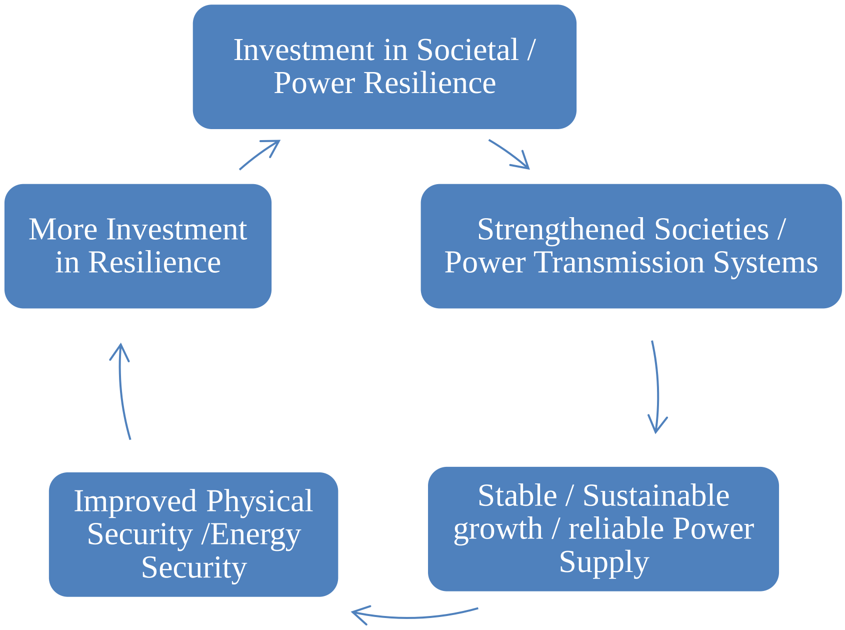
Dual Feedback Loop: Climate-Security Nexus

Figure 8: Negative Feedback (Vicious Cycle)



Negative Feedback (Vicious Cycle): Investment in Societal / Power Resilience (climate adaptation, infrastructure hardening) → Strengthened Societies / Power Transmission Systems (modernization, protection) → Stable / Sustainable growth / reliable Power Supply, Societal and Economic Growth (industries thrive, jobs created) → Improved Physical Security /Energy Security (reduced crime due to better social conditions) → More Investment in Resilience of the societies and power infrastructure (feedback into better preparation for climate events).

Figure 9: Positive Feedback (Virtuous Cycle)



Conclusion

In Pakistan, climate change and physical security are jointly causing serious threats to the power transmission sector. This holistic understanding is yet not fully uncovered with regard to these interlinked dynamics the area needs further explorations in future studies. While such climate-combined events increase in frequency and intensity, they disrupt functionality not only in terms of energy infrastructure but also heighten a set of looming security threats due to the increased vulnerabilities at societal levels. The framework by Barry Buzan, Five Sectors of Security, allowed a look at such complexities in more substantive means to derive insight for an analysis of implications for energy crises. This study concluded that the top-down approach has to be critically balanced with strategies that can harmonize issues of environment and security to reach resilience and sustainability in the energy systems of Pakistan. The study showed a direct relationship of climate-security nexus while grounding on power systems. The feedback loops both positive and negative showed direct significant impact on climate-security nexus on power transmission system.

Recommendations

To alleviate the social and economic impacts of climate change on original communities and reduce associated crimes and physical security threats to transmission systems, it's pivotal to apply targeted community engagement and development programs. One recommendation is to establish community-grounded climate adaptability programs, enhancing social cohesion, and adding mindfulness of climate impacts. Investing in community policing enterprise can foster better connections between law enforcement and original residents of area, improving security around transmission structure. By engaging community members in monitoring and guarding assets, it becomes easier to identify implicit threats and criminal elements that may target energy means. The National Climate Change policy should be incorporated at veritably introductory frame in planning stage like earning the climate flexible anti sharp material for installing the transmission lines. The perpetration on public climate change policy should be done in true letter and spirit not just calling the climate change just hot air as it has significant impact on economic conditions of the state and potential to affect the National Security posture.

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Appendix-I

Table 10: Climate-Energy (interaction & feedback loop). Events Transmission segment of energy sector

Date	Incident Description	Location	Impact
Jun-18	High temperatures	Karachi	Extensive outages across the city.
Jun-19	High temperatures and humidity	Karachi	Extensive outages affecting industrial areas.
Sep-19	Flooding from monsoon rains	Baluchistan	Significant power outages and economic losses.
Dec-19	Heavy fog led to reduced visibility	Northern Punjab	Delayed maintenance resulted in extended outages.
Feb-20	High winds	Northern Punjab	Major disruptions in electricity supply.
Aug-20	Heavy rainfall	Punjab	Extensive power outages affecting daily life.
Sep-20	High humidity caused corrosion	Karachi	Affected reliability of power supply.
Jan-21	High winds	Punjab	Major disruptions in electricity supply.
Mar-21	Windstorms	Baluchistan	Major disruptions in power supply.
Mar-21	Windstorms	Southern Punjab	Major disruptions in power supply.
Jul-21	Landslides caused by heavy rains	Azad Jammu & Kashmir	Disrupted electricity supply to rural areas.
Aug-21	Monsoon flooding	Sindh	Loss of power to urban areas for days.
Aug-21	Heavy rainfall	Baluchistan	Significant power outages affecting local communities.
Sep-21	Strong winds	Khyber Pakhtunkhwa	Significant power outages in the region.
Sep-21	Monsoon rains caused flooding,	Baluchistan	Loss of power affecting daily life and businesses.
Sep-21	Severe rainstorms led to major flooding	KPK	Loss of power affecting critical services.
Jan-22	Heavy snowfall	Gilgit-Baltistan	Significant outages impacting local communities.
Mar-22	High winds and heavy rain	Baluchistan	Major disruptions in power supply.
Jul-22	Severe rainstorms	Baluchistan	Widespread power outages and disruptions.

Jul-22	Heavy rains caused severe flooding	Sindh	Loss of power to large urban areas.
Jul-22	Monsoon flooding	Sindh	Extensive outages in urban areas.
Jul-22	Heavy rainfall resulted in landslides	Khyber Pakhtunkhwa	Widespread outages in affected regions.
Jul-22	Heavy rain caused flooding	Sindh	Disrupted power supply to large urban areas.
Jul-22	Monsoon rains led to significant flooding,	Sindh	Loss of power to urban areas for days.
Aug-22	Flooding from heavy rainfall	Sindh	Power outages affecting both urban and rural areas.
Aug-22	Sudden severe rainfall	Sindh	Extensive outages affecting millions.
Aug-22	Heavy rains	Northern Punjab	Disruptions to power supply in multiple districts.
Aug-22	Severe flooding	Sindh	Loss of power affecting critical services.
Aug-22	Flooding from heavy rains	Sindh	Extensive outages affecting millions of people.
Aug-22	Flooding from heavy rainfall	Northern Punjab	Loss of power supply affecting rural areas.
Aug-22	Sudden heavy rains	Sindh	Extensive outages affecting millions.
Dec-22	Heavy snowfall	Gilgit-Baltistan	Extended outages during winter months.
Jan-23	An extreme winter storm	Gilgit-Baltistan	Significant outages impacting local communities.
Feb-23	Severe weather	Gilgit-Baltistan	Major disruptions in electricity supply.
Aug-23	Flooding from heavy rainfall	Sindh	Power outages affecting both urban and rural areas.
Aug-23	Heavy rainfall in urban areas	Lahore	Disruption of electricity supply in many neighbourhoods.
Aug-23	Flooding from heavy rainfall	Sindh	Power outages affecting both urban and rural areas.

Table 11: Climate-Security nexus (interaction & feedback loop). Transmission segment of energy sector

Date	Incident Description	Location	Impact
Jan-18	Thieves took advantage of poor weather conditions to access remote transmission lines.	Gilgit-Baltistan	Significant outages affecting remote areas.
Jul-18	Insurgents sabotaged transmission lines during heavy rains, causing power outages.	Baluchistan	Significant blackouts in Quetta and surrounding areas.
Dec-18	Thieves exploited heavy fog to steal transmission equipment	Northern Punjab	Extended outages and loss of critical services.
Jan-19	Severe winter storms led to attacks on exposed transmission lines in rural areas.	Gilgit-Baltistan	Power shortages during harsh winter conditions.
Jan-19	Heavy snowfall caused physical security vulnerabilities in remote transmission lines.	Gilgit-Baltistan	Significant outages during winter months.

Aug-19	Flooding caused instability in pylons, leading to sabotage by local insurgents.	Baluchistan	Disruption in power supply affecting remote areas.
Dec-19	Increased theft incidents of electrical components due to poor visibility during fog.	Northern Punjab	Significant delays in repairs and extended outages.
Jul-20	Increased incidents of theft of electrical equipment during heavy rain seasons.	Punjab	Prolonged outages and costly repairs.
Jul-20	High humidity caused rust and structural issues in pylons, inviting theft.	Karachi	Increased repair costs and outages.
Aug-20	Theft of transmission line equipment during monsoon season led to outages.	Khyber Pakhtunkhwa	Disruption in electricity supply in rural areas.
Sep-20	Heavy monsoon rains led to the collapse of a transmission tower, making it vulnerable to sabotage.	Punjab	Extended outages affecting surrounding communities.
Sep-20	Increased rainfall made transmission lines more susceptible to vandalism.	Khyber Pakhtunkhwa	Prolonged blackouts across affected areas.
Sep-20	Increased humidity levels led to rust and structural failures in pylons, causing outages.	Karachi	Affected reliability of power supply.
Dec-20	Thieves exploited poor visibility during foggy weather to steal electrical components.	Northern Punjab	Extended outages and loss of critical services.
Jan-21	Transmission lines were attacked during heavy winds	Sindh	Significant power outages affecting multiple districts.
Mar-21	Militants attacked a transmission line	Baluchistan	Disruptions in power supply during critical weather events.
Mar-21	High winds during a storm caused the collapse of a transmission tower, facilitating an attack.	Khyber Pakhtunkhwa	Major blackouts in affected regions.
Mar-21	Severe storms led to sabotage of transmission lines	Khyber Pakhtunkhwa	Disruptions in power supply during critical weather events.
Mar-21	Insurgents attacked transmission lines during a severe storm	Khyber Pakhtunkhwa	Significant power outages in urban and rural areas.
Aug-21	Attacks on pylons increased during extreme climatic conditions.	Khyber Pakhtunkhwa	Major outages affecting urban areas.
Sep-21	Heavy rains washed away soil around pylons, making them vulnerable to sabotage.	Punjab	Outages due to structural failures in affected areas.
Jul-22	Flooding enabled easier access for thieves to sabotage transmission infrastructure.	Sindh	Increased outages and repair costs due to vandalism.
Jul-22	A rise in theft of electrical components during heavy rain made repairs difficult.	Punjab	Extended outages in agricultural areas.

Jul-22	Theft incidents increased during heavy rainfall when visibility was low.	Punjab	Prolonged outages affecting daily life.
Jul-22	Increased rainfall caused structural failures in transmission lines, inviting theft.	Sindh	Extensive outages affecting local economies.
Aug-22	Theft of copper wires from transmission lines during floods	Sindh	Widespread disruptions in electricity supply.
Aug-22	Increased flooding led to increased reports of theft of transmission line materials.	Sindh	Prolonged outages and costly repairs.
Aug-22	Flooding led to vulnerabilities in transmission infrastructure, encouraging sabotage.	Punjab	Increased outages affecting local industries.
Aug-22	Insurgent groups took advantage of floods to attack transmission infrastructure.	Sindh	Major disruptions in power supply across the province.
Aug-22	Increased rainfall led to flooding, making transmission lines vulnerable to vandalism.	Sindh	Prolonged outages affecting agricultural areas.
Aug-22	Flooding allowed easier access for insurgents to attack transmission lines.	Baluchistan	Major disruptions affecting economic activities.
Jul-23	Attacks on transmission lines increased during periods of extreme weather, leading to significant outages.	Sindh	Major disruptions affecting urban life.
Jul-23	Severe weather conditions facilitated theft of transmission line materials.	Punjab	Significant delays in repairs and extended outages.
Aug-23	Security forces reported an increase in attacks on pylons during extreme weather events.	Baluchistan	Major power outages affecting urban and rural areas.
Aug-23	Heavy rainfall caused flooding that exposed pylons to vandalism and sabotage.	Baluchistan	Major outages affecting economic activities.
Aug-23	Attacks on transmission lines surged during extreme weather events.	Khyber Pakhtunkhwa	Major disruptions affecting essential services.