Seismic Shockwaves: Analyzing the Impact of the Earthquake Hazards in Pakistan from 1922-2023 through GIS Modeling and Socioeconomic Consequences

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Abstract

All through the globe, Earthquakes give serious difficulties to the hardness and flexibility of the framework and society. Pakistan is particularly inclined to seismic dangers due to its geographic area along dynamic plate tectonics limits. This study offers an intensive survey of Pakistan's seismic Earthquake events over the past hundred years where 143,936 deaths are reported, taking a gander at their recurrence, size, and impacts on society. Total 34 out of 35 earthquakes have been reported with magnitude 5 or more than 5. Total 9 out 35 earthquakes had magnitude more than 7 reflecting severity. The examination shows eminent contrasts in the impacts of quakes, going from horrendous events making numerous passings and broad dislodging less extreme seismic occasions with more modest social ramifications. This study features the need for areas of strength to execute risk-decrease techniques to develop earthquake flexibility further and lessen obstructions and property harm during seismic occasions, given the examination of authentic examples and geological circulation of tremors. To make stronger foundations and networks, the exploration additionally accentuates the meaning of complete calamity risk the board techniques, for example, early advance notice frameworks, missions to bring issues to light, and limit building projects. The consequences of this study might coordinate asset assignment and future endeavors by the public authority to decrease gambles and further develop flexibility in Pakistan's seismic event-inclined regions. Pakistan can improve its status and limit the impacts of future seismic tremors by cooperating and making designated interests in decreasing and dealing with catastrophe gambles, prompting a safer and economic future for everybody.

INTRODUCTION:

The seismic action in Pakistan, arranged inside a region of significant tectonic activity, presents a significant Earthquake risk with significant socio-economic implications (Lomnitz, 2013). Functional Earthquake determining and the condition of information encompassing seismic occasions have been broadly contemplated to moderate the effect of such disasters (Jordan et al., 2011). Understanding the mechanics of earthquakes and attributing them is principal in evaluating seismic risks and upgrading readiness measures (Scholz, 2019). As of late, online entertainment stages like Twitter have arisen as significant instruments for seismic tremor identification and observing, mirroring the advancing scene of the calamity of the executives (Earle et al., 2011). Regardless of endeavors to further develop tremor well-being and hazard evaluation, challenges endure, especially in districts like Pakistan where quake security accomplishments are compared with progressing weaknesses (Jain, 2016; Ellingwood, 2001). The staggering quake occasions in Pakistan, for example, the Muzaffarabad seismic tremor of 2005, highlight the earnest requirement for hearty tremor risk appraisal and relief methodologies (Ali et al., 2009). Concentrates on noticed seismic ways of behaving and harms, strikingly during the Kashmir tremor of 2005 and the Iran quake of 2013, give vital experiences into the weaknesses of constructed conditions (Naseer et al., 2010; Rafi et al., 2015). Moreover, the flowing impacts of tremors, including avalanches set off by seismic action, emphasize the complex idea of quake debacles and highlight the significance of coordinated calamity-demonstrating approaches (Sato et al., 2007; Barkat et al., 2017). Geographic Data Framework (GIS) has arisen as an amazing asset for seismic tremor debacle evaluation and perception, offering important experiences into spatial examples of harm and weakness (Abdalla and Tao, 2005). Using GIS-based approaches, specialists have created modern models for tremor risk appraisal, harm assessment, and settlement investigation, adding to further developed debacle readiness and reaction procedures (Hashemi and Alesheikh, 2011; Hassanzadeh et al., 2013). By coordinating different datasets and high-level scientific strategies, for example, support vector machine demonstrating and weight of proof displaying, GIS works with thorough quake risk the board (Xu et al., 2012; Dou et al., 2019). The utilization of GIS in quake fiasco reenactment and metropolitan arranging empowers partners to envision and assess the possible effect of seismic occasions, directing informed dynamic cycles (Xu et al., 2008). Understanding the impacting elements of family weakness and the long-haul financial outcomes of seismic tremors is significant for planning viable recuperation and versatility-building drives (Wang et al., 2015; Irshad et al., 2012). Besides, utilizing longitudinal reviews and observational examinations, for example, those directed in Indonesia, reveals insight into the nexus between catastrophic events, family government assistance, and long-haul business recuperation (Dartanto,

2022). Assessing human losses and surveying building harm stay integral to tremor risk the board endeavors, requiring interdisciplinary methodologies that consolidate designing ability with financial examination (Maqsood and Schwarz, 2011; Spence and In this Way, 2009). The authentic audit of seismic tremor occasions and orderly writing surveys give significant experiences into the human effect of quakes, illuminating strategy mediations and strength-building measures (Doocy et al., 2013). All in all, tending to the perplexing difficulties presented by quakes in Pakistan requires an all-encompassing methodology that coordinates logical information, mechanical developments, and financial contemplations to upgrade flexibility and relieve the effect of future seismic occasions. This far-reaching approach should be educated by thorough logical examination, drawing on experiences from worldwide tectonics, tremor risk appraisal, and the debacle of the executive's systems. Thus, this exploration article expects to add to the comprehension of quake influences in Pakistan, zeroing in on a seismic occasion that happened somewhere in the range of 2022 and 2023. By utilizing Geographic Data Framework (GIS) demonstrating methods, this study tries to break down the spatial circulation of the impacted region, survey the harm to families, assess the extent of the tremor, and examine the all-out number of setbacks. Moreover, as we dig into the complexities of seismic tremor influences in Pakistan, it is fundamental to recognize the more extensive financial setting inside which these situations develop. Pakistan, in the same way as other non-industrial countries, wrestles with difficulties like destitution, lacking framework, and restricted admittance to assets, which fuel the weaknesses related to catastrophic events (Ao et al., 2021). Understanding the interconnection of these elements is critical for conceiving all-encompassing ways to deal with catastrophe the executives that focus on value, inclusivity, and versatility working at all degrees of society (Shah et al., 2020). By inspecting the differential effects of quakes on different gatherings, including underestimated networks, ladies, and people with inabilities, this exploration tries to feature the requirement for designated intercessions that address the remarkable necessities and weaknesses of these populaces (Khan et al., 2015; Irshad et al., 2012). Eventually, by integrating information from assorted trains and drawing in partners from across areas, this exploration attempts to add to the aggregate work to assemble more secure, stronger networks that can endure the seismic difficulties representing things to come. The joining of different datasets and high-level insightful techniques will give a nuanced comprehension of the tremor's repercussions, consequently illuminating proof-based arrangements and systems for quake readiness, reaction, and recuperation. By combining bits of knowledge from an extensive variety of academic writing and exact examinations, this exploration tries to add to the more extensive talk on seismic tremor risk the board, and flexibility building endeavors in Pakistan and then some. Additionally, by looking at the particular instance of the

quake in Pakistan, this exploration means to contribute significant bits of knowledge that can be applied to comparable settings universally, upgrading how we might interpret seismic tremor influences and further developing debacle risk decrease measures around the world. The meaning of this study lies in its capability to illuminate strategy choices, metropolitan arranging drives, and local area-based mediations pointed toward decreasing weakness to seismic risks. As tremors keep on presenting huge dangers to human existence, foundation, and monetary solidness, there is an earnest requirement for interdisciplinary exploration that coordinates land, designing, social, and natural viewpoints. By getting over these disciplinary cutoff points and using innovative methods, for instance, GIS showing, this assessment attempts to push our understanding into shake impacts and add to the progression of flexible social orders prepared for persevering through seismic shocks. Through composed endeavors with accomplices, policymakers, and affected networks, the revelations of this review can be changed over into significant systems that redesign disaster availability, moderate risks, and advance sensible improvement in earthquake-prone districts.

METHODOLOGY:

Study Area:

The study region of this exploration article centers around Pakistan, a nation situated in South Asia with a complex geological scene portrayed by critical structural action. Pakistan lies at the crossing point of the Indian Plate and the Eurasian Plate, making it significantly powerless against seismic dangers like quakes. The specific event being examined happened someplace in the scope of 1922 to 2023, addressing a massive seismic occasion in the regions. Pakistan's various geography, going from high mountain ranges in the north to oceanfront fields in the south, adds further multifaceted nature to its seismic bet profile. The affected area encompasses different metropolitan, rural, and distant locales, each with its fascinating monetary and normal characteristics. Huge metropolitan networks like Islamabad, Lahore, and Karachi are focus points of the general population and monetary activity, while far away steep locales, including the northern areas of Gilgit-Baltistan and Azad Jammu and Kashmir, are the more pitifully populated anyway and also frail against seismic risks. The review region envelops an extensive variety of building types, from usual mud-block structures in provincial towns to current tall structures in metropolitan habitats, each introducing various degrees of decrease of earthquake. Additionally, the financial scene of Pakistan is different, with aberrations in pay, admittance to assets, and levels of advancement across areas. These financial elements impact the flexibility of networks to seismic occasions, influencing their capacity to get ready for, answer, and recuperate from quakes. Grasping the elements of the review region, including its geographical, natural, financial, and segment attributes, is fundamental for completely evaluating the effects of the quake

and contriving powerful relief techniques. Through itemized spatial examination and GIS demonstration, this exploration expects to give an all-encompassing comprehension of the tremor's impacts on the different scenes and networks of Pakistan, consequently illuminating designated interventions to upgrade strength and lessen weakness to seismic risks.

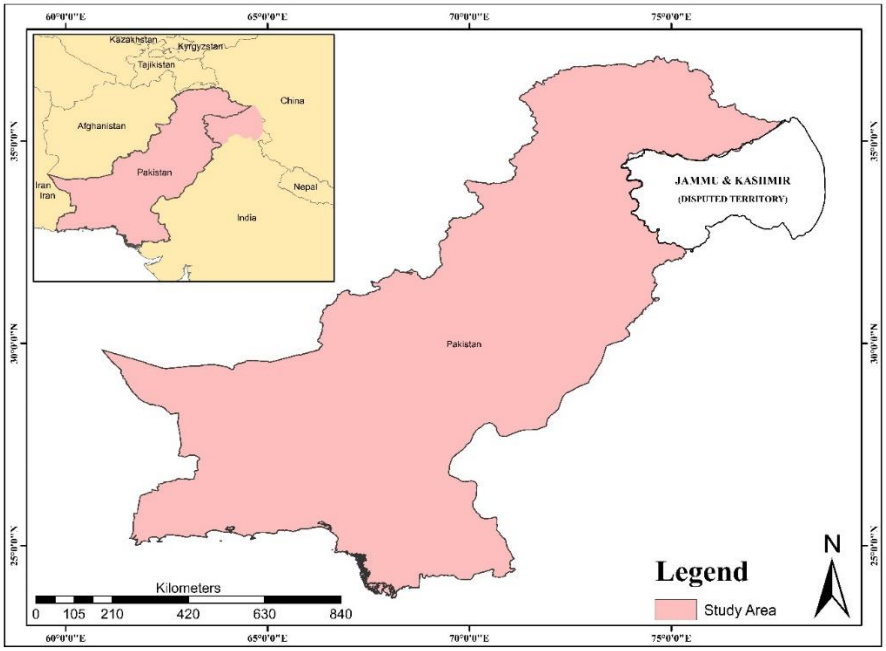

Figure 1: Study Area Map of Earthquake-prone regions 1922-2023

Data Collection:

The data collection process for this research includes gathering an extensive variety of data from different sources to thoroughly break down the effects of seismic earthquakes in Pakistan somewhere in the range of 1922 to 2023. First and foremost, seismic information traversing the predefined period will be acquired from trustworthy sources, including authentic earthquake data sets, government offices like the Pakistan Meteorological Division (PMD), and worldwide associations having some expertise in seismic checking like the United States Geological Survey (USGS). These datasets will give fundamental data on the area, greatness, and power of tremors happening in Pakistan over the last hundred years. Also, information on the complete number of impacted regions, all outhouses, and all outpacing coming about because of Earthquakes will be accumulated from government reports, debacle-the-board organizations, scholastic investigations, and pertinent writing. This includes scouring through authentic records, logical distributions, and official reports to assemble exhaustive and precise data on the financial effects of seismic occasions. Also, satellite imagery and remote sensing information will be used to survey the spatial degree of quake

influences, recognize harmed foundations and impacted networks, and portray the limits of the review region. By utilizing a thorough information assortment process that draws upon different sources and datasets, this exploration plans to give a hearty groundwork to the ensuing GIS demonstrating and spatial investigation, empowering a point-by-point assessment of seismic tremor influences in Pakistan for the last 100 years.

GIS Analysis:

The GIS modeling process for this research includes a deliberate and coordinated way to deal with and examine the effects of earthquakes in Pakistan somewhere in the range of 1922 to 2023. Firstly, GIS software, for example, ArcGIS or QGIS will be used to make spatial portrayals of the all-out impacted region, complete houses, seismic tremor size, and all-out passings. The seismic information obtained from dependable sources will be brought into the GIS programming and georeferenced with spatial datasets like managerial limits, geographical guides, and satellite imagery to represent the review region exactly. Topical guides will then be created to picture the appropriation of the completely impacted region over the long run, giving experiences into the spatial degree of seismic influence influences across various regions of Pakistan. Furthermore, maps showing the absolute number of houses impacted by tremors from 1922 to 2023 will be made to feature regions with high groupings of damaged or destroyed houses, subsequently supporting the appraisal of housing influences. Moreover, a guide showing the greatness of tremors kept in Pakistan throughout the predefined period will be created to imagine the spatial circulation of seismic movement and distinguish locales inclined to high-size quakes. Ultimately, a guide showing the complete number of passings coming about because of seismic tremors in Pakistan will be built to distinguish regions with high death rates and patterns in quake fatalities. Through spatial examination methods like overlay examination, area of interest examination, and spatial autocorrelation, examples, patterns, and connections in the GIS-created guides will be distinguished and measured, giving important bits of knowledge into the spatial and fleeting elements of tremor influences in Pakistan. The GIS demonstrating cycle will be approved through correlation with ground truth information, authentic records, and master information, and the discoveries will be deciphered to recognize key bits of knowledge for quake risk the board, fiasco readiness, and moderation systems. At long last, limits and vulnerabilities related to the GIS displaying sequence will be recognized and addressed to guarantee the strength and solid quality of the outcomes. Through this far-reaching GIS demonstrating approach, this exploration means to give a point-by-point and nuanced examination of quake influences in Pakistan for the last hundred years, adding to the comprehension of seismic perils and the improvement of effective risk reduction measures.

Spatial Analysis:

The spatial examination part of this exploration is a critical stage in completely looking at the effects of quakes in Pakistan somewhere in the range of 1922 and 2023. This stage includes utilizing different spatial investigation strategies to reveal examples, patterns, and relationships inside the GIS-produced maps. Overlay examination, right off the bat, will be directed to recognize spatial connections and cooperations between various layers of information, like the conveyance of impacted regions, lodging influences, tremor size, and losses. By overlaying these layers, spatial examples of weakness and strength can be recognized, featuring regions with elevated chance and those displaying more noteworthy versatility to seismic risks. Additionally, area of interest investigation will be utilized to recognize areas of genuinely critical bunching of tremor influences, for example, districts with high groupings of harmed houses or raised death rates. This investigation will empower the identification of focal points of weakness, which can illuminate designated intercessions and asset portions for calamity relief endeavors. Moreover, a spatial autocorrelation examination will be conducted to evaluate the level of spatial reliance or grouping in seismic tremor influences across various districts of Pakistan. This examination will assist with recognizing spatial examples and patterns in seismic tremor influences, for example, the engendering of harm from epicentral regions to encompassing districts. Moreover, factual measures, for example, thickness examination will be utilized to evaluate the spatial dissemination of quake influences, giving experiences into the power and seriousness of seismic occasions in various pieces of the country. Through these spatial examination methods, this exploration plans to reveal the spatial elements of seismic tremor influences in Pakistan, recognize areas of uplifted weakness, and illuminate proof-based methodologies for calamity risk decrease and versatility building drives. Moreover, approval of the spatial investigation results through correlation with ground truth information and master information will guarantee the unwavering quality and exactness of the discoveries, subsequently upgrading the strength of the exploration results. By utilizing spatial examination procedures inside the GIS structure, this exploration attempts to give significant experiences into the spatial and fleeting examples of earthquake influences in Pakistan, at last adding to the improvement of powerful arrangements and methodologies for alleviating the dangers related to seismic hazards.

Validation and Interpretation:

Validation and interpretation are basic parts of the technique for this exploration article, guaranteeing the precision and unwavering quality of the GIS-produced maps and spatial examination results. The approval cycle includes looking at the GIS-produced maps and spatial investigation results with ground truth information, verifiable records, and master information. This correlation confirms the consistency and arrangement of the discoveries

with true perceptions and existing data sources. Ground truth information, for example, field overviews, harm appraisals, and satellite imagery, gives direct proof of seismic tremor influences on the ground, empowering approval of the spatial dissemination of impacted regions, harmed houses, quake greatness, and losses. Verifiable records of past seismic occasions in Pakistan offer important bits of knowledge into the spatial and transient elements of quake influences over the long haul, working with the approval of the exploration discoveries inside a more extensive authentic setting. Furthermore, master information from seismologists, geologists, catastrophe executives subject matter experts, and other pertinent partners can give basic contributions to approving the exactness and importance of the GIS-produced maps and spatial examination results. When approved, the discoveries are deciphered to distinguish key bits of knowledge into the spatial and transient elements of seismic tremor influences in Pakistan. This translation includes examining the spatial examples, patterns, and relationships uncovered by the GIS-produced maps and spatial analysis results.

Table of Earthquake Parameters:

A table is used in the methods section to display important parameters about earthquake incidents in Pakistan in a methodical manner. The table includes important information such as the initiation year of the earthquakes, the particular locations, magnitudes, the count of displaced persons due to the incidents, total fatalities, and the total number of impacted populations. Presenting this data in a tabulated manner allows readers to readily understand and contrast the attributes of different earthquakes within the designated period. This organized style improves the clear and effective communication of important information about the earthquake occurrences being studied, aiding in a thorough comprehension of their effects on the impacted areas and the general public. The initial year, the location, magnitude, number of homeless people, total number of fatalities, and total population impacted by the earthquakes are all correlated with a particular column in the table. The tabular style facilitates a concise and organized display of the data, enabling readers to promptly comprehend essential details about each seismic occurrence. Presenting the data in this way allows researchers to methodically examine and compare the features of various earthquakes, pinpointing trends, patterns, and relationships that might guide future study and analysis. The table is a useful reference for readers who want to comprehend the extent and consequences of seismic occurrences in Pakistan over the selected period. The report offers a detailed summary of the size of each earthquake, its geographic location, and its social implications such as relocation, deaths, and the total number of people impacted. The table improves the availability and readability of the methodology portion, setting the groundwork for analyzing and discussing earthquake consequences in Pakistan.

RESULTS AND DISCUSSIONS:

The GIS-generated maps give important experiences into the spatial and temporal dynamics of earthquake influences in Pakistan somewhere in the range of 1922 and 2023. The guides represent the conveyance of the maximum impacted region, absolute houses, quake greatness, and all-out passings, revealing insight into the degree and seriousness of the seismic occasions and their ramifications for the impacted district and its populace. The guide of the impacted region uncovers spatial examples of tremor influences across Pakistan, with specific areas encountering more elevated levels of seismic action than others. Focal points of seismic tremor action are clear in regions along significant separation points, for example, the Himalayan and Karakoram ranges in the north and the Makran coast in the south. These districts are portrayed by rough territory and high populace thickness, compounding the weakness of networks to seismic risks. The conveyance of the impacted region features the requirement for designated mediations to reinforce fiasco readiness and versatility-building activities in these high-risk regions. Also, the guide of maximum houses impacted by quakes delineates the spatial appropriation of lodging influences, with bunches of harmed or annihilated houses amassed in areas of high seismic action. Metropolitan focuses like Islamabad, Lahore, and Karachi are especially helpless, given their thick populaces and deficient framework. Country people groups in sloping locales are likewise in danger, with conventional mud-block houses demonstrating vulnerability to tremor harm. The far and wide annihilation of houses highlights the critical requirement for measures to upgrade building versatility, further, develop lodging principles, and elevate more secure development practices to alleviate the effects of future seismic occasions. Besides, the guide of tremor extent portrays the spatial circulation of seismic action, with locales encountering changing degrees of quake force. High-extent tremors are pervasive in structurally dynamic regions, presenting critical endangers to life, property, and framework. The spatial dissemination of tremor size features the significance of executing severe construction laws, reinforcing basic foundations, and growing early admonition frameworks to limit the effect of future seismic occasions. At long last, the guide of absolute passings coming about because of tremors gives experiences into the human cost of seismic dangers in Pakistan. Focal points of tremor-related fatalities match with areas of high seismic action and populace thickness, stressing the lopsided effect of quakes on weak networks. The spatial circulation of absolute passings highlights the requirement for designated intercessions to upgrade calamity readiness, further develop crisis reaction capacities, and reinforce medical care foundations to decrease death rates and moderate the consequences of seismic events.

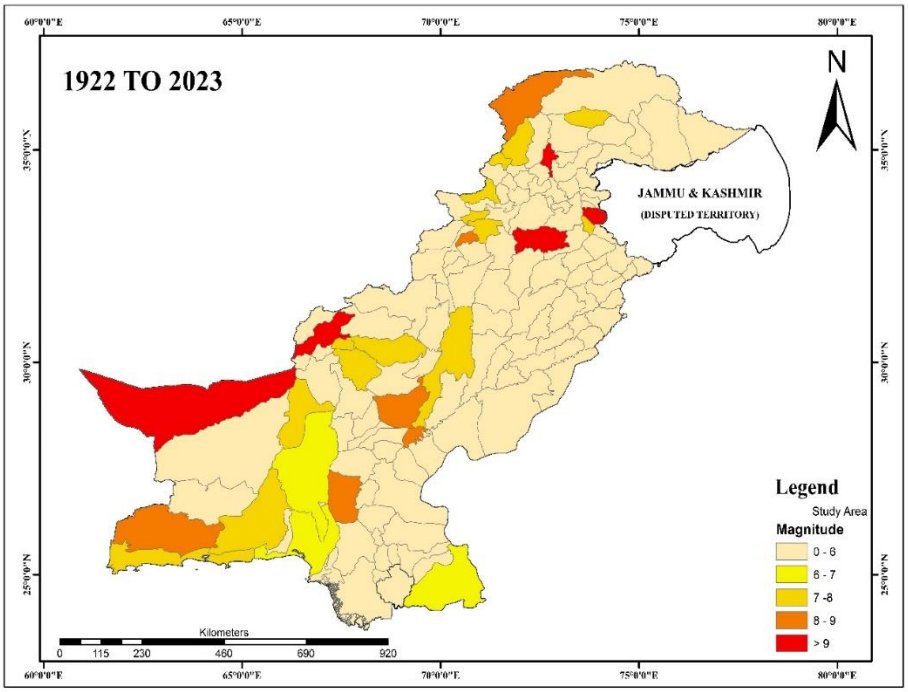

Figure 1: Earthquake Magnitude Intensity Map of Pakistan

In Figure 2 the magnitude map of Pakistan, seismic activity is addressed utilizing a color ramp that depicts different magnitude ranges. The guide utilizes a slope of varieties to envision earthquake sizes the nation over. Locales encountering seismic occasions with sizes going from 0 to 6 are portrayed in an unobtrusive yet detectable skin tone, showing generally minor seismic action. As the size expands, the variety force changes to an energetic lemon tone, implying seismic occasions with extents somewhere in the range of 6 and 7. Regions, where earthquakes arrive at extents of 7 to 8, are addressed in a striking yellow shade, showing critical seismic action prepared for making areas of strength moderate. Besides, districts encountering tremors with sizes somewhere in the range of 8 and 9 are portrayed in a strong orange tone, featuring the uplifted seismic gamble and potential for far and wide harm. At last, seismic occasions surpassing an extent of 9 are portrayed in a distinctive red tone, representing outrageous seismic action with the potential for horrendous results. By utilizing this variety incline, the greatness map successfully imparts the changing degrees of seismic danger across Pakistan, giving significant bits of knowledge to earthquake risk management and disaster preparedness actions.

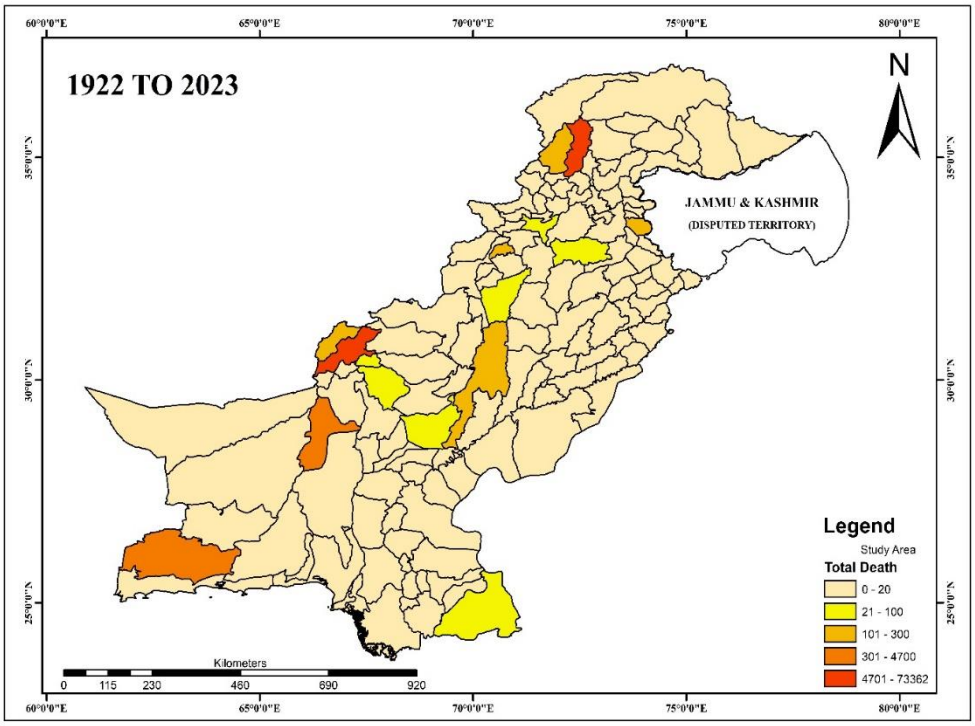

Figure 2: The casualties of the earthquake map of Pakistan 1922-2023.

The casualties on Pakistan's earthquake map offer a graphic depiction of the number of people who died from seismic activity in various parts of the nation. The GIS-generated map uses a gradient of colors to show different levels of casualties, providing information on where fatalities are concentrated and helping to pinpoint areas with high numbers of casualties. Regions with minimal casualties, between 0 and 20 fatalities, are represented with a muted skin tone, suggesting a slight to moderate seismic effect. As casualties rise, the color shifts to a lemon color, indicating areas with 21 to 100 casualties and highlighting a significant impact on local populations. Regions with deaths between 101 and 300 are depicted in a conspicuous brown color to emphasize locations where seismic occurrences have caused substantial loss of life. Districts with mortality numbers somewhere in the range of 301 and 4,700 passings are displayed in striking orange tone, addressing critical tremor impacts and broad annihilation. Locales with a mortality count surpassing 4,700 passing are featured in lively red tone, addressing a significant death toll and the basic prerequisite for compassionate guidance and catastrophe reaction. Red districts with lost lives going from 4,700 to 73,362 connote the region of the shocking death toll, with serious and expansive impacts on living souls. Utilizing this variety

slope, the seismic tremor guide's losses offer pivotal bits of knowledge to calamity the board specialists. This takes into account designated intercessions and the allotment of assets to the most distressed areas, eventually supporting effective calamity reaction and recuperation exercises. The setback part of the seismic effect concentrates on taking a gander at the extent and geological circulation of passings across Pakistan to decide the human expense of seismic events. A variety of slopes with various scopes of all-out passings is utilized in the GIS-produced guide of fatalities to give a careful point of view of the impact on human existence.

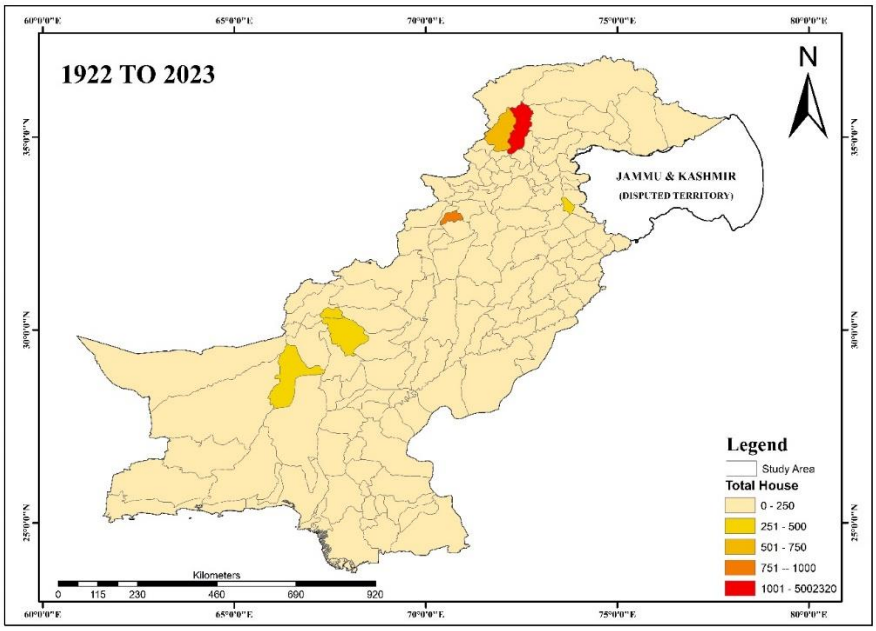

Figure 3: House damages Map by Earthquake in Pakistan 1922-2023.

The map of Pakistan shows the geographical distribution of housing effects caused by the earthquake. The GIS-generated image employs a color gradient to show varying levels of damage to dwellings, providing useful insights into the degree of residential infrastructure damage nationwide. Localized damage is represented by a modest skin color change in areas suffering relatively moderate housing effects, where the number of impacted houses ranges from 0 to 250. As more homes are impacted, the color becomes more intense, shifting to a lemon hue. This color indicates areas where housing effects vary from 251 to 500, reflecting a moderate amount of destruction caused to residential buildings. Areas with 501 to 750 impacted houses are shown in a strong brown hue, indicating places where seismic occurrences have caused severe damage to household infrastructure. Furthermore, places with larger housing impacts—that is, those with impacted home counts between 751 and 1,000—are shown with a bold

orange hue, signifying extensive damage and house demolition. The map highlights regions with over 1,000 impacted dwellings in a bright red hue, representing severe damage and the pressing need for housing restoration and rehabilitation. With the use of this color ramp, the total number of houses impacted by the earthquake provides disaster management officials and humanitarian organizations with vital information that helps them allocate resources and carry out targeted interventions to meet the housing needs of the affected communities and speed up their recovery and reconstruction. The number of houses impacted by Pakistan's earthquake map offers a thorough picture of how seismic events influence Pakistan's residential infrastructure. The map successfully conveys the regional distribution and intensity of housing effects by employing a color ramp with various ranges of impacted dwelling counts. In areas highlighted with a skin tone, showing low effect with impacted house counts between 0 and 250, residential buildings may have suffered slight damage or remained mostly undamaged. The degree of housing effects increases and indicates significant damage to household infrastructure as the hue shifts to lemon, which represents locations with impacted home numbers between 251 and 500. Areas highlighted in brown, representing 501 to 750 impacted houses, show a high level of damage to residential structures, including major structural damage and relocation of residents. The shift to an orange hue indicates regions where the number of impacted houses ranges from 751 - 1,000, signifying serious housing effects and a significant number of residential buildings potentially becoming uninhabitable. Lastly, places shown in red that have more than 1,000 impacted houses are considered to have suffered catastrophic damage, with most or all of the residential infrastructure either destroyed or seriously weakened. In areas with severe housing effects, a large number of residential buildings may have been entirely demolished. Lastly, areas highlighted in red that have more than 1,000 affected houses, up to 5,002,320, are areas that have suffered catastrophic damage. These areas may have lost most of their residential infrastructure, leaving communities destroyed and in dire need of long-term reconstruction as well as emergency assistance. The housing map is a crucial tool for evaluating the socioeconomic effects of seismic events, such as relocation, loss of livelihoods, and disruption to community cohesiveness, in addition to the direct physical repercussions. It also aids in long-term recovery and rebuilding planning by assisting allocate resources and initiatives to meet the housing requirements of impacted people and assist with rehabilitation and resilience-building efforts after earthquakes. Disaster management authorities and humanitarian organizations can more efficiently allocate resources and meet the short- and long-term housing needs of impacted communities by using the map's comprehensive color ramp to identify priority areas for housing rebuilding, rehabilitation, and recovery efforts. The map is a valuable tool for city planners, policymakers, and researchers

to evaluate the resilience of housing infrastructure to seismic hazards, guide land-use planning decisions, and create strategies to improve the earthquake resilience of housing in at-risk areas.

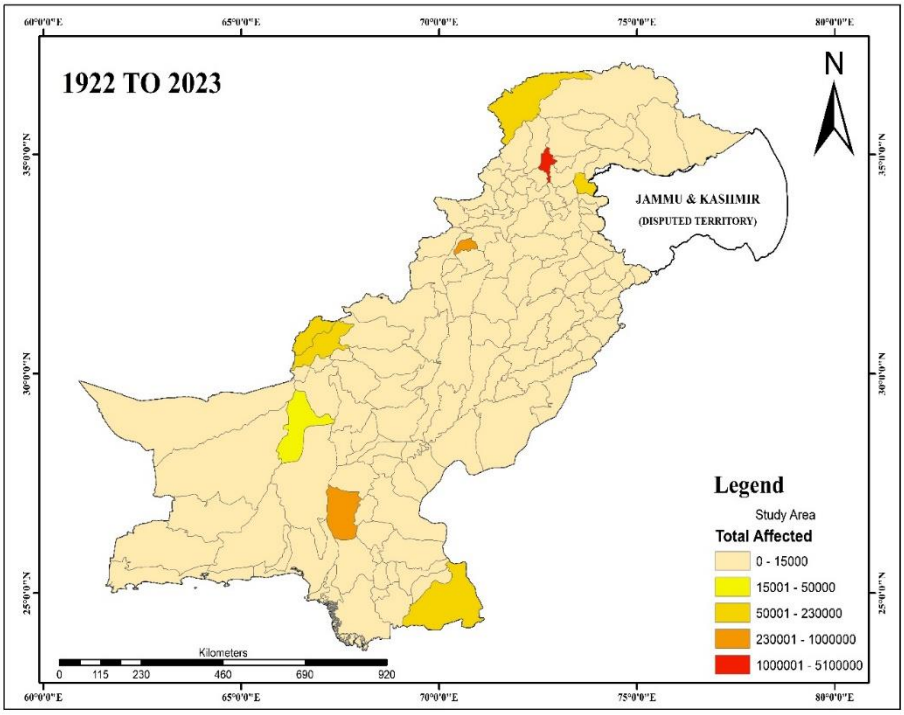

Figure 4: Map of Total affected people by Earthquake in Pakistan from 1922-2023.

Figure 5 shows the Pakistan earthquake map's total impacted population and provides a thorough visual representation of the effects of seismic activity on individuals across the country. This map uses a color ramp to show different ranges of impacted population counts, offering important insights into the geographic distribution and intensity of the social impacts of earthquakes. Areas highlighted with skin color, representing minor impact with impacted population counts between 0 and 15,000, are likely to see modest disruption, causing localized effects on communities. As the color changes to lemon, it indicates regions with population counts between 15,001 and 50,000, where the social repercussions are more noticeable, indicating a substantial number of people facing relocation, injury, or loss of lives. Areas highlighted in brown, representing populations between 50,001 to 230,000, experienced significant societal upheaval due to the earthquake, with a large number of people affected by displacement, injuries, and interruptions to vital services. The orange color transition indicates locations with population counts between 230,001 and 1,000,000, where the social

repercussions are severe and a considerable section of people may need humanitarian relief such as housing, medical treatment, and food assistance. Red regions with affected populations ranging from 1,000,001 to 5,100,000 signify areas of severe societal disruption where most of the population is affected, leading to high demand for humanitarian aid and long-term recovery support. The map of impacted populaces is fundamental for assessing the monetary, social, and compassionate results of tremors, coordinating reaction and recuperation activities, and affecting arrangement choices to further develop calamity availability and versatility. Following a tremor, partners can more readily apportion assets, plan for reaction exercises, and make centered intercessions to help influenced populaces and accelerate their recovery and recreation by obviously figuring out the size and spatial dispersion of the social effects. The affected populace map is additionally a fundamental apparatus for finding gatherings and networks that are bound to encounter financial difficulty in the outcome of seismic catastrophes. It helps coordinate social alleviation and advancement exercises to guarantee that help arrives at those in most need. Also, the guide directs the appropriation of assets and activities to help affected networks in reproducing their lives and methods for resources, in this manner adding to long-haul remaking and recuperation arranging. The guide gives a nitty gritty comprehension of the weaknesses and versatility factors influencing networks' recuperation from the quakes by including segment information and economic markets like pay levels, admittance to medical services, and levels of training. This extensive catastrophe-the-board technique advances a comprehensive and fair reaction by considering influenced networks' many requirements and interests and empowering practical recuperation and improvement results. The affected populace map is fundamental for working on the effectiveness of calamity reaction and recuperation exercises, advancing flexibility, and working with restoration following seismic events in Pakistan.

Table 1: Table of Earthquake Parameters

Start Year	Location	Magnitude	Number of Homeless	Total Deaths	Total Affected people
1923	Quetta	7.5	-	60,000	25,000
1945	Makran	8.1	-	4000	0
1955	Quetta	5.1	-	12	0
1972	Rawalpindi, Peshawar	6.2	-	100	5000
1974	North Indus R. Valley, Balakot, Patan	6.2	5200	4700	50200
1981	Karakoram, Darel, Tangir, Khanbari valleys	6.2	-	250	2000
1981	Koshkak	4	-	6	237

1984	Chitral-Landi Kotal (Hindu Kush)	6.5	-	4	12
1985	Chitral, Swat districts	7.4	-	5	12038
1986	Khuzdar area	5.2	-	0	750
1990	Hindu Kush region	6.6	-	11	250
1990	Kalat Area	6.1	-	11	40
1991	Malakand, Chitral, Peshawar area	6.4	29465	300	204794
1992	Quetta	5.7	-	4	200
1992	Peshawar, Kohat districts	6	2000	36	2100
1997	Harnai (Sibi district, Baluchistan Province)	6.3	10000	50	10100
1998	Rawalpindi, Peshawar	6.4	600	1	611
2001	Badin District, Tharparkar District,	7.7	-	12	914292
2002	Bajaur Agency district	6.3	-	3	0
2002	Administrative unit not available district	5.4	4000	17	15065
2002	Administrative unit not available district	6.3	-	19	140782
2004	Bisham Tehsil area, Mansehra District, Kohistan District districts	5.5	2320	24	13148
2005	Bisham Tehsil, Shangla District district area	7.6	5000000	73,338	5128309
2008	Ziarat District, Baluchistan province, Sibi District,	6.4	0	166	75320
2011	Quetta, Chagai districts	7.2	0	2	1000
2013	Karachi Central District, Karachi South District,	7.7	0	41	15175
2013	Awaran District, Chagai District,	7.7	0	399	185749
2013	Awaran District district (Balochistan province)	6.8	0	22	50
2015	Islamabad, Chakwal District, Gujranwala District,	7.5	133900	280	502590
2015	Khyber Agency district	6.3	0	3	85
2016	Gilgit-Baltistan provinces,	6.6	0	6	142
2019	Mirpur district	5.6	0	39	130398
2021	Hernai district i(Balochistan)	5.9	0	21	64100
2022	Lakki Marwat	5.9	0	43	0
2023	Khyber Pakhtunkhwa	6.5	0	11	939

The table shows quake events in Pakistan from 1923 to 2023, including start year, region, significance, number of penniless, complete passes, and outright impacted people. This broad dataset gives basic information on the repeat, reality, and social aftereffects of seismic occasions in various bits of the country throughout recent years. The most incredibly horrendous quake in Pakistani history occurred in 1923, when a 7.5-degree shake struck Quetta, leaving 25,000 people dejected and causing a stunning 60,000 fatalities. There have been vacillations in the effect of shakes throughout the period and between regions. For example, the 1945 Makran tremor, which had a size of 8.1, achieved critical passages at this point and didn't cause vagrancy. Associated with the table are quakes that have impacted society despite their more unassuming size. The 1955 quake in Quetta, which had a size of 5.1, provoked 12 lives, highlighting how frail structures and masses are to try and delicate seismic activities. The seismic quake between Rawalpindi and Peshawar in 1972, assessing 6.2 on the Richter scale, caused 100 fatalities and removed 5,000 people, highlighting the wide destruction achieved by shakes in thickly populated metropolitan networks. Also, the seismic episodes of the 1990s, recollecting the 1991 quakes for Malakand, Chitral, and Peshawar, showed the huge effects of shakes on society concerning people's development, passings, and hard and fast impacted locale. This tremor, which achieved around 30,000 fatalities and impacted more than 200,000 people, included the fundamental need to execute useful fiasco organizing and easing strategies to lessen organizations' weakness to seismic risks. Continuous years have seen a development in the amount of deadly shakes. One such seismic quake, assessing 7.6, occurred in 2005 in Bisham Tehsil, Shangla District, leaving more than 73,000 people dead and an astonishing 5 million people penniless. This appalling event uncovered that it is so critical to have strong structures, early exhortation systems, and useful fiasco response structures put in a position to decrease the effects of seismic catastrophes and engage in brief recovery and changing activities. Besides, the 2015 quakes in Islamabad, Chakwal District, and Gujranwala Region, which had a size of 7.5, left more than 130,000 people desperate and dependable 280 lives. This features the need to make building plans that are impenetrable to seismic quakes and complete procedures for land-utilize needed to lessen mishaps and damage to the establishment. Considering everything, the wide dataset shown in the table gives watchful information on the common and geographical instances of tremor influences in Pakistan. Focusing on the repeat, size, and social effects of quakes can help policymakers, researchers, and disaster board experts make data-driven arrangements to additionally foster shake flexibility, lessen bets, and reduce the impacts of future seismic events on organizations and establishments in Pakistan. The dataset highlights the necessity for thorough fiasco risk decline methodology, for instance, early notification ahead of time structures, public care missions, and cutoff building drives, to chip away at the adaptability of

organizations and diminish the impact of shudders on human life and property. Accomplices can further develop quake adaptability in Pakistan by analyzing the genuine setting and spatial scattering of seismic events to zero in on resources, allot support, and execute unequivocal measures to address shortcomings. The dataset is a remarkable resource for scholastics and policymakers hoping to use verification-based methodologies and drives to reduce the monetary repercussions of seismic quakes in Pakistan. Accomplices can use spatial and transient assessments of seismic activity to pinpoint high-risk districts, people with shortcomings, and fundamental establishments in danger of seismic hazards. This information can then be used to seek informed decisions concerning land-use composition, development regulations, and disaster response procedures to reduce bets and further foster adaptability. The table gives an organized dataset on the repeat, size, and monetary repercussions of quakes in Pakistan during the most recent hundred years, offering accommodating pieces of information. Accomplices could make strong plans to additionally foster shudder adaptability, lower risks, and decrease the consequences of future quakes in Pakistan by looking at true seismic models and geographical scattering of seismic occasions. Utilizing data to reduce risks and direct disasters is essential for making safer, more grounded networks and progressing acceptable improvement in earthquake-prone areas of Pakistan.

CONCLUSION:

This paper offers a thorough examination of earthquake occurrences in Pakistan throughout the last century 1922-2023, focusing on their frequency, size, and socioeconomic consequences. By studying a complete dataset containing crucial factors such as start year, location, magnitude, number of homeless persons, total fatalities, and total impacted population, this research gives unique insights into the geographical and temporal patterns of seismic activity in the area. The research shows notable differences in the effects of earthquakes, ranging from catastrophic incidents causing many deaths and extensive relocation to less severe seismic occurrences with smaller social consequences. The maps show the different parameters of earthquake disasters which affected Pakistan over the last century. The values on the maps represent the losses of lives, and households as well as affected people diversly. The results highlight the critical need for effective disaster risk reduction plans to improve seismic resilience and reduce the number of people and property lost during seismic occurrences. Concentrating on the authentic foundation and geological dissemination of tremors in Pakistan might help policymakers, scientists, and calamity the executives specialists make approaches and drives in light of proof to diminish gambles, further develop framework, and increment local area preparation. The exploration features the meaning of all-encompassing debacle risk the executives' procedures, for example, advance notice frameworks for catastrophes, schooling projects, and limit building

programs, to make increasingly strong networks and foundations. Partners might utilize an examination of seismic movement examples to distinguish high-risk areas, weak individuals, and key frameworks at risk for seismic dangers. This data can direct engage activities and asset dispersion to limit gambles and further develop strength. All in all, this study underlines that it is so pivotal to make a precautionary move to moderate Pakistan's seismic risks. Partners might pursue building more secure, more grounded areas and guaranteeing maintainable development in regions of the country that are inclined to quakes by utilizing information-driven experiences and arrangements given proof. Pakistan can more readily plan for and decrease the impacts of impending quakes, consequently protecting lives, occupations, and frameworks for people in the future, using helpful activities and brilliant interests in disaster risk mitigation and the board.

REFERENCES:

Abdalla, R. (2005). Integrated distributed GIS approach for earthquake disaster modeling and visualization. *Geo-information for disaster management*.

Agrawal, P. (2006). *Earthquake-resistant design of structures.*

Ahmad, N. (2014). Earthquake loss estimation of residential buildings in Pakistan. *Natural hazards*.

Alam, A. (2023). Regional Multifractal Variability of the Overall Seismic Activity in Pakistan from 1820 to 2020 via the Application of MDFA on Earthquake Catalogs. *Fractal and Fractional*.

Ali, Z. (2009). The Muzaffarabad, Pakistan, earthquake of 8 October 2005: surface faulting, environmental effects and macroseismic intensity. *Geological Society*.

Ao, Y. (2021). Impacts of earthquake knowledge and risk perception on earthquake preparedness of rural residents. *Natural Hazards*.

Barkat, A. (2017). Radon as an earthquake precursor in and around northern Pakistan: a case study. *Geochemical Journal*.

CXu. (2012). GIS-based support vector machine modeling of earthquake-triggered landslide susceptibility in the Jianjiang River watershed, China. *Geomorphology*.

CxU. (2015). Preparation of earthquake-triggered landslide inventory maps using remote sensing and GIS technologies: Principles and case studies. *Geoscience Frontiers*.

Daniell, J. (2014). The socioeconomic impact of earthquake disasters. *Earthquake hazards, risks, and disasters*.

Dartanto, T. (2022). Natural disasters, mitigation, and household welfare in Indonesia: Evidence from a large-scale longitudinal survey. *Cogent Economics & Finance*.

DAVOODABADI, F. (2013). GIS modeling of earthquake damage zones using ETM data and remote sensing-Bojnoord, Khorasan Province.

Doocy, S. (2013). The human impact of earthquakes: a historical review of events 1980-2009 and systematic literature review. *PLoS currents*.

Dou, J. (2019). Evaluating GIS-based multiple statistical models and data mining for earthquake and rainfall-induced landslide susceptibility using the LiDAR DEM. *Remote Sensing*.

Earle, P. (2011). Twitter earthquake detection: earthquake monitoring in a social world. *Annals of geophysics*.

Ellingwood, B. (2001). Earthquake risk assessment of building structures. *Reliability Engineering & System Safety*.

Freed, A. (2005). Earthquake triggering by static, dynamic, and postseismic stress transfer. *Earth Planet. Sci*.

Hashemi, M. (2011). A GIS-based earthquake damage assessment and settlement methodology. *Soil dynamics and earthquake engineering*.

Irshad, H. (2012). Long-term gendered consequences of permanent disabilities caused by the 2005 Pakistan earthquake. *Disasters*.

Jain, S. (2016). Earthquake safety in India: achievements, challenges and opportunities. *Bulletin of Earthquake Engineering*.

Jena, R. (2020). Seismic hazard and risk assessment: a review of state-of-the-art traditional and GIS models. *Arabian Journal of Geosciences*.

Jordan, T. (2011). Operational Earthquake Forecasting: State of Knowledge and Guidelines for Implementation. *Annals of Geophysics*.

JXu. (2016). Multi-criteria location model of earthquake evacuation shelters to aid in urban planning. *International Journal of Disaster Risk*.

Kagan, Y. (2004). Short-term properties of earthquake catalogs and models of earthquake source. *Bulletin of the Seismological Society of SCIENCE*.

Kanamori, H. (2004). The physics of earthquakes. *Reports on progress in physics*.

Khan, K. (2015). Recovering from disasters: a study of livelihoods in post-quake villages in northern Pakistan. *Disasters*.

Lomnitz, C. (2013). *Global tectonics and earthquake risk.*

Maqsood, S. (2011). Estimation of Human casualties from earthquakes in Pakistan—an engineering approach. *Seismological Research Letters,*

Maqsoom, A. (2022). An integrated approach based earthquake risk assessment of a seismically active and rapidly urbanizing area in Northern Pakistan. *Geocarto International*.

Naseer, A. (2010). Observed seismic behavior of buildings in northern Pakistan during the 2005 Kashmir earthquake. *Earthquake Spectra*.

Rafi, M. (2015). Observed damages in Pakistan due to the 16 April 2013 Iran earthquake. *Bulletin of Earthquake Engineering*.

Ranjbar, H. (2017). A GIS-based approach for earthquake loss estimation based on the immediate extraction of damaged buildings. *Natural Hazards and Risk*.

Rezaie, F. (2015). GIS modeling of seismic vulnerability of residential fabrics considering geotechnical, structural, social, and physical distance indicators in Tehran using multi-criteria …. *Natural Hazards and Earth System*.

Sato, H. (2007). Interpretation of landslide distribution triggered by the 2005 Northern Pakistan earthquake using SPOT 5 imagery. *Landslides*.

Scholz, C. (2019). *The mechanics of earthquakes and faulting.*

Shah, A. (2020). Factors affecting flood-induced household vulnerability and health risks in Pakistan: The case of Khyber Pakhtunkhwa (KP) Province. *International Journal of Disaster*.

Shapira, S. (2018). The impact of behavior on the risk of injury and death during an earthquake: a simulation-based study. *Natural Hazards*.

Shaw, R. (2015). Hazard, vulnerability, and risk: the Pakistan context. *Disaster Risk Reduction Approaches in Pakistan*.

Spence, R. (2009). Estimating shaking-induced casualties and building damage for global earthquake events. *Earthquake Hazards Reduction Program*.

Sullivan, K. (2010). Earthquake mortality in Pakistan. *Disasters*.

Sullivan, K. (2010). *Earthquake mortality in Pakistan*. Retrieved from Wiley Online Library

Yadav, R. (2012). A probabilistic assessment of earthquake hazard parameters in NW Himalaya and the adjoining regions. *Pure and applied geophysics*.

Yariyan, P. (2020). Earthquake risk assessment using an integrated Fuzzy Analytic Hierarchy Process with Artificial Neural Networks based on GIS: A case study of Sanandaj in Iran. *International Journal of Disaster Risk Reduction*.