Capacity Building Experience for Disaster Risk Reduction in Central Asia

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Abstract. A capacity building experience in Central Asia is illustrated, which consisted in the organization of a series of
10 eight training workshops devoted to the different components of risk assessment, focused on earthquakes, floods and select-
ed landslide scenarios. Specifically, the activity consisted of five country-based workshops on exposure assessment, organ-
ised one in each of the involved Countries (i.e. Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan),
plus three thematic workshops on hazard, vulnerability and risk modelling, organised at the regional scale of Central Asia.
The capacity building workshops provided participants an opportunity to learn about international practice and methodolo-
15 gies related to natural risks assessment, as well as to discuss the value of methods applied for large-scale risk assessment,
showing how they complement and advance what was previously done in the region. The involvement of local scientific
experts (including invited speakers) was essential in recognizing and supplying relevant information from methodologies
previously applied in each country, as well as to discuss the possibilities offered by the newly proposed procedures and to
validate their products. To increase the impact of the capacity building activities and to cascade the training, local universi-
20 ties, research institutes and associations were involved, so as to reach younger professionals and experts.

In view of the restrictions imposed by the Covid19 emergency, all workshops were held in online mode; this restriction
eventually turned out to be an advantage, as it allowed for a much broader participation, beyond any expectations, especially
for the regional thematic workshops. Participation was active and varied, involving not only individuals from academy and
research institutes, but also a significant number of representatives from Ministries, professionals, young experts and stu-
25 dents. The feedback from participants, received through anonymous evaluation forms, was especially useful and positive,
indicating that the topics covered by the workshops were relevant to their current work and that participants are likely to use
the presented tools and data in their activities. It also provided valuable indications that were considered when planning the
subsequent activities.

Lessons learned from this capacity building activity are discussed, including a summary description of the workshops struc-
30 ture, their attendance and feedback from participants. The experience collected during the workshops is summarized here
and generalized in order to support future experiences of this kind, in the region and worldwide.

Keywords: Capacity building; Disaster risk reduction; Exposure assessment; Multi-hazard; Central Asia

1. Introduction

35 Disasters associated with natural hazardous events have only a partial "natural" component (Mizutori, 2020): while the
triggering event can be a physical phenomenon controlled by Nature, its consequences largely depend on the amount and
vulnerability of the exposed assets managed by Humans (Cardona et al., 2012a). Climate change, urbanization and
population growth are expected to exacerbate natural risks in the future. All components that contribute to natural disasters,
in fact, are by far not static. On one side climate change may increase the frequency and extent of hazardous events (e.g.
40 floods and landslides), on the other side vulnerability and exposure will evolve over time under geographic, political and
socio-economic drivers. For example, the typology and number of buildings and infrastructures can change, modifying
exposure and, potentially, expected losses in case of disasters. In order to reduce disaster risk, it is vital that governments,

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policymakers and practitioners take science-based, informed decisions accounting for the complexity of interactions between hazard, exposure, vulnerability and climate change (Ismail-Zadeh, 2021). According to UN definition (https://www.un.org/en/academic-impact/capacity-building), capacity building refers to the process of developing and strengthening the skills, instincts, abilities, processes and resources that organizations and communities need to survive, adapt, and thrive in a fast-changing world. An essential ingredient in capacity-building is transformation that is generated and sustained over time. Accordingly, capacity building includes all activities related to the development of human resources, management (strategic, organisational, knowledge and information management), and also the creation of an environment that favour the sustainability of development. Disaster risk management is important not only for saving lives, but also to preserve the long-term sustainable development of a country (Wen et al., 2023), and must account for the transboundary as well as for the evolving features of risks assessment over time. To face these challenges, the European Union, in collaboration with the World Bank and the Global Facility for Disaster Reduction and Recovery (GFDRR), created the program "Strengthening Financial Resilience and Accelerating Risk Reduction in Central Asia" (SFRARR). The ultimate objective of the program was to improve financial resilience and risk-informed investment planning, aiming to advance disaster and climate resilience in Central Asia. In this framework, the objective of the capacity building activities was to increase the existing expertise of regional institutions, governments, local experts and research groups with a role in Disaster Risk Management (DRM) and emergency planning in Central Asia countries (Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan). To do so, a series of regional workshops was carried out, involving technical and scientific communities from the five countries, to build local capacity on all the components of risk assessments. A total of eight fully online workshops were carried out, addressing different topics: five workshops, one for each country, were dedicated to exposure, while three were dedicated, at regional scale, to hazard, vulnerability, and risk, respectively.

The capacity building workshops provided an excellent occasion to discuss and demonstrate the value of the methods that were applied for large-scale risk assessment in Central Asia, and to show how they complement and advance what was previously done in the region in the field of disaster risk reduction (e.g. Bindi et al., 2012; Pittore et al,. 2020; Mavlyanova et al., 2021). The involvement of local scientific experts was essential in recognizing and supplying relevant information from methodologies previously applied in each country, as well as to discuss the possibilities offered by the newly proposed procedures and to validate their products. To increase the impact of the capacity building activities and to cascade the training, local universities, research institutes and associations were involved, so as to reach younger professionals and experts.

Special attention in the capacity building activities was devoted to the exposure component. Specifically, five country-based workshops have been organized to provide training on methods in exposure data collection, and on combination of ground data with remote sensing data (e.g. Wieland et al., 2015; Pittore et al., 2020). These workshops allowed sharing knowledge with local experts, and provided an opportunity for discussing and including a greater amount of locally collected information (e.g. grey literature, personal communications) into the exposure assessment (Scaini et al., 2023a,b). During the workshops participants were involved in hands-on exercises and trained with the goal to enable them to autonomously develop and update the exposure layers in future. The specific organization and content of the lectures, the tutorials, the active panel discussions and presentations by local expert speakers, as well as the use of capacity building materials recommended by the World Bank (e.g. on-line course on "Understanding Risk" available at: https://olc.worldbank.org/content/understanding-risk), substantially contributed to the success of the training.

In summary, the objective of the capacity building activities, realized through a series of eight workshops, was to enhance the understanding of the overall approach and methodologies applied for the risk assessment, and their potential applications by key local experts and stakeholders. This was especially relevant for the workshops on exposure mapping, where participants (young professionals in particular) had the opportunity to interact with international and local experts and get timely explanation on state-of-the-art methodologies. We wish the capacity building activities provided them *"food for*

thought" and a view on models and practical tools for risks assessment, namely the basic information and collaborations network that are needed to put the proposed methods into practice, so as all participants may contribute with their specific expertise to disaster risk reduction in Central Asia.

90 **2. Methodology**

2.1 Structure and content of capacity building workshops

To achieve capacity building and training of local experts in DRM in Central Asia region, the following eight Workshops were held (see Table 1 for details):

- Five **Country-based Workshops on Exposure assessment**, one workshop in each of the involved countries:
95   Kazakhstan, Kyrgyz Republic, Tajikistan, Uzbekistan and Turkmenistan. These workshops, which account for the country-specific needs and data availability, had a significant practical training component, involving analysis of selected test cases and hands-on software tutorials. Each workshop included a final panel discussion, focused on challenges and possibilities offered by the proposed methodologies towards building a comprehensive exposure database in the respective countries.

100 - Three regional **Thematic Workshops** on the different components of risk assessment, namely: **Hazard modeling, Vulnerability modeling and Risk assessment**. These methodological workshops introduced participants to the international practice, methodologies and tools implemented for harmonizing risk assessment at the regional scale of Central Asia. The program also included selected contributions from qualified local and national experts, providing state-of-the-art description of existing data and applications in their respective countries. Each workshop
105   comprised focused discussions in order to identify the main issues and challenges encountered by the participants; the workshops on Vulnerability and Risk modeling, in particular, had two panel discussions, one manly focused on available data and their harmonization, and another on implementation of the proposed methodologies.

2.2 Organization of capacity building workshops

110 Workshops lectures and materials, particularly hands-on exercises, were tailored on local communities of scientific and technical experts. Local experts/partners contributed to the discussion of contents and preparation of training materials, which allowed to successfully transfer the knowledge to the participants. All workshops allocated space for questions and interaction with the participants, in order to collect the feedback of the local communities.

In view of the restrictions imposed by the Covid19 emergency, **online organization** of the workshops turned out to be a
115 necessary and valid alternative to in-person workshops. Due to the virtual organization of the activities, the workshops had a longer duration, namely 4 days, half-day only, instead of 2 full days originally planned for in-person workshops. In this way participants were allowed sufficient time to practice independently and interact with lecturers about data (especially during Exposure workshops); this organization also allowed to better deal with the technical difficulties that were faced by some of the participants (e.g., connection problems). The program of all workshops, except for the Turkmenistan country-based
120 workshop, was organized according to a similar structure: specifically, the activities were scheduled over 4 days (from Tuesday to Friday), in the afternoon only (approximately from 14:00 to 18:00 pm, local time), which turned out the most convenient time especially for participants from Ministries and Agencies. The workshop on Exposure assessment in Turkmenistan had a shorter duration (3 days, about 3 hours/day) and simplified agenda, with less exercises/online forms, in order to meet the specific audience and connection resources available in the Country. The online organization mode, in spite
125 of the mentioned (non-critical) technical difficulties and possibly reduced interactions, had the main advantage of significantly increasing the audience of the workshops. In fact, instead of the 40 participants who were originally foreseen for the in-presence workshops, the number of attendees exceeded 100 individuals for the Country-based workshops and 300 individuals for the Thematic workshops.

130 To enhance participation and visibility of the organized workshops, different strategies were adopted. Besides the official invitation letters to Ministries and governmental Agencies, formal invitations were sent to a list of Research Institutes and Universities identified by Local partners in their respective countries. Dedicated web pages for each workshop, including full agenda and registration instructions, were published; all the web pages and application forms were set up and in both English and Russian versions.

Participation was open to scientific/technical experts and practitioners, including research groups, engineers, territorial
135 planners, representatives of the main institutions and facility managers from all Central Asian countries. Participation was allowed by invitation and through an on-line application process. Some restrictions on the number of participants to the Country-based workshops were imposed by the need to create individual accounts for hands-on exercises on exposure assessment. Such restrictions were released for the regional thematic workshops, which allowed removing limitations on the number of participants; this increased significantly the participation, which exceeded 300 individuals from Central Asian
140 countries. Participation in the capacity building workshops of young professionals and students was promoted advertising the workshop among professors and students from relevant university courses, with the assistance of Local Partners.

All workshops were delivered in English and/or Russian, with simultaneous translation between the two **languages**. The associated training materials specifically developed for the Workshops (e.g., presentation slides, lecture notes, forms for hands-on exercises) were also released in Russian and English; the training materials were made available for download to
145 the participants by the end of each Workshop. In addition, existing on-line courses and materials, including those previously developed by the World Bank (https://olc.worldbank.org/content/understanding-risk - also available in both Russian and English language), were suggested to participants to get the basic general background information, and were especially recommended to young professionals and researchers before attending the Workshops. Besides sharing the workshop materials, the lecturers remained available in the aftermath of the training activity, in order to answer questions related to the
150 workshop content and provide support with exercises.

At the end of each Workshop, participants were requested to compile an anonymous questionnaire to gather suggestions for potential improvements. The feedback received via the **Evaluation form** was extremely positive for all workshops, and the received comments and suggestions provided useful indications that were considered when planning the subsequent activities. The evaluation forms included a section devoted to tutorials and hands-on exercises, which also allowed us
155 assessing how many participants were able to follow and carry out practical exercises, and to get some feedback on the comprehension level of the training activities.

Summary participation reports were compiled, to provide an overview of the participation in the Country based and Thematic Workshops, including:

- some general statistics about the participants (e.g., gender, language, specific skills), obtained based on information
160 from Application/Registration forms, as well as a summary of attendance information collected during the Workshop;
- the responses to the Evaluation Form (anonymous online form) that was compiled by the Participants, with their feedback on the Workshop activities, including their comments and suggestions.

An overview of the workshops content is provided in the next section; a summary discussion of the attendance and output of
165 each capacity building activity is provided in the following.

TOPIC	TIME	VENUE	TITLE
Exposure mapping	11-14 May 2021	Almaty Kazakhstan (Online)	Towards a regionally-consistent exposure database for Central Asia: characterizing buildings, crops and infrastructure in Kazakhstan
Exposure mapping	15-18 June 2021	Biškek Kyrgyzstan (Online)	Towards a regionally-consistent exposure database for Central Asia: characterizing buildings, infrastructure and croplands in Kyrgyz Republic
Exposure mapping	27-30 July 2021	Dushanbe Tajikistan (Online)	Towards a regionally-consistent exposure database for Central Asia: characterizing buildings, infrastructure and croplands in Tajikistan
Exposure mapping	19-22 October2021	Tashkent Uzbekistan (Online)	Towards a regionally-consistent exposure database for Central Asia: characterizing buildings, infrastructure and croplands in Uzbekistan
Exposure mapping	1 - 3 December 2021	Ashgabat Turkmenistan (Online)	Towards a regionally-consistent exposure database for Central Asia: characterizing buildings, infrastructure and croplands in Turkmenistan
Hazard Modelling	15-18 January 2022	Almaty Kazakhstan (Online)	Challenges of Multi-Peril Hazard Modeliing at Regional Scale: Assessing Earthquake, Flood and Landslide Hazard in Central Asia
Vulnerability Analysis	22-25 February 2022	Almaty Kazakhstan (Onlline)	Vulnerability modelling for disaster risk assessment at the regional scale: an application in Central Asia
Risk Modelling	26-29 July 2022	Almaty Kazakhstan (Online)	Risk modelling for earthquake and flood disaster mitigation in Central Asia

Table 1. List of capacity building workshops

3. Country-based Workshops on Exposure Mapping

3.1 Country-based workshops description

Five country-based workshops focused on exposure assessment were organized in each of the involved target Countries, namely Kazakhstan, Kyrgyz Republic, Tajikistan, Uzbekistan and Turkmenistan, according to the list provided in Table 1. The workshops aimed to provide the basis towards the development of a regionally consistent exposure database for Central Asia, by means of the characterization of buildings, infrastructure and croplands in the different Countries, taking into account the local needs and available data (Scaini et al., a,b, this volume) .

All five workshops shared a similar structure, with significant time allocated to tutorials and hands-on exercises, as well as with the involvement of Local Expert Speakers, who presented their experience in exposure assessment for different perils in the specific Country. A final panel discussion closed each workshop, focused on the advantages and possible challenges in the application of the methodologies and data presented during the Workshop, towards the development of an up-to-date database of assets for risks assessment in the Country.

The theoretical and methodological framework for developing a regional-scale exposure datasets were introduced (e.g. Pittore et al., 2020; Crowley et al., 2020). The exposure data available for each specific Country were presented to put the basis for the hands-on activities, for which a sample set of already-collected data sources was provided. Participants were trained by tutors, who guided them using provided tools, as well as to prepare the necessary input data for exposure analysis. Case studies were selected amongst the national data available from past studies and projects on exposure assessment at the sub-national (e.g. Bindi et al., 2011), national (ARUP, 2016; Free et al., 2018) and regional scale (Earthquake Model Central

190 Asia project, https://www.emca-gem.org/). Exercises were focused on residential buildings, transportation system and critical infrastructures.

Tutorials and exercises were focused on exposure fundamental topics, including:

- Guidelines for identifying, collecting and managing exposure data, including key attributes required for risk assessment (e.g., construction type and commercial value) collected using specific forms:

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- Access to an online mapping tool (created using Lizmap, https://www.lizmap.com/en/) and familiarization with basic map editing operations;

- Identification and access to online resources (e.g. exposure datasets available at global and regional scale);

- Validation of existing exposure datasets based on additional data (e.g., aerial images) for selected areas.

Hands-on exercises were carried out by making use of a set of specifically developed online forms (on Google platform) and tools (using Lizmap), tailored for exposure data collection in the respective Countries. Exercises were carried out in an

200 interactive mode: after the preliminary explanation, the necessary time was left to participants to fill in the forms, and results could be immediately checked and discussed by the tutors. After the completion of the exercises, a specific time was allocated to question and answer and/or review of the results, in order to interact with the participants, receive feedback and estimate the impact of the training.

These workshops, especially the tutorials and practical exercises, were tailored on participants' scientific and technical

205 expertise. Along with the application forms, in fact, participants were requested to compile a questionnaire, which allowed identifying target groups (e.g., students, experts) and their interests and skills. A message with preliminary technical information, necessary to carry out the hands-on exercises, including credentials to access the used software (i.e., Lizmap) and to links to ad-hoc materials/video tutorials, was delivered to registered participants a few days before the workshop, in order to allow them setting up and testing their computers for the exercises. Additional training materials (e.g., papers and

210 manuals) were provided upon request.

One of the objectives of these country-based workshops was to provide the opportunity to gather missing information and to validate the exposure data layers with local participants, within their respective countries. Methodological and data harmonization was promoted as much as possible between the involved Countries, particularly during panel discussions. Large-scale exposure assessments, in fact, rely on regional scale data sets that must be complemented and validated with

215 local data, which are highly reliable but scarcely available. For this reason, expert knowledge plays a crucial role in order to grasp the characteristics of the assets (e.g., building typologies) and generalize them to a wider territory. Accordingly, cross-checking and validation of large-scale remote sensing data versus national and local data and expert knowledge was one of the relevant activities carried out in the framework of the Exposure workshops. During the hands-on session participants had the possibility to get a deeper insight on both typologies of data, and to appreciate the value of remote sensing data. This

220 eventually may provide the basis for future development of a specialized community of local experts, receptive and capable to exploit the different technologies.

3.2 Country-based workshops participation

The Country-based workshops on Exposure assessment were the first five Capacity Building activities. As they were

225 addressed only to participants from the specific Country, the potential audience was naturally limited, compared to the thematic workshops; nevertheless, the number of registered participants (both applying online or nominated by Ministries) almost always exceeded the expected number of participants (originally limited to 40 individuals in presence, and 60 online). Figure 1 provides a synoptic view of the attendance for the different Exposure Workshops. It is possible to observe that participation increased progressively in the consecutive workshops, except for Turkmenistan (due to the significant technical

230 connection difficulties). Participation was quite stable throughout the four-days of the Workshops, and more than half of the attendees received the certificate (i.e., participated for at least 3 days).
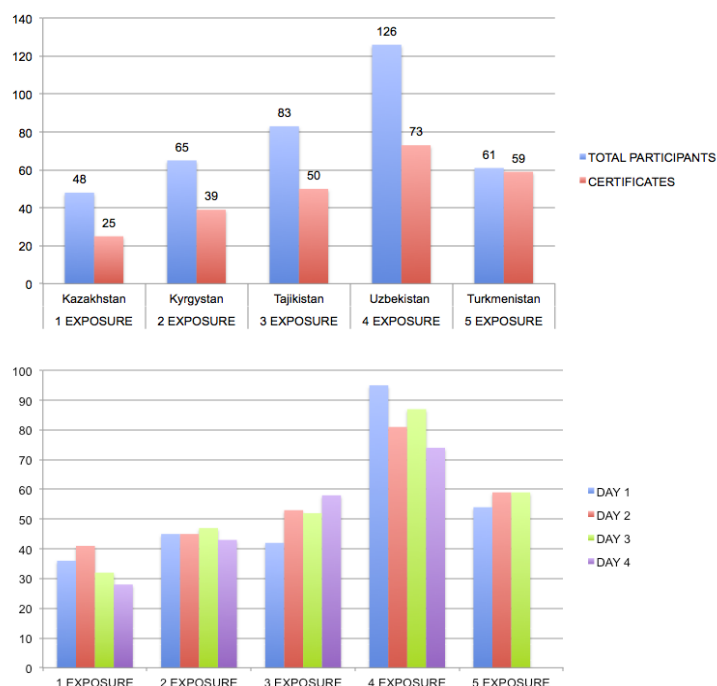
Figure 1. Number of participants in each of the five Country-based workshops on Exposure assessment: 1-Kazhakstan; 2-Kyrgyz Republic; 3-Tajikistan; 4-Uzbekistan; 5- Turkmenistan). Top panel: total number and number of participants with certificate. Bottom panel: daily participation in each workshop.

A statistical overview of the general characteristics of registered participants, both general features (e.g., gender, age, occupation) and specific features relevant to the Workshops (e.g., knowledge of GIS, engineering experience, type of data used) is provided in the following.

The statistics of participants' **gender** (Figure 2a) shows that, even if participation of female was significant, there was a prevalence of male individuals, which could be observed in almost all countries, except Turkmenistan; the unbalance was especially evident in Uzbekistan. Most participants had an **age** below 40 years; while participation was prevalently in the age range 30-40 years in Kazakhstan, Uzbekistan and Turkmenistan, younger individuals with age 20-30 years prevailed in Tajikistan and Kyrgyz Republic (Figure 2b).

The participation of **students** was quite comparable in the different countries, although the proportion of students was rather low in Turkmenistan (Figure 3a). The knowledge of **English language** turned out to be comparatively high in Kazakhstan, and low in Turkmenistan. In all countries most of the participants understand English, at least in written form; still, a quite significant portion (about 20-30%) of the participants declared that they do not understand English (Figure 3b).

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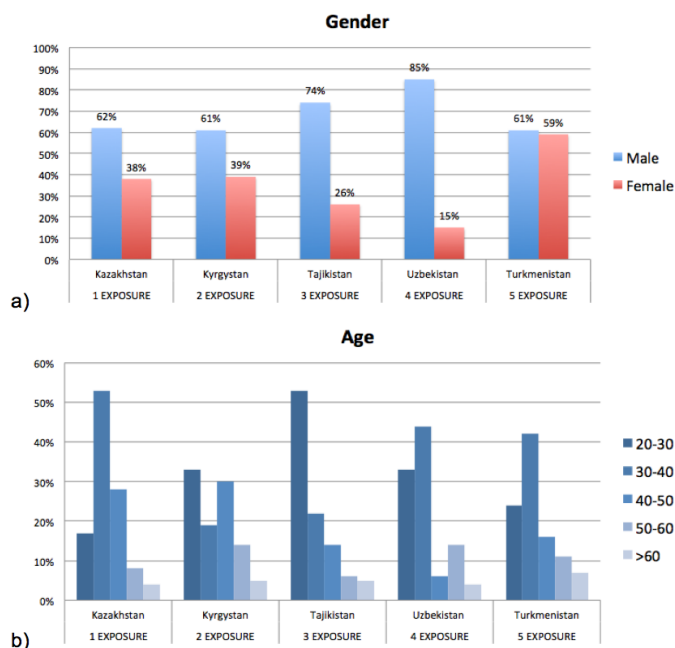
255 Figure 2. Distribution of participants versus: a) Gender and b) Age for each of the five Country-based workshops on Exposure assessment.
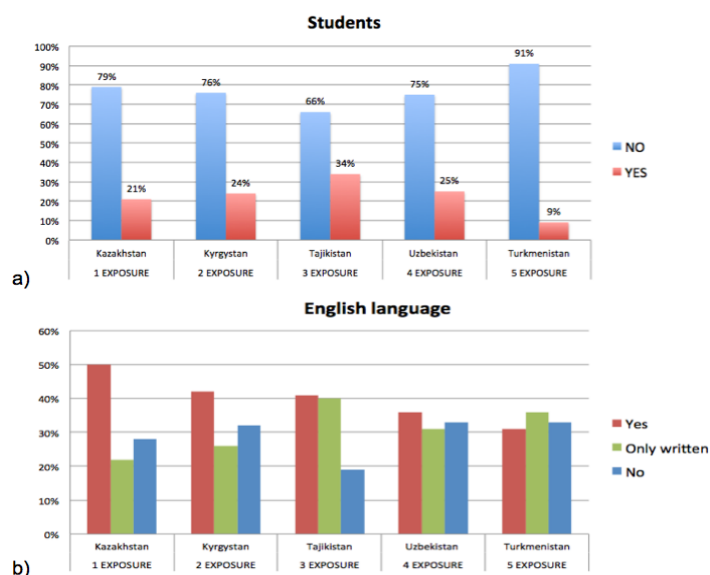
260 Figure 3. a) Percentage of students and b) knowledge of English language for the participants of the five Country-based workshops on Exposure assessment.

In all country-based workshops most participants were from Academy and Research institutes; involvement of professionals was also remarkable (about 15-20%) in most of the countries. In Kazakhstan, Turkmenistan there was a significant

265 participation of representatives from Ministries (Figure 4a). The analysis of the type of data used by participants, revealed quite a heterogeneous situation in the different countries, with the majority of participants declaring use of different sets of

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data (i.e., Other data). Similarly to Uzbekistan, most of the participants in Turkmenistan were familiar with Building stock and Infrastructure data, whereas in Tajikistan and Kyrgyz Republic they were more familiar with Land use and Croplands data (Figure 4b).

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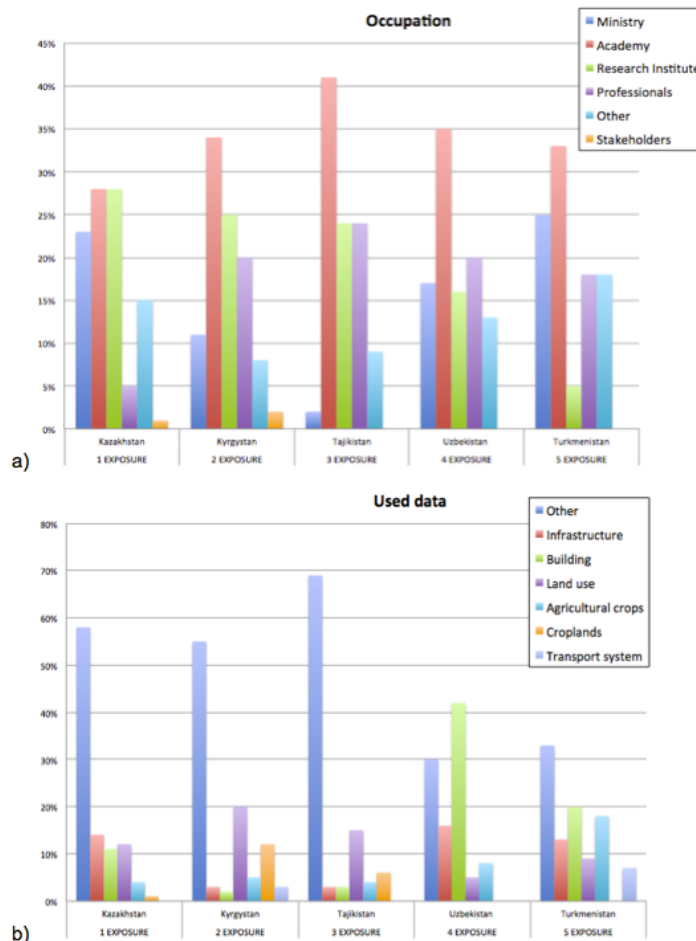
Figure 4. Participants a) occupation and b) used data in the five Country-based workshops on Exposure assessment.

The **engineering expertise** declared by participants (i.e., knowledge of buildings and infrastructure typologies and their

275 features) was fairly good, ranging from intermediate to high, with about 70% of individuals with expertise equal or above the average level (Figure 5b). A rather different situation was observed in Kazakhstan, where the percentage of involved professionals was much (Figure 4a). The declared **knowledge of GIS** (Geographic Information System), instead, tended to be intermediate or low (Figure 5a); the declared expertise with GIS also turned out lower in Kazakhstan, compared to the other countries.

280 The experience in collecting and handling national-scale ground base data, such as population or agricultural census data, is fairly good; in almost all countries the majority of participants declared an experience equal or better than average (Figure 6a). The situation with remote sensing data is quite similar, though with a larger percentage of individuals declaring no expertise with such data (Figure 6b).
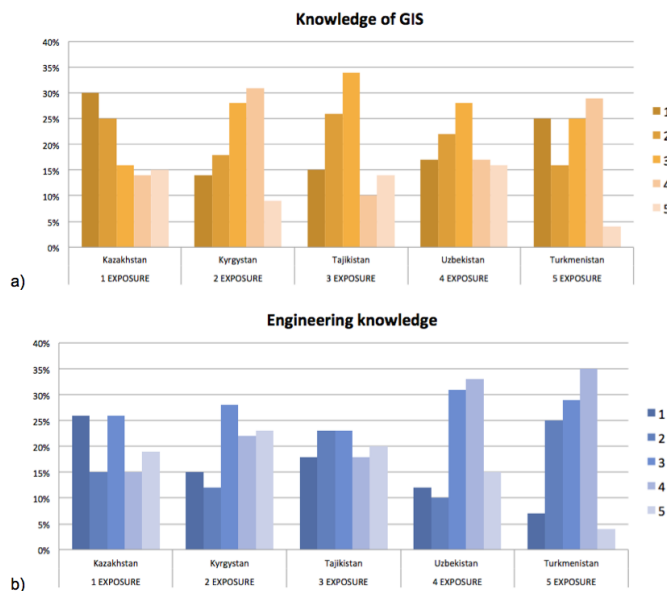
Figure 5. a) GIS knowledge (1=Never used 5=Expert user) and b) Engineering knowledge (1=No experience 5=Major experience) declared by the participants of the five Country-based workshops on Exposure assessment.

Figure 6. Experience in collecting and handling: a) national-scale ground base data (1=No experience 5=Major experience) and b) remote sensing data (1=No experience 5=Major experience) declared by the participants of the five Country-based workshops on Exposure assessment.

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4. Thematic workshops

The structure and duration of the Thematic workshops was similar to that of Country-based Exposure workshops (four days, half-day only); however, a larger number of presentations by Local Experts was allowed, in order to provide an overview of past experience with different risks in the five countries of Central Asia. Moreover, two panel discussions, involving

300 Directors and Expert Speakers, were organized in the framework of the Vulnerability and Risk workshops, to discuss the newly presented methodologies and their implementation in view of the current regulations in Central Asian countries. A session on Disaster Risk Financing (DRF) was also organized by World Bank experts in the framework of the workshop on Risk assessment, to create a bridge towards future practical actions for risk mitigation in Central Asia. A summary description of the content of each Thematic Workshop and of related participation is provided in the next sections.

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4.1 Thematic workshop on Hazard Modelling

Title: "*Challenges of Multi-Peril Hazard Modelling at Regional Scale: Assessing Earthquake, Flood and Landslide Hazard in Central Asia*"

Description: Hazard is one of the components of risk assessment and usually represented by the intensity and frequency of

310 the hazardous events (e.g., earthquake, floods, landslides) that might affect a certain region. Hazard assessment aims at estimating the characteristics of such future events through the analysis of historical data and the development of mathematical models to complement the limited information given by direct observations. Hazard assessment techniques are different for each peril and for the different spatial scales of application, which are set depending on the objective of the analysis.

315 This workshop covered the different models and methodologies adopted for regional-scale seismic (Field et al. 2003; Pagani et al., 2014), flood (Ciarapica and Todini, 2002; Dottori and Todini, 2011) and landslide (Catani et al., 2013; Wichmann, 2017) hazard assessment, underlining the importance of merging information from global and local datasets, results from past existing studies and newly developed techniques. Examples of past hazard assessment in the region and/or at global scale were also taken into account (e.g. Plekhanov and Medeu, 2019; Ward et al., 2013 for floods; Abdullabekov et al., 2012;

320 Ischuk et al., 2018; Silacheva et al., 2018 for earthquakes; Strom et al., 2017; Havenith eta l., 2015a,b for landslides) . Large-scale risk assessment, in fact, relies on the use of regional scale models and data sets (e.g., earthquake catalogues for seismic analysis, river flow, precipitation and temperature records for flood hazard, landslide inventories for landslide analysis) that must be complemented and validated with local data, which are conversely often available only for limited areas.

Practical examples were provided to illustrate the methodology for earthquake, flood and landslides hazard assessment, with

325 a focus on the hazard models developed within the SFRARR project. The exercises were focused on the following fundamental topics:

- Guidelines for collecting and managing regional hazard data, including input required to hazard modeling and data potentially suitable for validation;
- Access to software and familiarization with basic processing tools;
330 - Access to online resources;
- Preparation of the necessary input files for the subsequent hazard modeling starting from sample data;
- Visualization and interpretation of hazard calculation output;
- Validation of the current datasets based on additional data;

A brief panel discussion, involving Directors and Local Speakers, closed each day of the Workshop, providing an

335 opportunity to discuss the presented methodologies towards up-to-date hazards assessment for seismic, flood and landslide risk mitigation in Central Asia (Poggi et al., a,b; Rosi et al., 2023).

4.2 Thematic Workshop on Vulnerability Analysis

340 **Title:** *"Vulnerability modelling for disaster risk assessment at the regional scale: an application in Central Asia"*

Description: Reliable risk assessment depends on the adequate quantification of vulnerability, which estimates how prone assets are to suffer certain levels of damage in case of natural disasters. Vulnerability can be assessed through the analysis of historical damage/loss data or, alternatively, the development of analytical models to complement the limited information given by direct observations. Vulnerability assessment techniques are different for each peril and exposed asset type, and for

345 the different spatial scales of application.

This workshop provided an overview on the methodologies available and those adopted within the development of regional-scale earthquake (World Bank, 2010; World Bank, 2020; Reinoso et al., 2017) and flood (Kok et al., 2004; Dottori et al., 2016; Huizinga et al., 2017) vulnerability assessment. Practical examples were provided to guide the audience through the development and application of regional scale vulnerability models, with a focus on models developed within the SFRARR

350 program in Central Asia (Salgado-Gálvez et al., in review). The lectures covered the following theoretical and methodological topics:

- Methodologies for the development of regional earthquake vulnerability models;
- Methodologies for the development of regional flood vulnerability models;
- Development of seismic vulnerability curves for Central Asia: methodology and results;

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- Development of flood vulnerability curves for Central Asia: methodology and results;
- Component-based flood vulnerability of residential buildings: a step-by-step overview of the INSYDE methodology;
- Methodologies to derive earthquake vulnerability models: practical applications;
- Use of the vulnerability curves to compute losses caused by a seismic event and a flood event.

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4.3 Thematic Workshop on Risk Modelling

Title: *"Risk modelling for earthquake and flood disaster mitigation in Central Asia"*

Description: The Thematic Workshop on Risk modelling in Central Asia aimed at providing participants an overview of the methodologies that can be applied to produce regionally consistent risk estimates (Cardona et al., 2010, 2012b). The

365 workshop benefited, in particular, from the main findings, data and results gathered at each country's level during Exposure workshops. Moreover, it built on theoretical background provided during Hazard and Vulnerability workshops, in order to provide a general view of the most important aspects of risk assessment from the regional point of view of Central Asia.

Participants were demonstrated the approach followed for risk assessment and loss estimation and got familiar with several risk metrics. Examples of loss calculation and risk model calibration/validation were provided, as well as recommendations

370 on how to use loss estimates in the framework of Disaster Risk Management strategies. The lectures and tutorials covered the following general topics:

- Review of the components of risk assessment (hazard, exposure and vulnerability);
- What is Probabilistic Risk Assessment?
- Probabilistic and deterministic scenarios;

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- Common outputs of risk modelling (metrics and meaning);
- Examples of risk results;
- Applications of probabilistic risk assessment;
- General overview of the CAPRA platform (www.ecapra.org);
- Sections and components of the CAPRA platform;

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- Outputs and results;
- Hands-on session on deterministic risk assessment;

- Hands-on session on probabilistic risk assessment.

The workshop included a session on Disaster Risk Financing (organised by World Bank) and ended up with a Round Table with the participants, where suggestions about how to introduce the results of the regional-scale risk assessment developed

385 within the SFRARR program (Salgado-Gálvez et al., in review; Berny et al., in review) in the countries standard practices, accounting for local regulations and procedure, could be discussed.

4.4 Thematic workshops participation

The Thematic workshops on Hazard, Vulnerability and Risk assessment were the last three Capacity Building activities

390 carried out. As they were addressed participants from all five Central Asian countries, the potential audience was much broader, compared to the country-based workshops. Moreover, the activities carried out during the hands-on exercises did not impose any limit to the number of participants (e.g., number of specific software accounts), therefore it was not necessary to limit a priori the number of participants. As a result, the actual number of individuals attending the workshops, including those registered online or nominated by Ministries, was several times larger than the originally expected number of

395 participants, and it exceeded 300 attendees in the last workshop. Following World Bank indications, participation was checked twice per day (before and after the break), including both registered individuals, as well as additional non-registered participants. As for the country-based workshops, a significant number of non-registered participants attended the workshops; several participants also joined in groups, using their institutional account, which further complicated checking attendance. Anyway, only participants who attended at least 3 days out of 4 total days of the Workshop were entitled to

400 receive the Attendance Certificate.

Figure 7 and Figure 8 provide a synoptic view of the attendance for the three Thematic Workshops. It is possible to observe that participation was remarkable for all events, with a maximum attendance in the last workshop on Risk assessment (Figure 7a). Participation was pretty stable throughout the four-days of the Workshops: in all cases more than half of the attendees were entitled to get the certificate (i.e., participated for at least 3 days). Variability was larger during the Risk

405 workshop; as a result, the number of issued certificates was comparable to that of earlier Thematic workshops, in spite of the larger number of participants. Figure 8 shows that large part of the individuals attending the workshops was from Uzbekistan, followed by Kazakhstan; in both these countries, besides the received online applications, there was also a significant number of nominated participants from Ministries and Agencies. In Turkmenistan the majority of participants were nominated ones, with a limited number of online applications.

410 A statistical overview of the general characteristics of registered participants, both general features (e.g., country, gender, age, occupation) and specific features relevant to the Workshops (e.g., knowledge of GIS, engineering experience) is provided below.
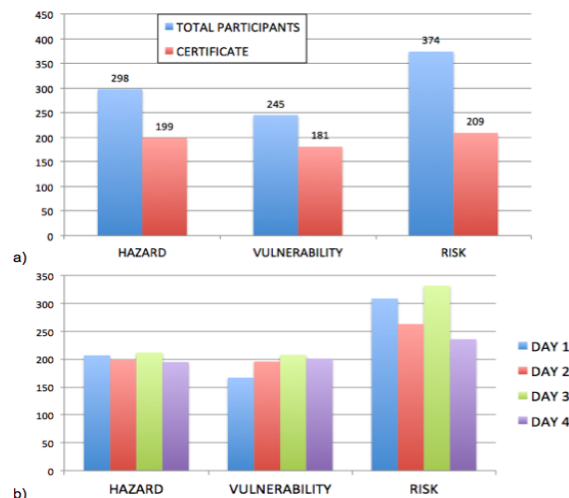
Figure 7. Number of participants in each of the three Thematic workshops on Hazard, Vulnerability and Risk assessment: a) total number and number of participants with certificate; b) daily participation in each workshop.
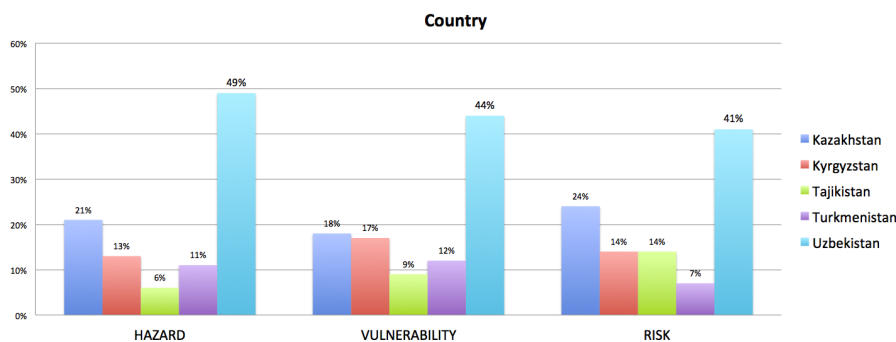

Figure 8. Distribution vs. Country of participants attending the Thematic workshops.

The situation with participants' **gender** (Figure 9a) was very similar for all workshops: even if participation of female individuals was significant (35% on average), there was a prevalence of male individuals. The majority of participants had an **age** below 40 years; while participation was prevalently in the age range 30-40 years for the three workshops, a larger percentage of senior participants was observed in the Risk workshop (Figure 9b). The knowledge of **English language** was very similar for all workshops: about 40% of the participants understand English (both spoken and written), about 35% only in written form, while about 25% of the participants declared that they do not understand English at all.

The participation of **students** was rather different in the three workshops (Figure 10a); the proportion of students was very high in the Hazard workshop, possibly due to the larger involvement of participants from Academy and Research institutes, while it was quite low in the Risk workshop, where there participation of representatives from Ministries and Professionals was prevalent. Involvement of Professionals and Ministries was remarkable in Vulnerability and Risk workshops (Figure 10b).

14

a)

b)
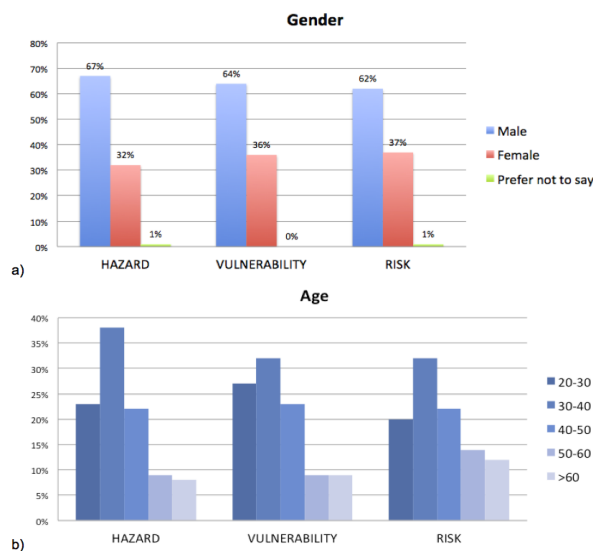
435   **Figure 9. Distribution of participants versus: a) Gender and b) Age for each of the three Thematic workshops.**
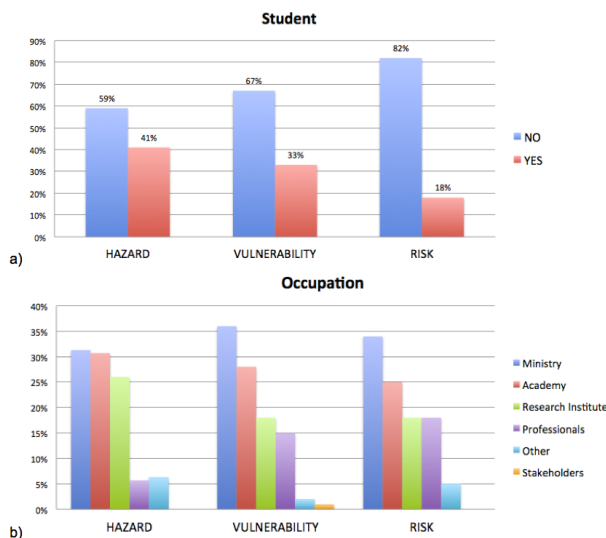

a)

b)

Figure 10. Percentage of students (a) and occupation (b) of the participants for each of the Thematic workshops.

440   The **risk type** with which participants were most familiar was Earthquake risk, eventually combined with Floods; several
participants declared expertise with different kind of risks. The **knowledge of GIS** (Geographic Information System)
declared by participants was mostly an intermediate one, with a moderate prevalence of individuals with expertise equal or
above the average level (Figure 11a). The **engineering expertise** (i.e., knowledge of buildings and infrastructure typologies
and their features) is more heterogeneous, with a non-negligible part of individuals declaring no engineering knowledge in
445   Hazard and Vulnerability workshops (Figure 11b). The experience in collecting and handling national-scale ground base data
is good, as in all workshops the majority of participants had an experience above or equal than average (Figure 12a). The
situation with remote sensing data, instead, displays a larger percentage of individuals declaring no expertise with such data,
especially in Hazard and Risk workshops (Figure 12b).

15
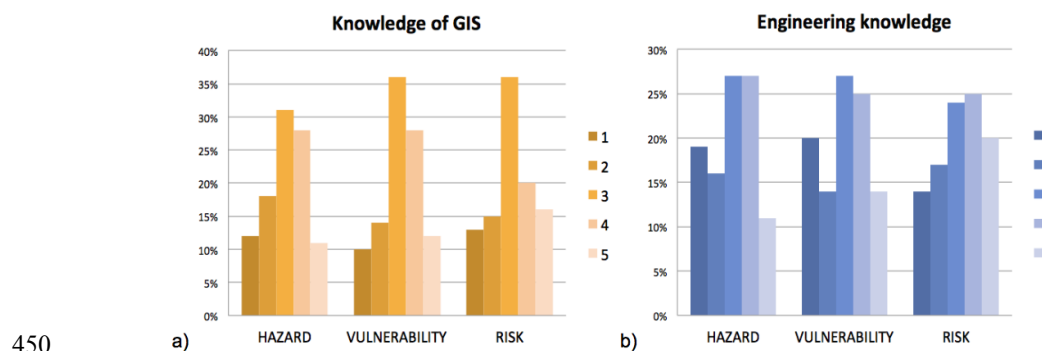
Figure 11. a) GIS knowledge (1=Never used 5=Expert user) and b) Engineering knowledge (1=No experience 5=Major experience) declared by the participants of the Thematic workshops.
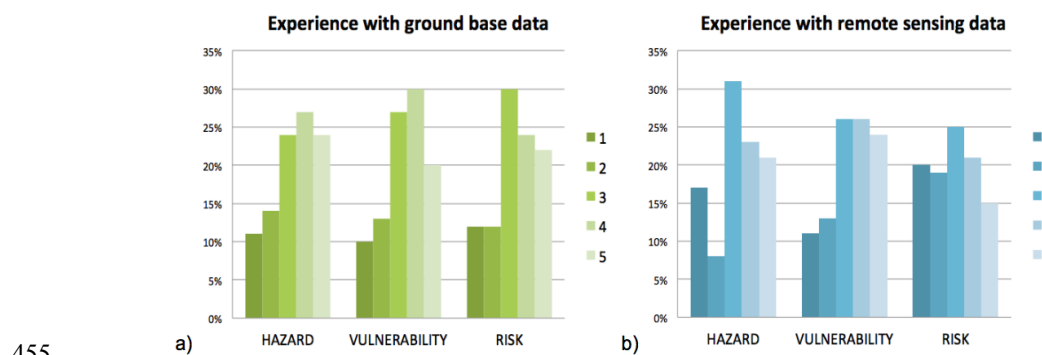
Figure 12. Experience in collecting and handling: a) national-scale ground base data (1=No experience 5=Major experience) and b) remote sensing data (1=No experience 5=Major experience) declared by the participants of the Thematic workshops.

5. Feedback from workshop participants

At the end of each capacity building workshop, the participants were requested to compile an anonymous evaluation form, so as to assess the effectiveness of the training and to gather suggestions on how to improve the future training. The feedback, received both through the anonymous evaluation forms and via email, was especially positive and encouraging, indicating that the topics covered by the workshops were relevant to their current work and that participants are likely to use the presented tools and data in their future activities. The evaluation forms also included a section devoted to tutorials and hands-on exercises, which allowed assessing how many participants were able to follow and carry out practical exercises (duly taking into account the possible technical difficulties with connection and used platforms), and to get some feedback on the comprehension level of the training activities.

The questionnaire was set up on Google Forms and was composed of three sections. The first two sections included a set of 18 close-ended questions (where respondents had to choose from a set of pre-defined responses), aimed at assessing the quality and organization of the lectures and of the practical exercises, respectively. The last section aimed at collecting suggestions and comments about the workshop from the participants, in the form of free text. A fairly large number of participants provided their response: on average, feedback was received from about 45% of the attendees, with a maximum of 135 filled forms collected for the Risk workshop. All the received comments were shared and discussed with the World Bank, providing useful indications that were considered when planning the next activities. A summary description of the feedback from participants of the Country-based and Thematic workshops, is provided in the following.
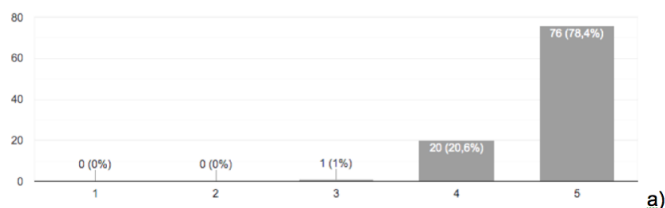
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480   *5.1 Organization and relevance of the lectures*

The first section of the questionnaire was devoted to the quality and organization of the lectures, and consisted of the following set of closed-ended questions, with an answer in the range from 1 to 5 (1=Poor, 5=Very good):

    1.1   How useful do you think the workshop was?

    1.2   How was the topic of the workshop covered?

485   1.3   What was your impression on the content of the workshop?

    1.4   How was the workshop structured?

    1.5   Was the workshop pitched at the right level?

    1.6   How was the lecture material prepared?

    1.7   Which part of the workshop activities would you expand?

490   1.8   Which part of the workshop activities would you reduce?

    1.9   How relevant was the workshop to your current work/research activity?

    1.10   How likely will you use the presented methods and tools in your work/research activity?

    1.11   How likely will you use the presented data sources in your current activity?

    1.12   How likely would you attend an advanced workshop on similar topics?

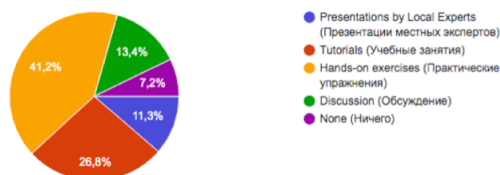495   Examples of the received feedback are provided hereinafter.

Figure 13. Examples of feedback provided by participants to: a) question 1.1 and b) question 1.7 of the Hazard workshop.
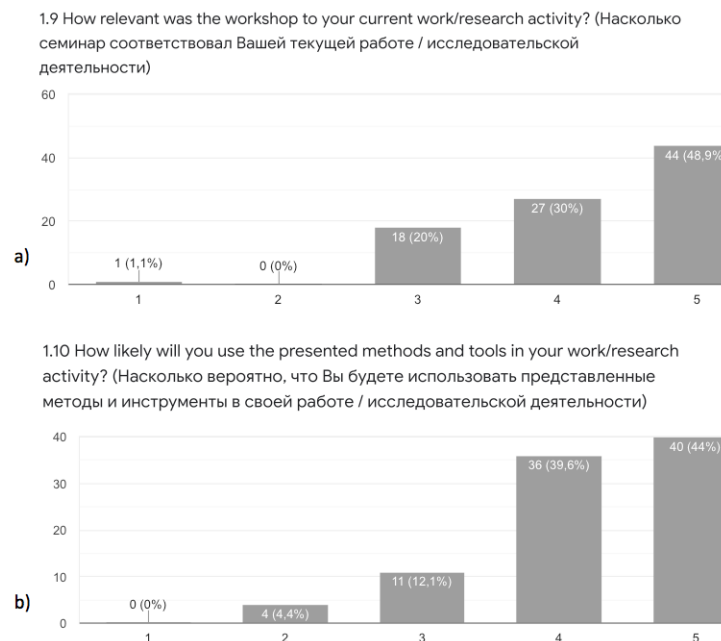
500

Figure 14. Examples of feedback provided by participants to: a) question 1.9 and b) question 1.10 of the Vulnerability workshop.

505 In almost all workshops, the large majority (i.e. 80% or more) of the answers to the questions 1.1 - 1.6 were very positive, namely 4 or 5 (i.e. Good or Very good), as shown in Figure 13a. Regarding the part of the activities to be expanded (question 1.7), the most frequent one was hands-on exercises, while in general none of the activities should be reduced (1.8), as shown in Figure 13b.

The response to the questions on the relevance of the workshops to the participants' current work or research (question 1.9), 510 as well as those on the possible future use of the presented methods and data (questions 1.10 and 1.11), evidenced the good/high relevance of the training in their future activities (see Figure 14 for an example). The interest of participants is confirmed by the responses to the question 1.12, where the large majority (more than 80%) of the participants indicated that they are likely/very likely to attend an advanced workshop on similar topics.

515 *5.2 Practical exercises*

The second section of the questionnaire refers to the hands-on exercises; it consisted of the following six closed-ended questions, with allowed answers in the range from 1 to 5 (1=Poor, 5=Very good):
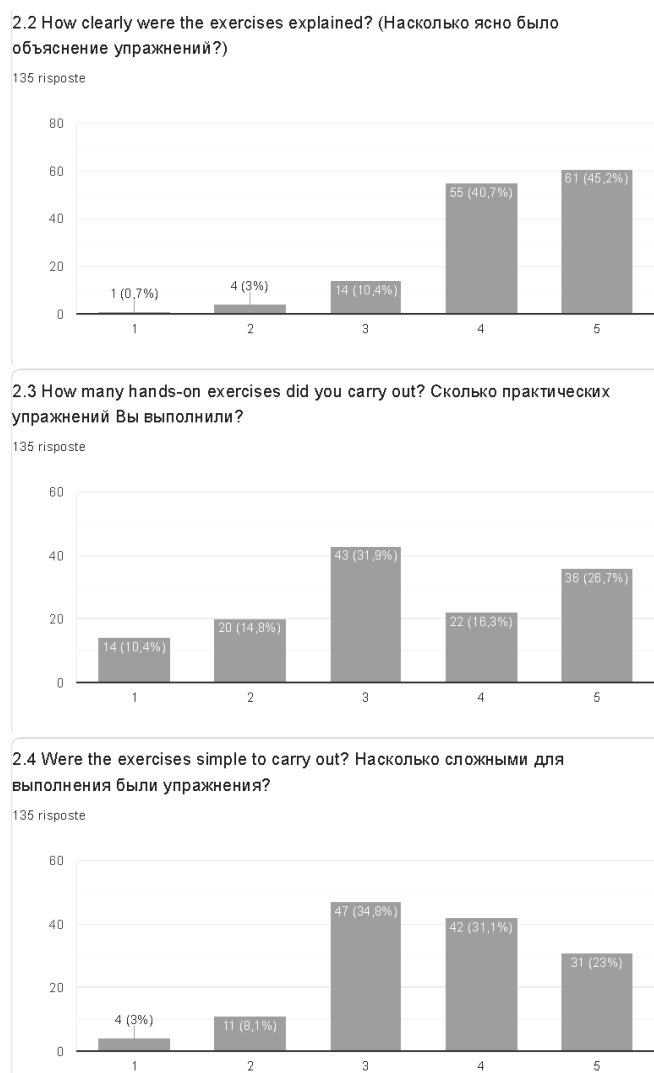
2.1 How was the quantity of practical exercises?

2.2 How clearly were the exercises explained?

520 2.3 How many hands-on exercises did you carry out?

2.4 Were the exercises simple to carry out?

2.5 Were the support and answers from the lecturers sufficient?

2.6 Have you got any technical difficulties to carry out the exercises?

An example of the received feedback for questions 2.2-2.4 is provided in Figure 15; the full set of collected responses is 525 available in Annex 3.

Although the answers in this section displayed certain variability amongst the different workshops, still the feedback was very satisfactory. In fact, most of the participants considered the quantity of practical exercises fairly good (question 2.1) and

well explained (question 2.2; e.g., Figure 15 top panel). During the workshops, particularly the Exposure ones, most of the participants were able to carry out a rather good number of hands-on exercises (see question 2.3 in figure 44; 1 stands for no exercise done, while 5 stands for all exercises done), despite the technical difficulties with the connection and with the Google forms that were faced in some countries (question 2.6).

The attendees found the exercises moderately simple to carry out, with a score prevalently in the range from 3 to 5 (question 2.4; Figure 15 bottom panel), thanks also to the support from the lecturers, which was considered pretty good (question 2.5).

Figure 15. Examples of feedback provided by participants of the Risk workshop to the questions related with hands-on exercises, namely: 2.2 Clarity of explanations (1 = Poorly; 5 = Skillfully), 2.3 Number of exercises carried out (1 = None; 5 = All exercises) and 2.4 Difficulty (1 = Too difficult; 5 = Adequate)

5.3 Comments by the participants

In addition to the feedback based on closed-ended questions discussed above, several participants also provided their free
545   comments, both through the online form and via email.

The received comments highlight the relevance of the training, which was considered useful for the attendees in their
practical work, especially for young scientists. Training sessions were found productive, as they allowed sharing
experiences, data and useful links. Though the large majority of comments were very positive, still a few of them evidenced
some difficulties in carrying out practical exercises and suggested extending the allocated time, as well as sharing manuals
550   and video tutorials, possibly in advance of the workshop.

Several comments also pointed to the need for follow-up workshops, to be organized more frequently and/or on a regular
basis, especially practical training on tools and software. Finally, some participants would have preferred if the workshops
were held in person, rather than online; this option was discussed during the training activities organisation and was found
not viable, due to the continued Covid-19 pandemic. At the same time, the online organization allowed broadening
555   significantly the participation in the capacity building workshops and facilitated attendance from the different countries of
Central Asia

6. Discussion and conclusions

The capacity building activity carried out in Central Asia involved more than 1000 participants from the Central Asia
560   countries (Fig. 1, 8) into country-based or thematic workshops. Participants belong to different age and gender groups (Fig.
2, 9) and have different expertise (Fig. 3, 4, 5 ,6 , 7 and 10, 11, 12, respectively for country-based and thematic workshops).
The collected feedback was overall very positive (Fig. 13, 14, 15) and contributed to identifying potential improvements for
future activities of this kind. However, in order to assess and monitor the long-term impact of capacity building in the region,
it would be recommended to organize periodic activities taking advantage of the insights provided here.

565   All workshops (country-based and thematic) accommodated a panel discussion in which participants could express their
thoughts and outlook on the topic at stake. The discussions highlighted challenges and priorities to improve regional-scale
disaster risk reduction (Table 2). Such challenges are common across the disaster risk reduction related topics analyzed in
the project (namely, exposure, hazard, vulnerability and risk) and underline the central role of both emergency procedures
and long-term strategies related to governance. The importance of training and capacity building targeted to different
570   communities was also pointed out and envisaged for the future (e.g. develop specific training programs for students,
specialists and policymakers).

During the country-based exposure workshop, additional information was provided, such as the identification of building
typologies potentially deprecated, and the potential of systematic building seismic classification, already being developed in
some Central Asia countries. Such information was used to develop the regional scale buildings exposure model (Scaini et
575   al., 2023a,b). The involvement of construction stakeholders was also underlined as a potential good practice to reduce
exposure and vulnerability.

The information and insights collected during the workshop (e.g. Table 2) supported the regional-scale risk assessment
performed during the SFRARR program, and can potentially support further DRR efforts in the region.

General challenges	Specific challenges
Data challenges	Data availability
	Data fragmentation
	Data usability
	Data sharing
	Data validation
	Update of hazard, exposure, vulnerability and risk models
Capacity building challenges	Need to clarify risk-related definitions
	Identify strategies to foster local participation
	Increase knowledge and skills in countries, so far are concentrated among few experts
Scientific challenges	Identify common exposure (and risk) assessment methodology
	Explore relationship between exposure and vulnerability
	Use of new technologies (drones, machine learning, ...)
	Fragmentation of scientific institutions
	Systematic update of hazard, exposure, vulnerability and risk models
Emergency management	Coordination and cross-boundary operations
	Need of monitoring systems and early warning
	Need for drills and exercises to raise risk awareness
	Prioritization of interventions
Risk governance	Communication with ministries
	Economic issue and lack of financial resources
	Need to harmonize legal framework
	Need to harmonize data and knowledge management (including maintenance) across boundaries
	Lack of political will to harmonize risk-related data, knowledge and legal framework

580

Table 2. Challenges related to disaster risk reduction identified and mentioned during the country-based and thematic workshops.

The panel discussions allowed identifying the main challenges related to data, scientific knowledge, capacity building activities, emergency management and risk governance. Based on this experience, we identify the following recommendations for future capacity building activities in the region:

- The definition of capacity building activities should involve local participants as much as possible, including heterogeneous groups also through invited talks and panel discussions. This increases the attendance, but also the impact of the activity. Academics can develop a shared knowledge base and discuss further developments, experts and stakeholders can identify the best practices and promote their implementation, and young professionals can receive specific training and prepare to join the experts community.

- Capacity building activities should rely on data related to the local context. In this sense, during the activity it is recommended to collect, share and manage both data and knowledge and devote additional efforts to cross-validate country-based experiences within a regional-scale working group. This process is paramount both to increase awareness of the existing knowledge in local participants and to develop regional-scale DRR strategies, which are strongly needed at both short and long-term.

- During the capacity building activity, it is important to devote additional effort into organizing practical activities such as exercises, circumventing the limitations due to remote attendance, in order to involve participants in an interactive way. A hybrid mode can also be envisaged in case of technical difficulties (e.g. lack of internet access).

600   •   Language barriers should be crossed by including, as much as possible, an online translation system (e.g. synchronous translation). Language issues can also arise in case datasets, documents or other knowledge types are developed in only one language.

•   Some topics (e.g. exposure) can be approached with country-based workshops that allow grasping the specific challenges of each country and identifying the points of contact and the possible synergies. Exposure is intrinsically

605   linked to multiple risks, and offers the possibility to tackle emerging issues (e.g. heat waves, water use and drought) or issues that are specific to a single country.

Such remarks are developed based on the capacity building activities developed within the SFRARR program for Central Asia, but provide insights for similar activities to be carried out in other disaster-prone areas at the regional or sub-regional scale. However, future capacity building activities should be carefully pondered to account for the local context and its

610   specific needs and requirements, in order to guarantee its effectiveness.

7. Acknowledgements

Data availability

The technical reports produced during the SFRARR program, containing detailed information on the organization of each

630   workshop, are available upon request to the corresponding author.

Author Contributions

AP conceptualized the research and AP, PC, ST developed the capacity building methodology. AP, CS, PC, ST defined the workshop content. AP analyzed the results of the capacity building activity and prepared the manuscript with contributions from all co-authors.

635   ### Competing interests

The authors declare that they have no conflict of interest.

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