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Exploring community-level landslide risk reduction strategies in the Global South

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BRITISH GEOLOGICAL SURVEY

MULTI-HAZARDS AND RISK (MHR) CHALLENGE AREA PROGRAMME
INTERNAL REPORT OR/22/078

Exploring community-level landslide risk reduction strategies in the Global South

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Summary

The aim of this report is to provide insight into community-based methods, approaches, and actions for reducing risk to landslides. More specifically, it presents a broad overview of recent studies on landslide risk reduction at community level, exploring the various landslide risk reduction measures recommended and/or implemented, and discusses the challenges and opportunities for the implementation of these measures.

The report draws on a wide range of applications investigating distinct case studies in different areas around the Globe, as well as more general studies on equitable resilience (how communities are really engaged) and landslide risk management within the context of Disaster Risk Reduction (DRR) in the Global South's vulnerable communities. The documented strategies are analysed from the perspectives of scale of intervention, their timing and sustainability, and the resources required for their implementation.

The review suggests that there is no *one-size fits all* solution for community-based landslide risk reduction. The integration of local knowledge into landslide risk reduction practices is context-specific and varies both in relation to the time of implementation (ex-ante or ex-post disaster) and historically, due to the dynamic nature of communities' structure and functioning. Its contribution to resilience (including coping and adaptation capacity) depends on the interaction with other types of knowledge (e.g., science based) and the general institutional setting (legal and governmental framework). Moreover, the scale of organisation and action, from individual to household and community level, influences the impact and long-term sustainability of mitigation measures. Nevertheless, overcoming barriers of knowledge, trusts, resources, and power at local level could enhance co-development and collaboration between communities and governmental and non-governmental organisation, communities

Landslide risk reduction cannot be addressed in isolation. Whilst our research focused on a single hazard approach, some DRR measures are shared across hazards, suggesting there is scope for cross-fertilisation and learning between communities affected by different hazards (e.g., volcanic, flooding, mass-movements, etc.). Indeed, this would prompt all actors involved to change their perspective and management of risk towards a systemic, integrated, holistic approach, as they work together to build greater resilience to likely future disasters.

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This desk-based study has been supported by the 'Understanding Risks and Building Enhanced Capabilities in Latin American cities' (URBE Latam) project, led by Professor João Porto de Albuquerque at the University of Glasgow. The project was funded through a UKRI (ESRC) Collective Fund award (ES/T003294/1) and ran between 2019 - 2023.

1 Introduction

1.1 BACKGROUND

Landslides are a geological hazard, which can pose a serious threat to lives and livelihoods particularly in hilly or mountainous regions around the world (Gariano and Guzzetti, 2016, Petley et al. 2005, Petley 2012). Climate change, the increased susceptibility of slopes to instability due to anthropogenic activities, growing urbanisation, uncontrolled land use and the increased vulnerability of populations and infrastructure are recognised as contributing factors which can increase landslide risk (Casagli et al., 2017).

Evaluations of landslide risk traditionally assess the "expected degree of loss due to a landslide (specific risk) and the expected number of lives lost, people injured, damage to property and disruption of economic activity (total risk)" (Varnes et al., 1984). As such, landslide risk can be mitigated either by reducing the probability of the hazard and vulnerability of exposed communities, or by increasing their coping capacity and resilience. Landslides are ubiquitous hazards in environments where destabilising forces exceed the strength of the earth materials that compose the slope, but their occurrence is increasingly linked with human activities such as construction, illegal mining and hill cutting (Froude and Petley, 2018).

In the context of marginalised communities, landslide risk may be exacerbated by, but not limited to:

- the rising occupation of marginal land for construction activities (most unplanned settlements are often found on such steeper, marginal, slopes and so intrinsically there is already a high susceptibility of slope instability) (Anderson and Holcombe, 2005);
- lack of protection and mitigation measures in areas exposed to landslide risk, with investments in Disaster Risk Reduction (DRR) measures being often directed toward relatively wealthier areas at the expense of the poorer neighbourhoods (Hallegatte et al., 2020);
- relatively low institutional strength and risk management policies favouring the protection of higher-value assets associated with more prosperous communities rather than those with the least adaptive capacities (Hallegatte et al., 2020);
- underestimation of the impact of landslide events, particularly those of frequent, small- and medium-scale as opposed to larger but less frequent ones (i.e., cumulative effects) due to (Holmes, 2009):
    - underreporting such as when a landslide is reported as an impact of a triggering event e.g. a hurricane
    - lack of appropriate policy response
    - the inability of traditional metrics (i.e., the repair or replacement value of damaged or destroyed assets) to appropriately measure the severity of disasters for the most disadvantaged communities who have few (or less expensive) assets to lose but whose socio-economic resilience and well-being is nevertheless affected.

Policymakers, practitioners and interdisciplinary researchers increasingly recognise the interconnections between climate change adaptation, Disaster Risk Management (DRM), and sustainable development (Mochizuki et al. 2018). The concept of resilience i.e. "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks" (Folke et al. 2005) or the 'capacity of disaster-affected communities to 'bounce back" (Manyena, 2006), has gained traction in international and national policy fields (Matin et al. 2018, Cutter, 2016). However, Mochizuki et al. (2018) highlight that there have been few attempts to clarify the conceptual relationship between risk (and its underpinning drivers of hazard, exposure and vulnerability) and resilience, highlighting this as "surprising given that resilience is a concept closely related to shocks, and the potential thereof (that is, risk)". They conclude that disaster resilience should not be measured separately from the drivers of risk a system faces.

1.2 LANDSLIDE RISK MANAGEMENT: TOP-DOWN VERSUS BOTTOM-UP APPROACHES

Landslide risk mitigation is an integral part of the landslide risk management process, and contingent on the outcomes of the landslide risk assessment. If the risk is tolerable or acceptable, no mitigation options need to be considered; if the risk is intolerable, risk mitigation options are considered and implemented, followed by monitoring and review of the results achieved (Fell et al., 2005).

Understanding landslide risk and strengthening disaster risk governance to manage disaster risk (the first two priorities of the Sendai Framework; UNDRR, 2015) constitute fundamental goals for reducing damage and losses due to landslides. In Section 1, we presented a non-exhaustive list of potential drivers increasing landslide risk in marginalised communities. Such drivers are reinforced by challenges like conflicting and unstable political agendas (Maes et al., 2018), lack of evidence for mitigation impact - if any, perpetuating a culture of response instead of prevention; distrust, miscommunication, and different risk perceptions between authorities, scientists, and populations at risk (Klimeš et al, 2019). These challenges reduce the effort towards achieving the Sendai goals, with the latter being equally adverse in bottom-up and top-down approaches for landslide risk reduction.

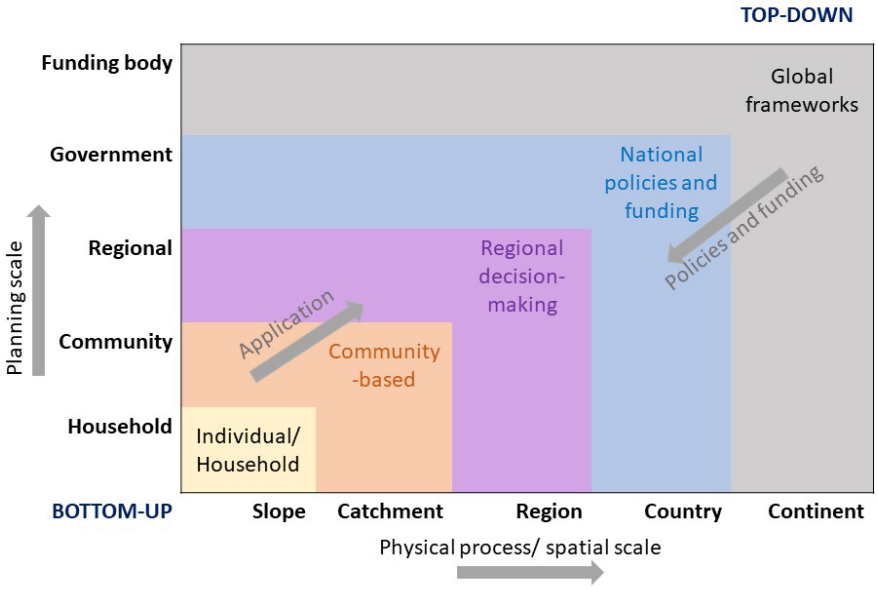

Figure 1 Diagram illustrating “top-down” versus “bottom-up” DRM approaches; on the y-axis, level of organisational planning; on the x-axis, the scale at which a hazard may occur (modified after Anderson, 2011b)

Historically, DRM falls under the remit of government organisations; the process of managing or mitigating disasters being typically based on technical capacities and expertise, with a centralised and hierarchical model of management. This ‘command and control’, or *‘top-down’* approach (Fig. 1) was founded on the assumption that “only by firm coordination and effective command [would] resources be deployed efficiently and effectively” (Scolobig et al., 2015).

With time, driven by international advocacy, civil society, and general academic support for a more people-centred approach to DRM, national governments have embedded strategies to enhance the capabilities of a community in disaster preparedness, response, recovery, and mitigation in their disaster risk plans. This end of the spectrum encourages *‘bottom-up’* approaches, where the burden is shared between a variety of different stakeholders and no actor holds sole responsibility for decisions and management of disaster preparedness, response, recovery, mitigation, and prevention (Scolobig et al., 2015).

Scolobig et al. (2015) identify and compare the key characteristics of the two approaches based on the underlying assumptions, approach, actors involved, and general process. One divergent characteristic between the 'top-down' and 'bottom-up' approaches is the provision of human (including know-how), material, financial resources for their implementation. 'Top-down' approaches tend to rely mainly on regular governmental funding and institutional support, while 'bottom-up' approaches have more diverse and often discontinuous resourcing, owing to the lack of institutional support.

Current studies in DRR demonstrate that over-reliance on top-down approaches has an adverse effect on community resilience, creating dependencies and incapacitating local-level stakeholders either through improper information flows, sub-optimal response, or relief actions (Munroe et al., 2013) undermining local capacities and underplaying the heterogeneity of communities (Sim et al., 2017). The UNDRR advocates for resilience to be enhanced at all levels, from the local to the international and defines resilience as "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management" (UNDRR, 2017)

1.3 AIM OF THIS STUDY

Community-based actions are examples of risk reduction strategies that build equitable resilience. Matin et al. (2018) define the term 'equitable resilience' as "that form of resilience which is increasingly likely when resilience practice takes into account issues of social vulnerability and differential access to power, knowledge, and resources; it requires starting from people's own perception of their position within their human-environmental system, and it accounts for their realities and for their need for a change of circumstance to avoid imbalances of power into the future".

Continued and appropriate community engagement can establish the ownership of solutions and sustainability of implemented risk reduction measures. In the context of landslides, community residents are not just passive receptors (i.e., those 'at risk') but also the people with the best practical knowledge of the slopes they inhabit and who can actively participate in delivering and implementing landslide risk reduction solutions (Anderson & Holcombe, 2013).

This non-exhaustive review study explores examples of community-based methods, approaches, and actions for reducing risk and increasing resilience to landslides. It focusses primarily on examples of studies, projects or initiatives involving informal settlements and/or marginalised communities located in the Global South. It describes the evidence, lessons learned, and good practice and builds on existent knowledge developed in projects such as the MoSSaiC (Management of Slope Stability in Communities) project (Mossaic, n.d), a program aimed at improving the management of slopes in communities in the Eastern Caribbean. Funded through the UKRI Collective Fund project 'Understanding Risks & Building Enhanced Capabilities in Latin American Cities (Urbe LATAM)', this study aims to gain insight into existent community-based landslide risk reduction strategies that can hopefully inform future community-based actions within the partner communities of the project in Colombia and Brazil.

At the core of community-based landslide risk reduction actions is the assumption that local communities can respond to natural hazards on their own if they are empowered and have adequate resources, although this assumption is not always met, particularly in vulnerable communities, as discussed further in Sections 3 and 4 of this report.

2 Methodology and overview of data

The report draws its findings from openly accessible publications that inform a literature review process where data is selected, analysed, and synthetised as described below.

1.2.1 Literature review

The literature review informing the development of this report (including both peer-reviewed and 'grey' literature) focused on two questions:

1. *What methods, approaches, and actions are used by communities to reduce landslide risk and increase resilience in informal settlements?*
2. *What evidence and lessons-learned exist on the impact of such methods, approaches, and actions? What challenges, opportunities, and barriers for implementation and transfer are documented in this body of literature?*

1.2.2 Data synthesis and integration

To address the questions above, we selected landslide risk literature from 2005 to 2022 (17 years). We completed two searches (Table 1), each using a search term to identify 'community-led' or 'community-based' landslide risk reduction. As of May 2022, these searches generated 159 results, with some publications likely to be returned in more than one of the searches.

Search term	Total returned results
'Community-based' OR 'community-led' AND 'landslide' AND 'risk' AND 'reduction'	76
'Community-based' AND 'landslide' AND 'risk'	83

Table 1 Literature review search terms using Google Scholar and Prevention Web search engines

We acknowledge that this search was non-exhaustive, and that other relevant publications may exist that were not returned with the combination of terms set out in Table 1. However, the boundaries placed on this review (both temporal and through the selection of search terms) enabled the rapid identification and analysis of a relevant sample of literature. The sample was further filtered for freely accessible (non-payable) publications written in English language and able to inform the research questions above. General observations from the review are captures in Section 1 and 2, while selected case studies illustrating community-based approaches for reducing landslide risk are presented in Section 3. In Section 4, good-practice, lessons learned, challenges, opportunities and barriers for implementation are described in comparison with findings from other studies. Finally, Section 5 summarises the outcomes of the report. All publications used for the development of this report are listed in the References section and those relevant for Sections 3 and 4 detailed in Appendix 1.

3 Community-based landslide risk reduction

3.1 DEFINITION OF COMMUNITY-BASED LANDSLIDE RISK REDUCTION

In the context of DRR, community-based landslide risk reduction usually refers to a suite of initiatives (e.g., methods, tools, and approaches) embedded within communities to provide an operational process for supporting community resilience. Landslide risk reduction measures can contribute to the prevention, response, recovery, or mitigation of future events. In general, such initiatives can be either (i) "owned" by the communities themselves who are at the heart of formulating solutions and participating in decision-making around their implementation (e.g., local stakeholder groups including individual households), (ii) centrally- or government-led, whereby local communities are not involved in decision-making processes but are the recipients of centrally driven actions; or (iii) "hybrid", involving a certain level of balance and negotiation of contributions from both centrally and community driven actions. In practice, the successful implementation of any top-down approach is very much dependant on the integration of local knowledge and the support of local stakeholders, with participatory science (citizen science)

being advocated as the optimal ground where a join co-production of knowledge by the scientists and the concerned populations leads to increased resilience of the hazard-prone communities (Cieslik et al, 2019).

Community-based landslide risk reduction supported by local knowledge is not without challenges. In line with the sustainable development goals, developing regions have invested significant efforts in establishing governmental institutions, policies, and mechanisms that may not be aligned with the traditional community-based approaches to DRR (Raška, 2019; see also section 3.3). Moreover, although participatory approaches have the potential to reduce risks by empowering communities to act in different capacities (e.g., provide useful data, create monitoring networks, building and maintaining structural equipment, communicate risk, etc.), they are vulnerable to changes such as periods of inactivity, reduction in (already stretched) resources, or restructuring of powers relations within the community (Stone et al., 2014; see also section 3.4).

This report focuses on regionally diverse experiences in improving community-based landslide risk reduction whereby communities rely on internal or external non-governmental resources (through NGOs, scientific community, charities, etc.) to reduce landside risk rather than on formal, institutional support. Three interlinked aspects of community-based landslide risk reduction are illustrated and discussed, namely the scale of intervention or actions, their timing and sustainability, and the resources required for their implementation.

3.2 SCALE OF INTERVENTION AND ACTORS INVOLVED IN THE IMPLEMENTATION OF LANDSLIDE RISK MITIGATION MEASURES

Community-based landslide monitoring and mitigation depends on a good understanding of capabilities and vulnerabilities across the community, including the scale at which different drivers or root causes of these vulnerabilities manifest themselves (Smith et al., 2021). For example, mitigation of landslide risk through changing land use practices (e.g., improved grazing practices or increase of forest cover; Sudmeier-Rieux, 2011) may require greater financial resources for action at household level than neighbourhood level due to the more lasting impact of the land use change effects.

Similarly, surface water management implemented at community level may be more difficult to scale-up than scale-down if implemented at an institutional (government) level, as described by Anderson et al. (2011a) in case study 1. The authors argue that the spatial resolution of landslide hazard assessment should match the scale of the instability when designing and developing effective risk reduction measures. This often means focusing on micro-scale land use management, typically at the household level (through the implementation of surface water drains for example). But as Carcellar et al. (2011) demonstrate, whilst the efforts of communities to develop and implement their own disaster-risk reduction have produced concrete local results, to move from small-scale successes to a mainstream approach (i.e.to city or regional development) requires government support. Such support may be translated into the formulation of enabling policies for more flexible building codes, institutionalising community-level actions (for instance, in monitoring local slope conditions, or developing local networks; Satterthwaite, 2011). Looking at community-based landslide risk mitigation strategies through the lens of scale, therefore, may help us to better understand the complex relationship between bottom-up versus top-down landslide risk mitigation approaches.

Case study 1: Reducing landslide risk in Eastern Caribbean through comprehensive surface water management (Anderson et al., 2011a)

The landslide risk reduction approach illustrated in this study is the well-established MoSSaiC approach (Management of Slope Stability in Communities), developed and implemented extensively in a selection of Eastern Caribbean small island developing countries. MoSSaiC is an integrated method for engaging policy makers, project managers, practitioners, and vulnerable communities in reducing urban landslide risk in developing countries. The approach is designed to identify the causes of slope instability and the vulnerability of the elements at risk at the scale of individual hillsides and communities, thus determining appropriate landslide

hazard reduction measures which are then constructed by the community. In this case the interaction between surface water infiltration and anthropogenic influences on slope hydrology (such as construction, earthworks, and vegetation change) were found to be the dominant mechanisms in determining the stability of the slope. This is a typical scenario for rapidly urbanising, unplanned communities in developing countries. The primary risk management strategy was therefore to design and build surface water drains and connect households to this new drainage network (Holcombe et al., 2011).

MoSSaiC is a multidisciplinary and holistic approach (involving local community, hydrologists, engineers, planners) which encourages multi-scale, multi-agency collaboration (government ministries and agencies part of the 'MoSSaiC Management Committee') for capacity building within the government. Historical evidence shows a reduced number of landslides reported in areas of implementation and policy uptake at national level which in turn encourage behavioural change and ensures sustainability of the model.

Beyond the opportunities provided by this approach (incorporating local institutions as the focus of adaptation projects, community-to-community transfer of knowledge, evidence-based successful interventions), communities are faced with several challenges which reflect the complexity of the approach proposed:

- international development agencies may have comparatively few staff on-the-ground, and therefore have little capacity (and maybe not the right incentives) to support this kind of approach as much as they would perhaps wish
- local communities will need extensive external support and/or resources to implement the approach; scaling up the approach has some immediate challenges, such as the lack of resources, engagement on the ground, or institutional capacity for adoption in other regions
- communication of the appropriate sequencing of the technical, policy and implementation phases, provision of shared resources to all stakeholders (to aid project initiation, implementation, and impact analysis), and encouraging behavioural change at the community level to manage surface water.

3.3 TIMING AND SUSTAINABILITY OF LANDSLIDE RISK MITIGATION MEASURES

Landslide risk mitigation measures can generally be classified into two broad categories, namely engineering and non-engineering. Examples for the former may include (Fell et al., 2005):

- approaches that reduce the frequency of landsliding (stabilisation measures such as groundwater or surface water drainage, slope modification, anchors, bioengineering, etc.)
- approaches that reduce the probability of the landslide reaching an element at risk (e.g., check dams, catch fences, retention walls, etc.)
- measures that reduce the spatial and temporal probability of the exposed elements (e.g., installation of monitoring and warning systems, community monitoring training)

Non-engineering measures may include:

- risk communication, community preparedness and public awareness campaigns, land use plans, enforcement of building codes and good construction practice, measures to pool and transfer the risks (e.g., insurance).

Each of these mitigation measures can further be implemented either prior (ex-ante) or after (ex-post) the occurrence of a hazard and will have an effect on reducing the hazard, exposure and vulnerability or increasing the capacity for preparedness and response.

The adoption of any one measure or action at community level depends on the short- or long-term capacity for implementation through plans and actions that may or may not be aligned to local or regional policies and priorities for development. For example, Smith et al. (2021) showed that, in NE Medellín, Colombia, the city's land use plan proposed a programme for urbanisation, legalisation and regularisation in the neighbourhoods of Pinares de Oriente, El

Pacifico, and Carpinelo 2. However, a significant number of houses in these areas are either situated along high voltage lines or located on slopes classified as high landslide risk or planned for future infrastructure projects. As a result, the land where the houses are situated is not recoverable and therefore these areas are not included in the city's land use plan, which will further make it unlikely that they will receive support to reduce landslide risk. In the same study, Smith et al. (2021), show that Vila Nova Esperança, an informal settlement in São Paolo, Brazil, has been designated as part of a land regularisation process, which in principle is not applicable to high and very high landslide risk areas unless mitigation works are carried out. Community leaders were interested to reduce the risk in high-risk areas to that they could be included in the land regularisation.

Case study 2: Community plan for Disaster Risk Reduction (Rodríguez-Gaviria et al., 2019)

The landslide risk reduction approach presented herein was initiated in 2018 - 2019 by the Faculty of Architecture and Engineering, University Colegio Mayor de Antioquia, as part of the "Community risk management in the neighbourhood of El Pacific (Commune 8, Medellin)" (Rodríguez-Gaviria et al., 2019). The aim of this project was to develop a community plan for the management of risks and increase collective capacity in the area. The specific objectives are to

- Implement a training school in community risk management in the study area
- Participation to identify risk scenarios at neighbourhood level for analysis and monitoring
- Propose DRR measures aligned to local planning efforts (development and land use planning)

The project takes a holistic view, considering all components of risk (hazard, vulnerability/fragility, exposure, and capacity), different types of hazards (landslides and floods), as well as multiple types of risk (i.e., technological, biological, population increase). It also promotes the use of mixed participatory research methods and tools (e.g., stakeholder interviews, field investigations, collection of primary and secondary data, etc.) employed during five different stages:

- Contextualisation
- Implementation of the Risk Management Training
- Development of methods and techniques for participatory disaster risk management planning
- Development and analysis of the community-based risk management plan and its alignment with the local development and land use planning
- Preparation of technical reports and integration of the plan at community level and in the framework of the territorial planning processes

In terms of landslide risk reduction, two types of measures are proposed:

a. *Structural measures:* bioengineering works for erosion control; restoration of forests and protection of ecosystems, including introduction of specific plants for soil stabilisation; development and maintenance of hydraulic infrastructure for runoff and rainwater management; adaptation of transport routes to drainage needs.

b. *Non-structural measures:* introduction of essential building construction standards; reactivate and strengthen community communication plans for disaster risk management (alerts, early warning, etc.); adaptation and signalling of evacuation routes; strengthen local production projects (orchards, community gardens, etc.); promote sustainability and environmental education and research; promote in-depth vulnerability studies and disaster risk management to local and regional authorities and organisations; establish a community fund for the maintenance of emergency equipment; manage and diagnose housing and infrastructure likely to be affected by different hazards; establish knowledge networks and develop different scenarios to increase the capacity of community to specific risks; encourage the inclusion of DRR measures in participatory budget;

promote the use of technology and mobile tools to strengthen capacity; carry out training for emergency situations.

For all measures above, the project proposes a methodology of prioritisation and ranking considering different risk scenarios, the costs/benefits, feasibility, impact and resources (incl. time) required, as well as the potential to be included in local planning strategies. In the latter case, the main legislative instrument against which the sustainability of the measures was assessed is the Municipal Plan for Disaster Risk Management (Plan Municipal para la Gestión de Riesgo de Desastres). The inclusion of measures in this document provides an official support for and recognition of the problems, but also provides a basis for the justification of local efforts to implement a training school in community risk management and identifying risk scenarios for analysis and monitoring at neighbourhood level.

3.4 SUPPORT AND RESOURCES FOR COMMUNITY-BASED OR COMMUNITY-LED LANDSLIDE RISK MITIGATION

Implementation of landslide risk reduction measures involves different actors and consequently depends on socio-economic and political relations within a community. As indicated in section 2, communities can and should take part in the decision-making process involving policies, regulations, planning, implementation, and maintenance of landslide mitigation measures.

Studies (Klimeš et al., 2019; Scolobig, et al.2015), indicate that even in cases where communities are empowered to shift from a 'passive' (e.g., inform on perceived level of risk and scientific models, bring evidence of slope instability, crowdsourcing data, post-disaster need mapping, geo-referencing observations and photographs organized via grass-roots, etc.) to an 'active' role (e.g., implement mitigation measures using contractors from the community, maintain mitigation measures, manage long-term projects, help formulate policy and governance strategies, etc.), complex interdependencies between social, economic and political factors, institutional particularities or the ever-changing and sometimes competing prioritises at household and community level can threaten the long-term sustainability of the adopted approaches.

Case study 3: The Red Cross soil bioengineering for resilience program in Honduras (Hostettler et al., 2019)

The landslide risk reduction measure described in this case study focuses on soil bioengineering. Soil bioengineering is defined as 'the use of living plants or cut plant material, either alone or in combination with inert structures, to control soil erosion and the mass movement of land to fulfil engineering functions' (Howell, 2001). Bioengineering not only has a high success rate, but is also more sustainable, environmentally friendly and affordable than many other available options.

Though soil bioengineering is increasingly promoted in countries in the Global South, many local communities still do not have extensive hands-on experience with this technique. This gap in knowledge is often still addressed through pilot projects headed by international agencies and development actors, with the aid of manuals, networks, and platforms (Hostettler et al., 2019). In 2018, an assessment of 73 sites established between 2010 and 2014 showed that (1) 83% of the sites were adequately maintained and (2) 69% of the sites fulfilled the function of soil stabilization. A cost–benefit analysis was conducted for two sites and indicated a cost–benefit ratio of 4.5 and 6 respectively. Some of the key factors for these high success rates include the fact that bioengineering is a locally adapted, easily implemented, cost-effective technology that offers landowners multiple benefits by increasing food security and creating income-generation opportunities.

In addition, the creation of well-functioning local emergency committees has proven highly effective in achieving this goal. When adequately trained, these committees are able to support the replication and maintenance of disaster-risk reduction measures at the community-level in the long term.

Nevertheless, despite its relative success, this approach can only maintain its capacity to provide soil protection and conservation, and thus potentially reduce landslide risk, if it is

constantly maintained. Ensuring long-term sustainability remains a challenge, as some communities are likely to disengage due to a widespread attitude of expecting government assistance and a lack of true initiative which seem to prevail in this study area. Therefore, authors emphasise that encouraging behavioural change and developing an improved exit strategy for the Red Cross is crucial to ensuring long-term change.

4 Reflections on community-based landslide risk reduction and resilience

Landslide risk reduction measures are implemented heterogeneously across different parts of the world. In a literature review study of 382 publications (between 2005 – 2015) on landslide risk reduction in tropical countries, Maes et al. (2017) show that of all DRR measures, landslide risk assessment is by far the most implemented DRR component (57%), while risk management and vulnerability reduction is the most recommended (38%). The particularly high number of landslide risk assessment studies in Africa (72%) was attributed to the fact that landslide hazards research is still an emerging discipline on the continent and governance remains a challenge for the implementation of other DRR actions. Authors also found that, while landslide risk management and vulnerability reduction is the most recommended component in all tropical countries, it receives more attention in Latin-America (42%) and Africa (40%) than in Asia-Pacific (27%).

Analysing the barriers for implementing landslide risk reduction measures by tropical region, Maes et al. (2017) found that the main examples reported are scientific and political in nature (30% and 29%, respectively). For example, the most important scientific barrier is the lack of a comprehensive landslide inventory and reliable hydro-meteorological data to enable adequate landslide risk assessment and subsequent slope management, as evidenced in studies by Anderson et al. (2011a) and DeGraff (2012). In addition to this barrier, there is the challenge of translating scientific evidence into practical applications and the lack of, or inefficient, risk communication (Maes et al., 2017). In terms of political barriers, the study finds the lack of a stable environment for scientific development, land use planning and ensuring the continuity of risk reduction actions as the most restricting political conditions (Maes et al., 2017). Although a good starting point for diagnosing challenges in landslide risk reduction in general, these barriers do not specifically explore the issues associated with mitigation of landslide risk in and by vulnerable communities.

This section briefly discusses coping and adaptive capacity in the context of community-based landslide risk reduction, along with some key reflections on challenges and opportunities for implementation, and good practices and lessons learned highlighted in the reviewed publications.

4.1 COMMUNITY-BASED COPING AND ADAPTIVE CAPACITY TO LANDSLIDE RISK

Community-based landslide risk reduction actions are related with the capacity to anticipate or to cope with future landslide events, which in turn depend on the availability of resources, opportunities, networks, and institutional or governmental support. According to Wamsler (2017) a **coping strategy** "*is constantly changing and adapting cognitive and behavioural effort to manage disaster risk or disaster impacts*". **Adaptation is** "… *part of cultural knowledge and practice evolved over time; in effect, part of the overall toolkit for life*" (Fiske et al, 2014). In other words, coping is not yet integrated response of affected communities to landslide disasters and adaptation is already a part of their resilience.

Actions such as bioengineering works, restoration of forests, introduction of plants for soil stabilisation, etc. can be taken to increase the capacity to anticipate and cope with future landslide risk (see section 3), but their effectiveness varies depending on the time of implementation with respect to the landslide event and across scales, from household to community and national levels. They can also result in positive or negative impacts on the

reduction of risk; for example, coping strategies such as learning from peers, cooperating with neighbours and locally established committees and networks could be seen as effective in both short and long-term, especially if supported by governmental levels (Schmidt-Thomé et al., 2018). However, borrowing from lenders at high interest rates and felling (cutting down trees) to use as firewood or to prevent them from falling during flooding events, which can be effective short-term, may be ineffective in the long-term (Rahman, 2012).

The implementation of positive and effective short and long-term coping strategies is important at all levels (household, community, national) engaged in community-based landslide risk reduction. This may enable affected people to strengthen their resilience and overcome some of the barriers and challenges for implementing landslide risk mitigation measures, some of which are further discussed below.

4.2 CHALLENGES AND OPPORTUNITIES FOR IMPLEMENTATION

Case studies presented in section 3 and Appendix 1 suggest that the integration of local knowledge into landslide risk reduction practices is context-specific and varies both in relation to the time of implementation (ex-ante or ex-post disaster) and historically, reflecting, for example, a change in technology or adaptation capacity. Its contribution to resilience (including coping and adaptation capacity) depends on the interaction with other types of knowledge (e.g., science based), government regulations, and institutions. Moreover, the scale of organisation and action, from individual to household and community level, influences the impact and long-term sustainability of mitigation measures.

In particular, two general findings from our desk-based study may inform future studies on community-based landslide risk reduction and the integration of local knowledge into mitigation and/or adaptation measures. *First*, one of the key challenges found was in ensuring the long-term empowerment of communities to act both in collaboration with government or non-governmental action plans as well as independently or in conjunction with other communities. Collaborative actions and context-specific risk communication are regarded as the main conditions for success (Klimeš et al., 2019), and a clear understanding of the actors and processes that represent barriers to creating a safer and resilient community are a prerequisite for this. For example, some mitigation measures and strategies require the active involvement of supporting organisations that have the know-how, credibility, and acceptance of local communities. This can come with the additional challenge of identifying long-term exit strategies for these supporting organisations and their successful implementation. Successful exit strategies have included the introduction of training programmes to ensure a legacy of competency and know-how within the community (Schmidt-Thomé et al., 2018; see also case studies 2 and 3). Furthermore, understanding whether and how local knowledge is supported or undermined by processes taking place at the local level, such as land use planning, risk zoning, or changes in social-economic institutions, is essential. *Second*, the role of local knowledge in landslide risk reduction through the implementation of mitigation measures is not straightforward and varies from case to case and in time depending on the power relations and actual resources available at local level. Local knowledge needs to be seen rather as a process than as content only. For example, Naess (2013) demonstrates that local knowledge is often treated as a source of inputs to conventional planning processes and science frameworks rather than as a knowledge system, and Smith et al. (2021) show the strong relationship between knowledge and power. Similarly, levels of power are linked to scales of intervention, in that equitable co-production of landslide risk reduction strategies assumes a willingness on the part of the different agents to engage in roles proportionate to their power to act, implement, respond, learn, etc. or power over institutions, communities, and resources.

4.3 GOOD-PRACTICE AND LESSONS LEARNED

Community involvement and capacity building for DRR has been a research topic for the Evidence and Lessons from Latin America (ELLA) network (http://ella.practicalaction.org/), a partnership spanning 15 institutions across Latin America, Africa and South Asia aiming at fostering south-south learning and context-specific knowledge transfer and adaptation. Based upon the successful implementation of two community participation initiatives in urban landslide

risk reduction in Latin America (see Appendix 1), experts from Africa and Asia discussed existing practices in their cities and how community involvement might be enhanced. Participants were encouraged to compare the two initiatives in urban landslide risk reduction in Latin America with their local realities and identify whether any of the practices involved might be adapted for use in their context (ELLA Learning Alliance, 2014).

The findings of the ELLA network study resonate with some of the reflections discussed above; they provide several key lessons that may be considered relevant for the design of future community-based landslide risk reduction programmes in the Global South:

- Cities across Africa, Asia and Latin America are home to a series of fragmented programmes to train local communities in DRR techniques, all of which demonstrate significant room for improvement
- 'Ownership' is key to the success of community programmes. Involving community members from the inception phase, rather than employing them to carry out DRR activities, can increase buy-in from community members and as a result DRR activities will be more effective
- There is no 'one-size fits all' solution for how best to train communities in DRR. Both bottom-up and top-down initiatives have proven to be successful at reducing urban risk, and it is likely that a combination of both approaches would achieve the best results; Institutional and financial support from governments can enable community programmes to be more inclusive and sustainable, however NGOs and local community groups play a vital role in raising awareness amongst communities
- Community involvement in DRR can be designed as a job creation scheme, thereby addressing other social development concerns; providing community participants with financial rewards for their involvement gives them an extra incentive to take part, and encourages other community members to take the activities seriously
- For many types of DRR, investments need to be made in infrastructure (e.g. monitoring networks, drainage equipment etc), as well as in capacity building.

One recent project may provide further useful insights into upscaling and transnational transfer of participatory landslide risk-reducing strategies for informal settlements in Latin America, namely "Co-production of Landslide Risk Management Strategies through Development of Community-based Infrastructure in Latin American Cities"[1], led by Dr Harry Smith, Heriot-Watt University.

5 Concluding remarks

Marginalised communities around the world, particularly those living in informal settlements in the Global South (Petley, 2012), are often exposed to landslides, which result in lives and livelihoods being lost or affected. Some of these regions will potentially experience increased exposure to landslides due to future changes in climate and socio-economic conditions (Kirschbaum et al., 2020), therefore finding better ways to manage current and potential landslide risk is important. The wide range of landslide mitigation measures available, from implementing protection barriers to bioengineering, are often difficult to implement not only due to social, economic, political, or environmental reasons, but also because they are often considered in isolation, without being embedded into a long-term development strategy (Smith et al., 2021).

As such, the identification of the most appropriate landslide risk reduction measures that can increase the resilience of vulnerable communities must begin with learning directly from them as to what are the most valued elements at risk, where are the areas of greatest concern, and what measures can be implemented sustainably to help reduce the risk or increase resilience.

[1] See also "Hillside communities learn to mitigate landslide risks", available at: https://rethink.earth/hillside-communities-learn-to-mitigate-landslide-risks/ and https://gtr.ukri.org/projects?ref=NE%2FP015557%2F1

This report presents a short review of community-based methods, approaches, and actions for landslide risk mitigation, analysed from the perspective of scale, timing & sustainability, and resources necessary for their implementation. Notwithstanding its limitations, this approach allowed us to compare more easily different mitigation strategies across case studies but also better understand their role and place in relation to other landslide risk management options, such as capacity building or risk communication.

The main conclusions of this study are that:

- Further attention should be paid to understanding the institutional, cultural, social and technological context that allows or hinders the adoption of certain community-based landslide risk reduction approaches;
- Communities are constantly evolving under the influence of external or internal factors, such as migration or age distribution. Thus, approaches to community engagement and participation in landslide risk reduction must constantly be re-evaluated, given the dynamic nature of communities' structure and functioning.
- Potential transfer and use of historical community-based approaches and practices must be critically evaluated with respect to conditions in which these approaches and practices were developed and implemented; and
- There is a limit to how much community-led or community-based strategies and approaches can achieve without the support and involvement of governmental or non-governmental agencies, and vice-versa; co-development and collaboration should strive towards overcoming barriers of knowledge, trust, resources, and power.

Effective landslide risk reduction requires a multi-disciplinary, holistic approach. Knowledge of landslide risk requires understanding of processes and mechanisms, spatial and temporal probability, vulnerability assessment, monitoring and modelling of the effects related to environmental and climate change. Such knowledge is not owned by any single stakeholder, therefore, partnerships between private and public, institutions, decision-makers and communities affected are key to implementing effective landslide risk mitigation measures. Beyond the scientific challenge, the implementation of landslide risk reduction in practice must be addressed in a comprehensive framework, whereby disaster risk management is integrated in the environmental policy and action and development plans of a community at all levels or organisation, from a particular neighbourhood or settlement to a city, region, or nation.

Lastly, landslide risk reduction cannot be addressed in isolation. Whilst our research focused on a single hazard approach, some DRR measures are shared across hazards, suggesting there is scope for cross-fertilisation and learning between communities affected by different hazards (e.g., volcanic, flooding, mass-movements, etc.). Indeed, this would prompt all actors involved to change their perspective and management of risk towards a systemic, integrated, holistic approach, as they work together to build greater resilience to likely future disasters.

Appendix 1

Summary table (see below for details on key take-aways, challenges, opportunities, and barriers to implementation of listed approaches)

	Approach	Purpose	Location	Source	Keywords
1	Soil bioengineering ▪ Establishment of community disaster management committees	Landslide prevention ▪ Reducing the frequency of landslides ▪ Capacity building	Olancho department, Honduras	Hostettler et al., 2019	Landslide risk reduction, Resilience, Community-based disaster risk management, Soil-bioengineering, Red Cross, Honduras
2	Surface water management	Landslide prevention ▪ Reducing the frequency of landslides ▪ Capacity building	Eastern Caribbean	Anderson et al., 2011a	Landslide modelling, Landslide hazard, Vulnerability, Disaster Risk Reduction, Community, Caribbean
3	Community plan for disaster risk reduction	Landslide prevention and preparedness ▪ Capacity building	El Pacific (Commune 8, Medellin), Columbia	Rodríguez-Gaviria et al., 2019	Disaster risk management plan, community, Medellín, Columbia
4	Community-rooted and community-driven DRR programme	Post-disaster response ▪ Capacity building	Philippines	Carcellar et al., 2011	Community organizations, Disasters, Risk Reduction
5	Community training	Post-disaster response ▪ Capacity building	Serrana Region, Rio de Janeiro, Brazil	ELLA Learning Alliance on Climate Resilient Cities, 2014	Community involvement, capacity building, DRR, ELLA
6	Local work force for landslide risk prevention ('Guardians of the Mountain' Project)	Landslide prevention ▪ Capacity building	Manizales, Colombia	ELLA Learning Alliance on Climate Resilient Cities, 2014	Community involvement, capacity building, DRR, ELLA
7	Participatory landslide hazard research and monitoring	Reducing the spatial and temporal probability of elements at risk ▪ Landslide hazard assessment, monitoring, and communication	Rampac Grande community, Carhuaz Province, Peru	Klimes et al., 2019	Community-based risk reduction, risk perceptions, landslides, participative methods, local knowledge, Peru
8	Community-based landslide observation network	Reducing the spatial and temporal probability of elements at risk ▪ Landslide risk assessment and communication	Thailand	Schmidt-Thome et al., 2017	Landslide observation network, landslide risk, community training, Thailand
9	Voluntary community-based monitoring (vigias)	Reducing the spatial and temporal probability of elements at risk ▪ Volcanic hazard monitoring and risk communication	Tungurahua, Ecuador	Stone et al., 2014	Disaster risk reduction, community-based monitoring, citizen science, Tungurahua, participatory

Approach 1: Soil bioengineering ▪ Establishment of community disaster management committees

Olancho department, Honduras | Hostettler et al., 2019

What does it involve?

Scientific risk studies combined with participative and inclusive mapping (determining the level of hazard, vulnerability, and risk) ▪ Analysis of vulnerability and capacities in each community ▪ Establishment of community disaster management committees ▪ Development of a participative process for slope stabilization through soil-bioengineering ▪ Partnership between NGO and community

What were the results?

73 sites established between 2010 and 2014 showed that (1) 83% of the sites were adequately maintained and (2) 69% of the sites fulfilled the function of soil stabilization ▪ CBA - cost-benefit ratio for 2 sites of 4.5 and 6, respectively

Key take-aways

High success rates due to bioengineering being locally adapted, easily implemented, cost-effective technology that offers landowners multiple benefits by increasing food security and creating income-generation opportunities ▪ The creation of well-functioning local emergency committees has proven highly effective in achieving community empowerment ▪ When adequately trained, these committees are able to support the replication and maintenance of disaster-risk reduction measures at the community-level in the long term

What are the challenges?

Long-term sustainability of landslide risk reduction measures implemented ▪ Long-term independence and empowerment of communities (ownership of measures implemented) ▪ Requires the active involvement of an organisation that has the know-how, credibility, and acceptance of local communities ▪ Defining long-term exit strategy for the supporting organisation and their successful implementation

What are the opportunities?

Community empowerment ▪ Socio-cultural sustainability (behavioural change to ensure long-term change) ▪ Training of competent local emergency committees ▪ Soil bioengineering allows potential risk scenarios to become opportunity scenarios by using the spaces generated to create ecological orchards as an added value and community incentive

What are the barriers to implementation?

Reaching an agreement with the landowners of critical sites ▪ Secure land tenure is a prerequisite ▪ Without constant maintenance, soil-bioengineering loses its capacity to provide protection and conservation ▪ Long-term project duration (partnership NGO & community) which may be dependent on funding and a high degree of credibility from the NGO side ▪ Risk of backslide on the progress made without the NGO's support and lapse back into inactivity are strong

Approach 2: Surface water management (roof-water, grey water, and overland flow of rainwater) ▪ Monitoring shallow groundwater conditions ▪ Construction of low-cost drainage systems

Eastern Caribbean | Anderson et al., 2011a

What does it involve?

Landslide hazard and drainage mapping, with residents indicating areas of perceived drainage and landslide risk. This information is combined with scientific determination of potential landslide triggering processes via CHASM model ▪ Reducing the surface water infiltration through the management of all forms of slope water (surface water management measures) ▪ Multidisciplinary and holistic approach (involving local community, hydrologists, engineers, planners ▪ Multi-agency collaboration (government ministries and agencies part of the 'MoSSaiC Management Committee') for capacity building

What were the results?

Reduction in the number of landslides reported ▪ Policy uptake at national level (encouraging behavioural change and ensuring sustainability)

Key take-aways

Extensive on-the-ground engagement with community members before formal project initiation, during implementation and post-project completion ▪ The importance of correctly sequencing the sharing of technical knowledge, advocacy at national policy level, development of appropriate implementation processes and engagement with donors

What are the challenges?

International development agencies may have comparatively few staff on-the-ground, and therefore have little capacity (and maybe not the right incentives) to support this kind of approach ▪ Local communities will need extensive external support and/or resources to implement the approach ▪ Communication of the appropriate sequencing of the technical, policy and implementation phases, provision of shared resources to all stakeholders (to aid project initiation, implementation and impact analysis) ▪ Encouraging behavioural change at the community level to manage surface water

What are the opportunities?

Incorporating local institutions as the focus of adaptation projects ▪ Changing the perceptions of individuals, governments, and international development agencies as to the most cost-effective way of reducing landslide risk (evidence-based successful interventions) ▪ Community-to-community transfer of knowledge ▪ The possibility that maintenance of the community-based drainage construction will be mainstreamed within Government budgets

What are the barriers to implementation?

Unlike individual household approaches to lower risk, this approach requires considerable community engagement in addition to that of national partners and international development partners

Approach 3: Community plan for Disaster Risk Reduction

El Pacific (Commune 8, Medellin), Columbia | Rodríguez-Gaviria et al., 2019

What does it involve?

Community risk management training schools ▪ Identification of risk scenarios ▪ Proposal of structural and non-structural DRR mitigation measures (for examples, see page 16) aligned to local planning

What were the results?

Community Plan for Disaster Risk Reduction and Knowledge of the El Pacífico neighbourhood of Commune 8 ▪ Community forum for dialogue where technical and practical notions of risk management were explored from a community, academic and institutional perspective

Key take-aways

The project proposes a methodology of prioritisation and ranking considering different risk scenarios, the costs/benefits, feasibility, impact, and resources (incl. time) required, as well as the potential to be included in local planning strategies

What are the challenges?

The success of the community plan for Disaster Risk Reduction is dependent on the support of local authorities and uptake in local planning instruments

What are the opportunities?

The inclusion of measures in this document provides an official support for and recognition of the problems but also a basis for the justification of local efforts to implement a training school in community risk management and identifying risk scenarios for analysis and monitoring at neighbourhood level

What are the barriers to implementation?

The approach requires an effective collaboration between communities, academia, and local governmental and social organisations

Approach 4: Community-rooted and community-driven DRR programme

Philippines | Carcellar et al., 2011

What does it involve?

Community-rooted data gathering (assessing the severity and scope of destruction and victims' immediate needs) ▪ Trust and contact building ▪ Support for savings ▪ Registering of community organizations ▪ Identifying needed interventions, including building materials ▪ Loans for house repairs negotiating for land for transit housing and land acquisition for permanent housing construction

What were the results?

Local NGO (PACSII) actions in Iloilo: their involvement in technical and multi-sectoral working groups, made possible through executive orders and other local policy, structures, opened a wider space for engagement to effect change in local policies (lowering the cost of interventions, assisting with resettlement, giving a voice to the urban poor, establish partnerships with international networks/organisations)

Key take-aways

Support programmes were developed and implemented to tackle vulnerabilities such as limited financial access; insecure land and house tenure; high risk locations; lack of organization.

What are the challenges?

The interplay of institutional partnerships of communities with local government, academia, private organizations and international partners ▪ Multi-stakeholder and scaled up disaster response and DRR intervention depends on the quality of leadership, organizational and governance strength of each of its urban poor communities, which allows them to act on their development agenda

What are the opportunities?

Identifies ways in which government and other stakeholders can support the needs and address the vulnerabilities of at-risk communities, mapping out possible entry points for incorporating DRR into the effort to scale up community-driven initiatives to the city level

What are the barriers to implementation?

Resources and the legal framework within which communities must operate ▪ The prerequisite needs for scaling up of community driven DRR processes at city level (empowered urban poor communities, deep and active collaboration between stakeholders; building on and sharing local knowledge and learning; leveraging internal and external resources)

Approach 5: Community training

Serrana Region, Rio de Janeiro, Brazil | ELLA Learning Alliance on Climate Resilient Cities, 2014

What does it involve?

Voluntary participation in community based DRR groups, followed by monitoring and on-going capacity building

What were the results?

Establish formal partnerships with community associations ▪ Community associations took part in the preparation of city contingency plans ▪ Establish two voluntary-based community DRR groups (and accompanying Training Manual), where training on community response, risk identification, vulnerability and resources and capacity assessment was provided ▪ Installation and testing of sirens by Civil Defence ▪ As a result of implementing community training and capacity building, lives were saved in the aftermath of a heavy rainfall event

Key take-aways

DRR comprises two dimensions: the equipment/infrastructure support + human capacity. If the latter is missing, the former cannot achieve its goal

What are the challenges?

Funding of activities ▪ Involvement of NGOs that are local rather than outside the community ▪ Knowledge transfer from organisations experienced in participatory, hands-on methodologies

What are the opportunities?

Use of hands-on participatory training method, in order to help engender a feeling of ownership and pride among group members

What are the barriers to implementation?

Lack of support from local institutions involved in DRR ▪ Lack of financial support ▪ Sustainability of community DRR groups ▪ Integration of community DRR group actions in local DRR planning

Approach 6: Local work force for landslide risk prevention ('Guardians of the Mountain' Project)

Manizales, Colombia | ELLA Learning Alliance on Climate Resilient Cities, 2014

What does it involve?

Local NGO contracted by city government to hire, train, and manage women in slope maintenance and its importance in terms of reducing climate vulnerability; also, maintain a census of settlements located in the city's high-risk zones via a mapping exercise which includes collection of household data (name, family size, ages, gender and occupations) and the identification of the construction of new informal settlements

What were the results?

Regular maintenance of slope infrastructure ▪ Knowledge dissemination on risk mitigation measures ▪ Monitoring and reporting of changes in informal settlements, infrastructure condition, household data for census purposes ▪ Bi-weekly training sessions

Key take-aways

The information collected by local women is verified by the municipal government and used to begin negotiations for relocation with residents of new informal settlements in areas of high vulnerability

What are the challenges?

Top-down approach, in terms of the project development, implementation and the design of the curriculum for bi-weekly training sessions. No input is sought from the community members regarding this programme, including the employees

What are the opportunities?

The project was developed as a local income generation initiative as well as a disaster risk management measure (local, single mothers who reside in peripheral areas, highly vulnerable to landslides and heavy precipitation were part-time employed to perform the work)

What are the barriers to implementation?

Slope maintenance work is high risk and a physically demanding job ▪ The pay is minimum wage and often insufficient to support families ▪ Bi-weekly training sessions do not include transferable job skills ▪ Employment contracts are typically only 3 months at a time (temporary solution to socio-economic vulnerability) ▪ Funding available for maintaining the programme (not self-sustaining)

Approach 7: Participatory landslide hazard research and monitoring

Rampac Grande community, Carhuaz Province, Peru | Klimes et al., 2019

What does it involve?

Local Peruvian research institute (INAIGEM) collaborating with experts from the Czech Academy of Sciences in a development project ▪ Participative techniques (semi-structured interviews, focus group meetings, presentations) and geomorphological and geological research to collect base information for DRR measures

What were the results?

Information about landslide events, hazard mitigation and perception, field work mapping campaigns ▪ Landslide hazard map ▪ System for monitoring landslide movement ▪ Installation of warning signs ▪ Landslide hazard perception change

Key take-aways

Effective community participation depends on effective knowledge communication to relevant stakeholders ▪ Community motivations and experience changed in time ▪ Previously mismanaged landslide hazard risk reduction actions resulted in delays in unacceptance of mitigation solutions and mistrust of experts from outside the community ▪ Changes within the community (social and power relations, access to resources, etc.) need to be taken into account when implementing DRR projects

What are the challenges?

In communities where trust in external actors or authorities is an issue, traditional practices are more readily adopted; however, these practices are not always the best informed or effective for landslide DRR

What are the opportunities?

Community members are actively involved in research activities and the construction works for landslide hazard monitoring and prevention

What are the barriers to implementation?

Mistrust in external actors (outsiders can be a rather high risk themselves and their knowledge is not necessarily considered to be trustworthy or the knowledge for mitigating the hazard at stake) ▪ Financial sustainability of the project (externally funded) ▪ Technical knowledge is sourced from external collaborators ▪ Success of the project depends largely on the community acceptance and collaboration

Approach 8: Community-based landslide observation network

Thailand | Schmidt-Thome et al., 2017

What does it involve?

The network focuses on training local people to understand the risks related to landslides and provides villages with simple tools to detect early signs of threatening landslides and evacuate villagers to safe places

What were the results?

Landslide risk map ▪ Establishment of a community-based landslide observation network ▪ Landslide risk reduction

Key take-aways

Top-down early warning actioning the deployment of trained villagers to observe the local precipitation and stream discharge; when critical levels are reached, warnings are issued via speakers and sirens

What are the challenges?

Top -down approach relies on coordinating institution at governmental level (Geohazards operation Centre, GOC) and the head of the village to initiate action ▪ Reluctancy to join the network due to potential loss of revenue from tourism ▪ Communities with seasonal tourism may have a lower level of preparedness ▪ Difficulty to give warning if landslide events occur at night ▪ Communities located in temporary housing and shelters are not part of the landslide network

What are the opportunities?

Training is organized in groups of villages that are located in the same catchment area. The volunteers are trained in search and rescue, first aid, landslide types, reading simple rain and runoff gauges, landslide triggering forces as well as landslide behaviours and impacts ▪ Simple colour scales on these instruments do not require literacy or technical training ▪ Public display of evacuation route map

What are the barriers to implementation?

Approach requires close collaboration between local and central DRR institutions, emergency agencies, meteo office, media, and local communities ▪ Training is voluntary-based and only a limited number of people are involved

Approach 9: Voluntary community-based monitoring (vigias)

Tungurahua, Ecuador | Stone et al., 2014

What does it involve?

The vigías network around Tungurahua provides collaborative risk reduction in response to a need to improve the communication of risk and the coordination of evacuations for communities around the volcano (it was initiated as a compromise following citizens' decisions to forcibly return to hazardous areas following an enforced evacuation)

What were the results?

Well-established communication protocols (daily communication) ▪ Enhanced community capacity and training ▪ Heightened levels of preparedness and trust in scientific advice ▪ Mediated relationship between scientists and public

Key take-aways

Community-based network performs multiple functions in reducing volcanic risk ▪ Establishing trust-based relationships between citizens, the vigías, scientists and civil protection authorities is one important factor in the effectiveness and resilience of the network ▪ Factors contributing to the longevity of the network include the motivations of the vigías, a clear and regular communication protocol, persistent volcanic activity, the efforts of key individuals, and examples of successful risk reduction attributable to the activities of the network"

What are the challenges?

The network relies on the support afforded by influential scientists, charismatic vigías and emergency management officials ▪ Officials working in key posts in regional risk management institutions have different priorities, resulting in inadequate resources or lack of support for the network ▪ The lack of institutional identity and lack of resources threatened the motivation of the volunteers

What are the opportunities?

The vigías network functions simultaneously as a source of observational data for scientists; as a communication channel for increasing community awareness, understanding of hazard processes and for enhancing preparedness; and as an early warning system for civil protection; enhanced social capital – through the relationships and capabilities that are fostered – and improved trust between partners

What are the barriers to implementation?

The functioning of the network is dependent in many ways on contextual factors (including geological, related with the recurrence of volcanic activity) ▪ Participation that goes beyond observations and enhancing community preparedness, i.e., that which involves equipment maintenance or other activities that directly benefits the work of the scientists, then payment is necessary and important

Appendix 2

Further resources on landslide risk mitigation measures (not restricted to but including community-based approaches):

- ✓ *Nature-based solutions for site-specific landslide risk mitigation*, Asian Disaster Preparedness Center (ADPC). 2020. ISBN/ISSN/DOI 9786245298037 (ISBN). Available at: http://www.adpc.net/igo/category/ID1644/doc/2020-qULw50-ADPC-Guidance_Document.pdf. This document is expected to serve as a Guidance Document on application of nature-based as well as hybrid solutions. Some of the good practices of bio-engineering for stabilization of vulnerable slopes and reducing the erosion potential is also included in the document.

- ✓ *The LaRiMiT Toolbox*, a technical tool for the quick selection of landslide risk mitigation measures. It is under development in the context of the Klima2050 research project (www.klima2050.no). Available at: https://www.larimit.com/. The toolbox includes approximately 70 structural mitigation measures. The structural measures are divided into ten categories and belong to class of measures either reducing hazard or reducing consequences

- ✓ Highland, L.M., and Bobrowsky, Peter, 2008, *The landslide handbook—A guide to understanding landslides*: Reston, Virginia, U.S. Geological Survey Circular 1325, 129 p., Appendix C, Introduction to Landslide Stabilization and Mitigation. Available at: https://pubs.usgs.gov/circ/1325/ . The Appendix illustrates mostly stabilization techniques that are currently available in North America, but examples from other regions or countries are also considered.

Glossary

Coping capacity - The ability of people, organizations and systems, using available skills and resources, to manage adverse conditions, risk or disasters. The capacity to cope requires continuing awareness, resources and good management, both in normal times as well as during disasters or adverse conditions. Coping capacities contribute to the reduction of disaster risks (UNDRR, 2017)

Disaster Risk Reduction - Preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development (UNDRR, 2017)

Disaster Risk Governance - The system of institutions, mechanisms, policy and legal frameworks and other arrangements to guide, coordinate and oversee Disaster Risk Reduction and related areas of policy. Annotation: Good governance needs to be transparent, inclusive, collective, and efficient to reduce existing disaster risks and avoid creating new ones (UNDRR, 2017)

Elements at risk - Population, buildings and engineering works, infrastructure, environmental features and economic activities in the area affected by a hazard (Fell et al., 2005)

Global South – The concept refers broadly to the regions of Latin America, Asia, Africa, and Oceania (Dados and Connell, 2012)

Resilience - The ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform, and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management (UNDRR, 2017)

Risk assessment - The process of making a decision recommendation on whether existing risks are tolerable and present risk control measures are adequate, and if not, whether alternative risk control measures are justified or will be implemented. Risk assessment incorporates the risk analysis and risk evaluation phases (Fell et al., 2005)

Risk management - The systematic application of management policies, procedures, and practices to the tasks of identifying, analysing, assessing, mitigating, and monitoring risk (Fell et al., 2005)

Risk mitigation - A selective application of ap-propriate techniques and management principles to reduce either likelihood of an occurrence or its ad-verse consequences, or both (Fell et al., 2005)

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