SEISMIC VULNERABILITY & RISK ASSESSMENT FOR ORGANIZATIONAL SAFE AND RESILIENT OPERATIONS – CENTRAL AND SOUTH ASIA EXPERIENCE

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Abstract

South and Central Asia is prone to high seismic risk. Large-scale earthquake events are reported, witnessed massive human losses and damages in this region. In view of these events, various development agencies and stakeholders have learnt lessons and started working in this direction of safe and resilient infrastructure development and continuity of operation planning during disasters. Accordingly, Aga Khan Development Network initiated Disaster Risk Management Initiative in 2011. In close coordination with all AKDN agencies, the initiative was implemented in five central and south Asian countries, viz. Afghanistan, India, Kyrgyzstan, Pakistan and Tajikistan. The purpose of the initiative was to promote organizational and community safety & resilience and mainstream disaster resilience in its development programmes. Since the region is prone to seismic activities, earthquake and collateral hazards were primarily considered for further planning. The network agencies have more than five thousand social and economic facilities / structures in stated priority countries, which includes education, health, community, commercial, residential etc., that were considered for the assessment. The seismic vulnerability and risk assessment based planning activities include facility inventorization, structural and non-structural vulnerability profiling (using rapid visual screening) and risk assessment followed by organization planning for seismic resilience. The facility inventorization intended to create profile of each facility by location, occupancy, functions, number of structures within the facilities with their type and the physical condition. The rapid visual screening survey was conducted for all facilities, which provided the structural and non-structural seismic vulnerability ranking and scores for the surveyed facilities to prioritize their mitigation plan. The risk assessment was estimated for each structures / facilities, which included expected structural and non-structural losses, damage grade, and causalities by temporal variation, rental and relocation losses and down time. Thus, the risk assessment resulted in operational dysfunction time, economic losses and human lives. The risk assessment methodology is developed based on Hazus® and other well-referenced / established methodologies. The input parameters are customized based on countries, seismic and soil condition. The paper discusses about the rationale, the methodology and computation process of all the activities. The paper further discusses the vulnerability and risk assessment outcomes. The risk assessment outcomes are the basis for organizational safety and resilience planning. The outcomes are systematically analyzed in close consultation with country agency stakeholders and advocated to incorporate in their organization policies and planning. It further discusses the approach adopted to mainstream seismic risk reduction in organization safety and resilience planning. The paper finally discusses challenges, opportunities, way forward activities and achievements.

Keywords: South and Central Asia, Seismic Vulnerability, Risk Assessment, Continuity of Operational

1. Introduction

1.1 South and Central Asia – Seismic Hazards

Recent national and international initiatives and commitments for the seismic risk reduction have certainly brought down the damage and loss risk in hazard prone region. Central and South Asia, including the territories of Afghanistan, India, Kyrgyzstan, Pakistan and Tajikistan are one of the most seismically active regions of the world (Fig.1). Global Earthquake Model (GEM) produced Global Seismic Hazard Map, which depicts Peak Ground Acceleration (PGA) [1] distribution with 500 years return period. The PGA were computed for reference rock conditions considering shear wave velocity (VS30) of 760-800 m/s. The map was created by collating maps using national and regional probabilistic seismic hazard models along with Open Quake engine.

Referring the map, the strip of south and central Asia have higher seismic hazard PGA. Thus, the region needs a pragmatic approach for seismic disaster risk reduction.

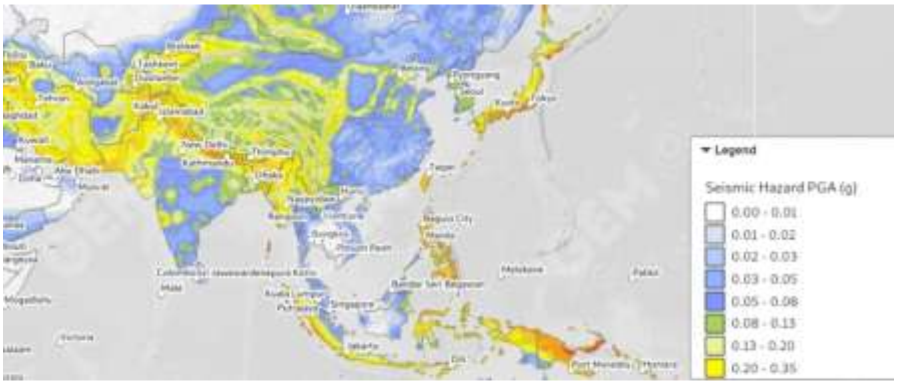


Fig. 1 – Seismic hazard maps of Central and South Asia [2]

1.2 South and Central Asia and Earthquake Events

Last 50 years earthquake events of south and central Asian countries are analysed using USGS earthquake catalogue [3] (Fig.2). Afghanistan has witnessed large magnitude earthquake events followed by Kyrgyzstan and Pakistan. However, Afghanistan and Tajikistan have recorded highest number of events. The events ranging from 4-5 to 6 M_w are highest in the region, which have potential for moderate structural and large non-structural damage and losses. There is an urgent need to mainstream seismic safety and resilience in all developed programmes.

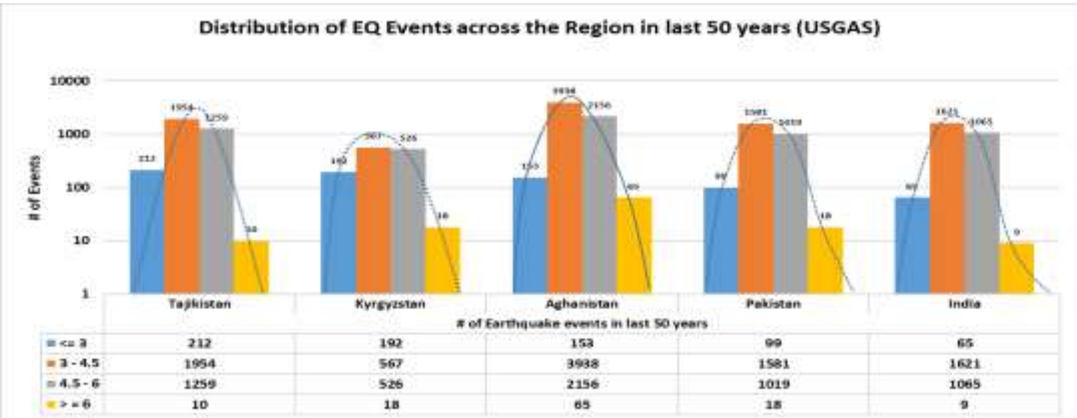


Fig. 2 – Distribution of earthquake event in the region [3]

2. Disaster Risk Management Initiative (DRMI) - Paradigm shift from disaster response to preparedness and mitigation

The previous section discusses the South and Central Asia proneness to multi hazards and large exposure of demography. The region has witnessed several major earthquakes and collateral disasters leading to life losses and properties. AKDN has substantial development programmes in the region in partnership with national, regional and local development actors, thus created large number of facilities and infrastructure. Kashmir earthquake 2005 rendered massive devastation of facilities and infrastructure in the region. The earthquake prompted critical thinking to initiate planning for continuity of operations (ConOps) and develop sustainable operation model. The study reveals that a single natural disaster event [4] could push the development growth for decades. This was evident during Banda Ache Tsunami (2000), Gujarat Earthquake (2005), Haiti

Earthquake (2010) and others. International, national and local disaster management mandates and policies are also contributing towards paradigm shift from disaster response to mitigation and preparedness. Hyogo Framework of Action recognized the importance of preparedness and mitigation to reduce the impact of disaster [5]. Hyogo Framework of Action emphasised that the approach should be of national and local priority with strong institutional support and continuous capacity building with systematic approach for risk reduction and control. Further Sendai Framework of Disaster Risk Reduction [6] put impetus on understanding the hazards, explain the reasons of damage and losses, strengthening the DRR governance, investment in risk reduction and integrate preparedness in response and recovery. These frameworks were well adopted by the national to local government authorities but were also well accepted by the non-governmental national and international organizations. AKDN is one of the lead organizations to foresee the current challenges for disaster risk reduction in operational areas and tap the opportunities to act on zero-tolerance to human losses and minimised operational and investment losses. AKDN [7] is working for decades in major development sectors including habitat, education, infrastructure, health, finance, telecommunication, agriculture, water resources, social and environmental protection in the region. In view of regional, local earthquake events, international and national mandates, AKDN envisaged setting up regional initiative on Disaster Risk Management Initiative (DRMI) in 2011 covering South and Central Asia operations.

2.1 Organization and Asset Exposure

Aga Khan Development Network (AKDN) has more than 5500 facilities [8] across the region. Table 1 shows that Pakistan has the largest operational asset. There are large number of community centres, education and health facilities, which have large occupancy and need safety and resilience to life safety and maintain continuity of operations.

Table 1 – Distribution of AKAH facilities in the region (As on 2014)

Primary purpose Usage	**Afghanistan**	**India**	**Kyrgyzstan**	**Pakistan**	**Tajikistan**
Commercial/Hospitality	90	-	-	153	8
Education	94	72	4	993	30
Health	123	3	-	476	4
Industrial/Utility	-	-	-	2	21
Community Centre (JK)	327	374	-	1987	1
Land Parcel	-	-	-	5	-
Office	216	44	56	210	81
Other	2	3	-	15	-
Recreational	1	-	-	10	-
Residential	1	13	1	77	3
Transportation	11	-	-	-	2
Warehouse	11	1	-	10	19
Grand Total	**876**	**510**	**61**	**3938**	**169**

2.2 DRMI and approach for disaster risk reduction

DRMI aimed to strengthen disaster risk reduction by promoting regional coordination and standardisation of good practices, and by working with donors, academia, government agencies and civil society to build existing capacity in disaster risk mitigation and preparedness with special emphasis on earthquake and collateral hazards. To achieve this, ambitious plan was prepared with four key goals viz., 1) assess hazard risk, 2) promote safety consciousness, 3) reduce risk and 4) build emergency response capacity in network agencies in close partnership with local and national stakeholders.

Goal One - assessment of hazard risk included collaboration with scientific and disaster risk reduction agencies, develop probabilistic and deterministic seismic hazard mapping of the region, microzontation of major city in its operation areas and benchmarking the cutting edge methodology for hazard, exposure and vulnerability assessment.

Goal Two - specific to promoting safety consciousness by developing and adopting holistic approach for safety to reduce the negative impacts for community and organization operations, transforming the target community attitude, perception towards safety, promoting self-reliant community to manage the risk at community and organization level.

Goal Three - primarily addressing the structural safety of the target region. the objective was to promote practices of national and international building codes, which need to be blended with culturally respectful building standards that are progressive yet tactful, pragmatic and yet effective, understand the vernacular building vulnerability and promote safe, resilient and sustainable building practices. Further to promote building safety through cost effective and efficient seismic retrofitting.

Goal Four - targeting and creating effective and efficient disaster response mechanism by formation of Community Emergency Response Teams, Disaster Assessment Response Teams, and lightweight Search and Rescue Teams, and co-development of government first response capacity.

2.3 Structural and Non-structural mitigation approach

The major resource intensive activities were related structural and non-structural mitigation. As it is evident, that earthquake doesn't kill people but building do. So, the major emphasis was given to identification of critical, priority facilities and infrastructure for their vulnerability and risk assessment and plan for incremental seismic risk mitigation. Following steps (Fig. 3) were taken to introduce structural and non-structural hazard mitigation planning.

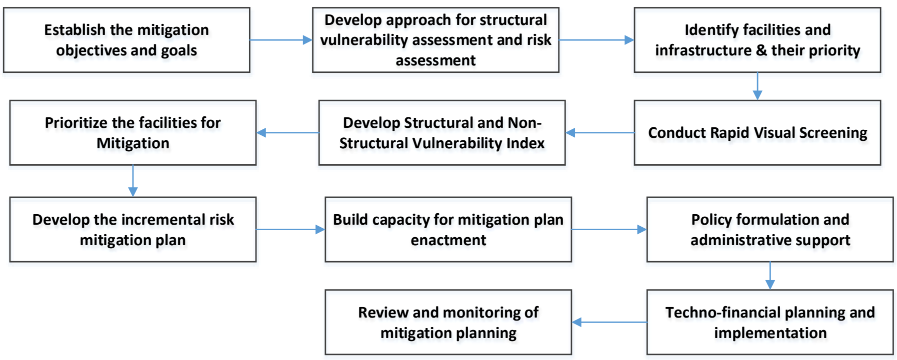


Fig. 3 – Approach for AKDN structural and non-structural hazard and risk mitigation

The agency leadership, professionals and team carried out series of consultative meetings to arrive at mitigation planning objectives and goals. The prime goal was to achieve zero death tolerance with mainstreaming disaster risk reduction into its strategic operations in the region. The approach for developed for structural and non-structural mitigation based on institutional experience and best national and international practices. All regional facilities and infrastructure (education, health, community, commercial, industrial etc.) were mapped with required attributes and geocoded for further assessment. The rapid visual screening (RVS) [9] process was developed considering local hazards, structural, non-structural vulnerability and risk contributing factors. A comprehensive approach was adopted to implement RVS. More than 5,500 structures and facilities were surveyed across Afghanistan, India, Kyrgyzstan, Pakistan and Tajikistan. An adequate capacity and skillset was developed with survey and assessment team to collect and analyse the data. The vulnerability assessment resulted in structural and non-structural vulnerability index. The scope of paper doesn't include details of

Rapid Visual Screening process. Further risk assessment methodology was evolved based on Hazus® [10] and other lead research methodologies. The paper elaborates the AKDN risk assessment methodology.

3. AKDN Risk Assessment Methodology

The prime purpose of risk assessment is to sensitize organizational safety and planning stakeholders to understand the potential impacts of physical, economic, social and operational assets due to impending earthquake events. In general, key risk indicators include impacts on life, resources and operations. Following these principles, the risk assessment indicators were developed. The key driving risk indicators were calculated including physical damage, human losses and asset physical & operational losses. Considering physical condition, natural hazards, demography, occupancy, usage, built-up area and other key governing factors, the facilities and infrastructure were ranked for priority mitigation planning. Based on available resources and institutional priority, the mitigation plan was implemented. Disaster risk reduction policies and guidelines were developed to enforce the planned mitigation activities with stringent monitoring and evaluation process. Following parameters were evaluated to assess the agency risk.

1. Structural damage and loss estimation
2. Non-structural damage and loss estimation
3. Casualty Estimation
4. Functional Loss estimation
5. Rental and relocation Estimation
6. Content Loss Estimation

3.1 Structural Damage and loss estimation

The first step was to identify the building typologies. As per the approach [9], 29 types of buildings were identified, whose empirical fragility functions were derived. For each typology the reconstruction cost by each region of the priority region of south and central Asia were calculated. Refer to the earthquake zones, maximum credible earthquakes (MMI 9) was considered for risk assessment. The fragility functions Mean Damage Ratio (MDR) was calculated. This resulted in calculating physical damage in. ATC 13 and Whitman Damage Probability Matrix were referred for the estimation of damage grades (Eq. (1)).

$$\text{Expected Structural Losses} = \textit{Unit cost of Reconstrutcion} \times \textit{Builtup area} \times \textit{Mean Damage Ratio} \quad (1)$$

Expected Damage Grade is defined within the range of Mean Damage Ratio, as given below.
If MDR: ≤10 – Slight, 10-30 – Moderate, 30-60 – Extensive and ≥60 – Collapse

3.2 Non-structural damage and loss estimation

Non-structural damage and loss estimation is essential as any facility has larger proportion of non-structural elements, which could be damaged even if the structure is undamaged. The estimation method is developed based on HAZUS-MH model.

The total Non-structural losses are sum of damage contributed by drift and acceleration actions to non-structural elements. The proportion of non-structural components are estimated based on field survey and expert opinion by the study region. Further Acceleration and drift sensitive non-structural repair and replacement ratio is calculated for the study areas following HAZUS-MH [10] guidelines. The equations Eq. (2), Eq. (3), Eq. (4), Eq. (5) are as below:

$$\text{Total Nonstructural Damage Cost} = \text{Cost of Acceleration sensitive nonstructural damage} + \text{Cost of Drift sensitive nonstructural damage} \quad (2)$$

$$Nonstructural\ replacement\ cost = Reconstruction\ cost \times Proportion\ of\ Nonstructural\ component \tag{3}$$

$$\text{Cost of acceleration sensitive nonstructural damag} = \text{Nonstuctural replacement cost} \times \text{acceleration sensitive nonstructural repair and replacement ratio} \tag{4}$$

$$\text{Cost of drift sensitive nonstructural damag} = \text{Nonstuctural replacement cost} \times \text{drift sensitive nonstructural repair and replacement ratio} \tag{5}$$

3.3 Casualty estimation

The casualty estimation is carried out using the lethality Ratio [11], Eq. (6).

Lethality Ratio = Occupancy rate(M1) × Occupancy during EQ Event (M2) × Occupancy Trapped (M3) × {(Injury distribution(M4)) +(Mortality post collapse(M5))} (6)

M1 to M5 factors are calculated based on the region and usage of the facility. The casualty model results in the grade of injury (Minor injury, Needs hospitalization, Life threatening and Deaths) to for each facility by temporal variation.

3.4 Functional losses estimation

Functional losses are estimated based on to the type of facility and modified building construction & clean-up time and construction time modifier. The modifier is based on delays in decision-making, resource mobilization to restore the facility functions. Functional losses are calculating in days.

Loss of function = building construction and clean-up time X construction time modifiers (7)

3.5 Rental and relocation cost estimation

For rental and relocation cost estimation, it is to be checked whether the facility is owned/operated/eased. In case the building is owned by the occupant, the relocation cost will be inclusive of rental and relocation costs. The recovery time will be considered from functional loss estimated. Further disruption cost is calculated per square meter.

Rental Cost = (Built-up area X Unit construction cost) X Rental Coefficient (8)

3.6 Content loss estimation

Every facility type has unique content values. Efforts are made to classify and develop the multiplier coefficients by the region and countries. Content damage ration is calculated by each usage type. The content is estimated following the equation

$$\text{Content replacement cost} = \frac{\text{(Reconstruction Cost) X (Content Percentage)}}{\text{Total Content Percentage (Structural + Nonstructural)}} \tag{9}$$

4. Risk Assessment Outcomes

4.1 Direct Monetary Loss

Based on the equations stated above, structural, non-structural, rent, and relocation loss due to designed earthquake are calculated (Table 2) by each country. Due to large number of facilities and asset in Pakistan, Afghanistan and Tajikistan, large losses are anticipated in these countries followed by Indian and Kyrgyzstan. Pakistan contributed 50 % of structural losses followed by Afghanistan (22%). Due to large number of facilities in Pakistan the average loss per facilities fall to US $ 16,000, while due to very limited facilities in Kyrgyzstan it's highest up to US $ 132,000. Similarly, analysis could be carried out for non-structural and rent and relocation losses. Fig. 4, presents the expected total losses by each country. In case any worst earthquake event, it could lead to estimated direct losses. Pakistan has larger expected losses followed by Afghanistan and Tajikistan. When Comparing Non-structural hazard losses, trend is similar to structural losses. Pakistan has larger rental and relocation losses followed by India and Afghanistan. Thus, it is imperative to address these losses in Pakistan, Afghanistan, and Tajikistan on immediate effect.

Table 2 – Consolidated structural, non-structural & rent/ relocation losses due to extreme earthquake event

	Structural		**Non-Structural**		**Rental & Relocation**	
Country Name	**Expected Total Loss (Million US $)**	**Expected Average Loss (,000 US $)**	**Expected Total Loss (US $)**	**Expected Average Loss (000, US $)**	**Expected Total Loss (US $)**	**Expected Average Loss (000, US $)**
Afghanistan	26.92	31.56	13.10	15.35	1.49	1.75
India	12.53	24.23	4.20	8.12	1.50	2.91
Kyrgyzstan	7.93	132.10	3.61	60.02	0.54	8.91
Pakistan	60.86	16.18	25.18	6.70	7.62	2.02
Tajikistan	14.15	81.35	6.73	38.64	0.655	3.76
Grand Total	**122.38**	**22.81**	**52.80**	**9.84**	**11.80**	**2,198**

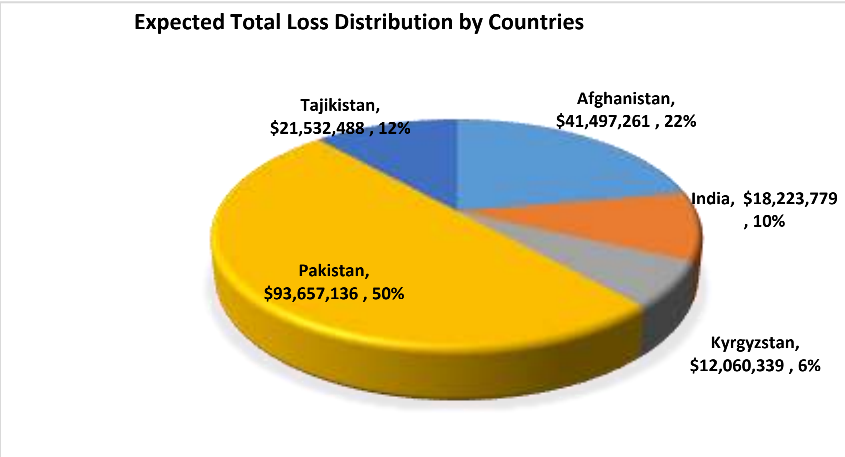
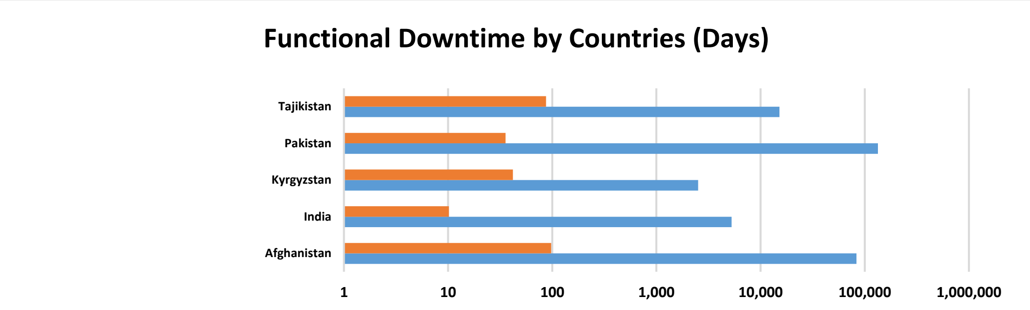


Fig. 4 – Expected total loss distribution by region

4.2 Functional loss

The downtime caused by earthquake event damages, the organization functions and operations will be disrupted. The same is estimated followed by equation discussed above. Highest downtime is estimated in Pakistan (Fig. 5) followed by Afghanistan and Tajikistan. Large downtime is reported due to large number of operations in these countries. However, if numbers are compared Afghanistan has just 22 % of Pakistan facilities and downtime is almost 63% of Pakistan. Average downtime per facility in Afghanistan is closer to 100 days followed by Tajikistan i.e. 90 days. This indicates Afghanistan and Tajikistan are most vulnerable to operational dysfunction, which will lead to economic, financial and social losses. There is a need to develop continuity of operations plan by agencies and their operations.



	Afghanistan	India	Kyrgyzstan	Pakistan	Tajikistan
Average of Expected Functional Downtime (Days)	98	10	42	36	87
Expected Total Functional Downtime (Days)	83,279	5,260	2,511	133,740	15,181

Fig. 5 – Functional downtime during the extreme earthquake event

4.3 Expected casualties

Following the Lethality Ratio [11], the casualty is calculated for the target countries. Two scenarios were considered, i.e. Worst and Typical condition. Worst condition scenarios are for the facilities with maximum occupancy. In case of education, community and commercial facilities, worst conditions are during mid-day when facilities are working in full capacity. The Typical case is when facility occupies average occupancy. The analysis deliberates (Fig. 6) that Pakistan followed by Afghanistan and Tajikistan have larger casualties.

AKDN is mandated for zero tolerance to any casualties and aims to develop strategic approach for casualties prevention and damage & loss reduction. The risk assessment and quantification set the basis for comprehensive Disaster Risk Reduction (DRR) planning at organization and field level. The following section discusses the strategy, approach and methodology for organizational safe and resilient operations.

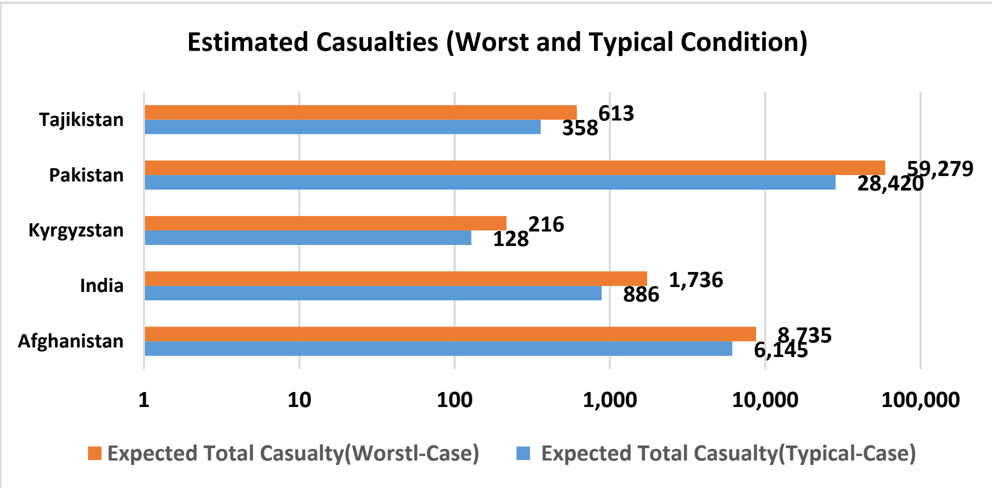


Fig. 6 – Estimated casualties during the extreme earthquake event

5. Risk Sensitive Mitigation Planning

The real time mitigation plan implementation was evolved based on vulnerability and risk assessment outcomes discussed in the earlier section. The sequence of the mitigation activities is detailed out as follows-

Report on Comprehensive Hazard, Vulnerability and Risk Assessment and their Mitigation Planning - based on the vulnerability and risk assessment, a comprehensive report is prepared describing seismic and non-seismic hazard distribution and their severity. This is followed by detailing out their structural and non-structural vulnerability contributing factors and vulnerability indices. This gives fare understanding of their vulnerability and supports in prioritizing for mitigation planning. Risk factors as discussed in the previous section provides the extent of damage and losses for money, time and functions. All these factors consolidate and prioritizes the facilities and structures for mitigation planning.

Fig. 7 – Report describing the vulnerability and risk portfolio by facilities

Prioritization for Mitigation Planning – in consultation with facility authorities, policy makers and subject experts, a comprehensive prioritization approach was developed. All facilities by countries and their usage grant was assigned for mitigation prioritization. This helped the agencies and national implementation team to shortlist the structures and facilities for mitigation planning.

Structural and non-Structural Assessment -The structural vulnerability assessment was carried out in two stages i..e level 2 and Level 3 Audit. Level 2 audit is designed for the simpler load bearing structure with most prevalent building typologies (low rise). It collects structural and architectural drawings, characteristics of structural and non-structural components and structure conditions, which results in structural and non-structural retrofitting. It follows the AKDN methodology [12] for structural audit, which is based on performance based seismic analysis of the existing facilities [13]. Level 3 audit is recommended for all critical (important and lifeline) structures. The Level 3 audit is case specific and will only be carried out for complex and large structures. The procedures in Level 3 employ linear or nonlinear analyses of the building under consideration and require the as-built dimensions and the reinforcement details of all structural elements. This phase of the evaluation usually requires laborious strength and displacement calculations and takes much longer time that the first two evaluation stages. Therefore, it is preferred to have small number of buildings to be assessed in this stage. The survey process comprises of structural data collection, analytical and experimental studies, destructive and non-destructive testing etc., geological and geotechnical studies, complete linear/non-linear analysis, cost-benefit analysis, tender documents for structures feasible for retrofitting, complete retrofitting designs, etc.

Non-structural Hazard assessment and retrofitting - In general, non-structural elements represent all components and elements of a building that are not part of the building's load-bearing structure. Non-structural elements can be broadly classified into Architectural Elements (AE), Mechanical, Electrical and Plumbing (MEP), and Fixture, Furniture and Equipment (FFE). Ideally, all non-structural components only contribute to the dead and movable loads but do not contribute to the transfer of these loads to the building's foundation. Dependent on a building's occupancy type, non-structural components may account for a large percentage of the construction costs or the building's economical value in general. These costs [14] may be up to 82% (office buildings), 87% (hotels) and 92% (hospitals) of the total. When it comes to mitigation measures, the costs for non-structural mitigation is substantially lower than structural retrofitting measures. While the building's structural safety is directly related to meticulous planning, designing and construction implementation precision, the non-structural safety is somewhat related to post-construction maintenance and a general safety policy of the facility. The costs and resource requirements for non-structural mitigation are recurring but are substantially minimal compared to structural mitigation efforts. It is easy and convenient for the facility managers to ensure higher quality of non-structural safety with limited available resources.

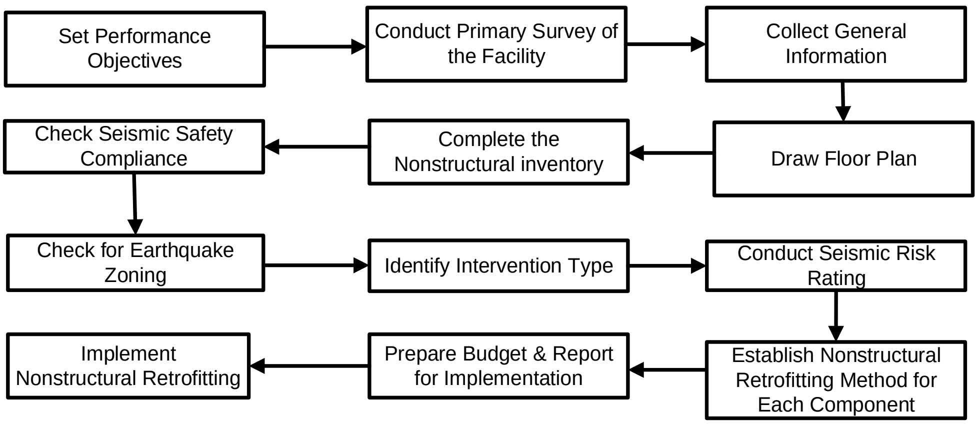


Fig. 8 – AKDN non-structural hazard mitigation approach

Preparedness and response planning- Apart from structural and non-structural hazard mitigation, it is imperative to create strong institutional and policy framework to ensure the efforts undertaken are continued and regular resources and skills were developed. Emergency Preparedness Measures (EPM) [15] is an intangible but essential part of Disaster Risk Reduction. The mitigation recommendations have attempted to strike a balance between structural and non-structural mitigation considering the local hazards, organizational mandate and available resources. It is obvious that mitigation will be only effective when structural mitigation (i.e., structural and non-structural retrofitting) is integrated with non-structural (functional, operational) components. These include institutional policy advocacy, training/capacity building, emergency planning and procurement of emergency support equipment. Table 3 explains various components to ensure the integration of DRR into an organizational development plan.

Table 3 – AKDN Non-structural Component, their elements and target stakeholders *(Amit Kumar, 2017)*

Non-structural components	**|Non-structural elements**	**Target**
Institutional advocacy	Safety policy enforcement	Agencies / Organization
	Safety and security officer appointment	Agencies / Organization
	Resources for structural and non-structural mitigation	Agencies / Organization
	DRR inclusive development planning	Agencies / Organization
Capacity building/training	Medical first response	Agencies / Organization
	Office safety	Agencies / Organization
	Earthquake drill	Agencies / Organization/ Community
	Earthquake resistant planning and safer construction	Engineering and construction agencies
	Incident command system	Emergency response agencies
	Non-structural hazard mitigation and retrofitting	Agencies / Organization
	Mass casualty management	Health facilities

Non-structural components	Non-structural elements	Target
Emergency planning	Continuity of operation plan	Agencies / organization
	Mass casualty management plan	Health facilities
	Comprehensive school safety plan	Education facilities
	Office safety plan	Agencies / organization

Policy enactment and institutionalization - DRMI was one of the key regional initiative of AKDN and plan was to keep this alive through mainstreaming into its core development mandate. The key activities discussed in this paper was integrated into AKDN new apex organization namely Aga Khan Agency for Habitat, which is mandated for ensuring safe, resilient and sustainable development considering all local and regional natural hazards and provide opportunity and services to maintain the initiative inertia.

6. Challenges and Opportunities

The data collection planning and implementation are impacted by the unavailability of information, weather, remoteness, prevailing safety and security of the region. Logistic support is complicated, and the coordination among the agencies are difficult. It will be smoother, if a buy-in process is established among the relevant agencies to conduct a coordinated survey. The ground support for the implementation of developed technology is minimum and need expedited efforts to meet the potential demand. Due to ignorance and limited awareness, stakeholders are working in silos ignoring the sensitivity of others. This leads to coordination complexities and more efforts are required to resolve the impediments. Unless the initiative outcomes and benefits are not tangible, the demand for such interventions will be relatively low. The mitigation options and strategies are proposed for the institutions. The options are evolved based on the needs and priorities, thus no additional efforts are required for stakeholder buy-in and ensure risk reduction. The options are cost effective and through cooperative societies, the cost can be further optimized to the larger extent. Although the methodology has been developed for the institutional buildings, it can be calibrated and applied to the mass housing for rapid seismic risk assessment and prioritization in the region. Awareness programmes can be developed to capacitate the relevant local Government.

7. Conclusion

South and central Asia is prone to multiple hazards. Many hazards are induced by the ground shaking leading to mass movement, liquefaction, subduction and other geophysical disaster events. In view of presence of AKDN in the region and larger operation with massive physical and economic infrastructure, there is a substantial seismic exposure. In view of large earthquake events in the region and vulnerable physical and economic asset, AKDN initiated scientific and evidence based risk reduction planning across its operational region. The paper discussed the approach for estimating damage and losses, operational dysfunction and casualty scenario by each country considering each facility. The damage and losses are estimated for structural and non-structural components and rental & relocation activities. Further, facility dysfunction could be impacting organization operation and require continuity of operation planning. Casualty estimates are imperative for zero tolerance mandate. Considering these factors, the risk portfolio has been prepared by primary purpose, agencies and countries. Due to higher exposure, Pakistan, followed by Afghanistan and Tajikistan are having higher risk portfolio. Though, Afghanistan has 25 % of Pakistan facilities, but having higher risk portfolio. Thus more attention is needed for Afghanistan. This helped the agencies by purpose to plan for risk reduction at institutional level. The paper further discusses action being taken for structural vulnerability reduction through detailed assessment for seismic structural and non-structural hazard mitigation. This is further supplemented with institutional advocacy, capacity building and emergency planning. The paper also discusses opportunity and challenges in implementing this ambitious regional risk reduction exercise. Due to diverse cultural and social condition in the region, data collection and collaboration was initially challenging. However, due to institutional mandate and constant ground support, the programme received synergy to implement across the region.

8. Acknowledgment

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