Eastern and Southern Africa Regional Seismological Working Group (ESARSWG) - Evaluation Report

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1. Summary

The Eastern and Southern Africa Regional Seismological Working Group (ESARSWG) is a network that serves the collaborative seismological data collection and analysis for the countries in the African rift system. The 9 nodes of the network are situated at either universities or government institutes in Ethiopia, Eritrea, Kenya, Malawi, Mozambique, Tanzania, Uganda, Zambia, and Zimbabwe. The members of nodes meet regularly for catalogue creation and the compilation of a bulletin which they share with the global seismological community. Most nodes operate a national network of seismological stations. In the past thirty years they have used the data they collected and analysed to inform national governments in the case of seismic events, provided information for disaster risk management officials in their respective countries and have raised awareness about seismicity in the region. They have also pursued other geophysics research and used it to provide information to government agencies, societal stakeholders and industry.

This evaluation has the aim to assess the development, functionality and impact of the ESARSWG-network since the inception of ISP funding in the late 1990s (Terms of References (ToR), p. 3). More specifically, the ToR spell out that the evaluation has the aim to to analyse and assess the *relevance, efficiency, effectiveness, impact and sustainability* of the network and its nodes in relation to ESARSWG's own set goals and objectives (ibid). To achieve the evaluation's aims we conducted a desk review of self-evaluation forms from each node, interviews with all current node-coordinators as well as with selected stakeholders, and four site visits in Uganda, Ethiopia, Tanzania and Mozambique. We presented the first conclusions to the network members in a follow-up survey, within which we asked for their assessment and ranking of persisting challenges.

The ISP through its network programme supports the regional collaboration of national actors with the aim to foster human and technical research capacities and the application for local development especially in the basic sciences. The principal goals of the network is to facilitate data collection, processing and exchange for the purposes of creating a regional seismic catalogue. In recent years there has also been an expanded focus on using these data, and others, for seismic hazard assessment.

Key Findings

Training: There are two training streams within the network. The main stream is operational in nature (connected to the routine processing of seismic data and catalogue creation). Most nodes have at least one skilled analyst with expertise in SEISAN. Many nodes, particularly university nodes, have a small number of trained analysts. Without the regional network there is a danger of capacity being lost with individuals leaving the node. The regional repository of knowledge at network level is one of the main strengths of the organisation. If funding were stopped it would likely quickly result in a significant loss of capacity in at least some nodes. It is also important that the network keeps up with global trends in seismic monitoring. The network should consider adopting new software (such as SEISCOMP3) and new technologies (such as real-time stations) and incorporate these into their training program as appropriate.
The second training stream is at MSc and PhD level. A number of participants received MSc training in the Ethiopian node (although this only operated for a limited period of time and for a small number of students). This program (ISP-funded scholarships for degrees in Ethiopia) is not currently active. The current model of

local research training is problematic in countries which lack an academic institution with professors with a high level of seismology expertise. Some countries also have a limited amount of seismological data which could hinder local research projects at PhD level. Funding for higher degrees is also a challenge.
Once trained there is a major challenge in retaining individuals with higher degrees. The local salaries available are not competitive compared to those offered by global seismological organisations (such as the ISC and the CTBTO) and so a number of graduates have moved abroad. Other regional organisations such as the Council for Geoscience in South Africa have also attracted network members. Members have also left for industry-related jobs. But it also seems that the network is playing an indirect role in the retention of trained staff. Brain drain will remain a major challenge for the foreseeable future, underscoring the need for the ongoing training of as many individuals as possible.
There is less network-based training available for technicians, and the maintenance of stations is a serious problem at some nodes (Sec. 2.2). It is possible that more technical training could help to keep stations running for longer in some nodes. While it is noted that the principal problems are related to funding for replacements and site visits, more informal direct contact may help to improve technical experience and capacity.

Research: Data collection capacity varies greatly across the network. This is the most important challenge faced by the network as it directly impacts their ability to achieve their primary goals in some member states. Training, bulletin creation and seismic hazard analysis are all compromised unless at least some data is generated. Capacity varies from 9 stations, with additional stations from international networks, with significant real-time data transmission capabilities to countries with long periods of no data collection. A number of national and network-level interventions are required to improve the situation. Support for station servicing and repair could help some countries maintain a minimum data collection capacity. Ultimately sustainability requires increased governmental investment for equipment maintenance and operation.
The catalogue is a valuable product of the network, as is the phase data generated to create it. Both of these are fed to the ISC which uses this information to generate their highly regarded global catalogue. Such global catalogues require regional and national data collection capacity and catalogue creation to be effective. There is general agreement that the sharing of data is a major success of the network. Universally network members report rapid international data-sharing in the event of a damaging or strongly felt earthquake. Stakeholders indicated satisfaction with the timeliness and quality of the information that has been provided by network members over the last few years.
It is acknowledged that the focus of the network is on long term monitoring and catalogue creation rather than the creation of large numbers of research publications. Nodes can have a significant impact by feeding into building codes and other government publications which are not very visible in 'academic' bibliographic analyses. One of the reasons for the comparative lack of 'ESARSWG' publications is the focus on looking for research opportunities that all members can participate in, rather than using the network to promote smaller-scale multilateral projects (with perhaps two or three partners). Given the nature of the network and it's priorities we do not believe the relative lack of publications should be viewed as a failure. That said there are clear opportunities for this aspect of the network to be developed, to encourage both network-wide research projects and smaller scale regional research projects within the group.

Knowledge Transfer: The data collected and compiled in the catalogue are used to contribute to the needs of international academe, the region and the respective network countries. The network members share their data with the ISC and therefore ensure that it can be used by the international scientific community. Beyond the collaboration and support by ISP, individual nodes collaborate with other international networks in the area of data collection and joint research projects. During the course of the past 30 years nodes in some countries have had access to stations provided by UNESCO, USGS, CTBTO, GFZ Potsdam, GTZ and Africa Array. They have also been involved in collaborative research projects like seismotectonic map of Africa, GSHAP, GEM.
Scientists of ESARSWG provide information to government officials in the case of earthquakes, advise officials concerning disaster risk management and preparedness as well as seismic hazard maps and provide data for

building codes. In some countries governments have become more aware due to recent seismic events, but are very slow in implementing changes based on the provided information.
Scientists also offer their expertise to private companies (insurance companies, construction companies) concerning insurance claims with respect to mining, for construction sites of dams and stadiums etc with site specific assessments. These consulting services also enable them to generate revenue to fund their activities. Finally, they are also engaged in outreach activities by providing information to the public.

Network governance and integration: ESARSWG is an informal scientific network that does not have a formal legal status. The node coordinators are currently working on a constitution to formalise their relationship and to be better equipped to raise funds from their respective governments. There are some overlaps in aims between ESARSWG and other international organisations such as the Africa Array project as well as the African Seismological Commission. This offers the opportunity for regular exchange. Apart from that the collaboration and exchange among the nodes is more of an ad-hoc nature. In case of an event, they contact colleagues from neighbouring countries in order to locate the event. In that sense, the funding of ISP has a great impact, because it ensures the connection among the node members.
However, there are also challenges with respect to the planning and communication. For example, the network could plan workshops and meetings further in advance. In addition, younger members perceive that the communication is only taking place between the older long term members/node coordinators and that newcomers are not properly introduced to the network's history, past activities and achievements. ESARSWG does not have its own website and lacks a regional data repository. Furthermore, some nodes feel excluded when not being elected as head of network - giving sentiment of exclusion and lack of ownership within the network. It should be noted that this may in part reflect differences in the level of experience and prioritisation of seismological activities in different nodes.
Another issue is tackling gender inequality in the network. Gender sensitive recruiting would be the job of the different node institutions. The lack of gender representation is acknowledged at each institution, but no solutions were formulated. This is no particular problem of the network or the geosciences, but of basic sciences in general. So far there seems to be little awareness among the male network members concerning the reasons for the lack of gender representation among students and staff and how to retain women technicians, analysts and scientists in the field.

Key Recommendations

Training:

- The workshop-based analyst training program should continue, longer (1 month) visits to a highly capacitated node could be considered if a major lack of capacity develops at a node due to personnel changes.
- lack of PhD-holders within the subject. Sandwich courses between an institution with a number of researchers and a high level of current capacity, such as Ethiopia, and local institutions may be a useful and cost-effective model and could be supported by ISP.
- In cases where the nodes are situated at government agencies with universities that lack geophysics programmes, one suggestion to facilitate the cooperation within the network would be to establish partnerships between the universities in all member states and to incorporate universities in, e.g. Mozambique and Zambia in the postgraduate capacity building.

Research and Knowledge Transfer:

- Provide network support to allow all members to contribute a minimum of one station, preferable real-time, to the network. Given funding constraints this support should be focused on nations which are struggling to provide any data to the collective, rather than be regarded as a 'right' for all members. In some cases this support may need to take the form of equipment purchase, but it could also mean funding for the maintenance of existing equipment.
- Greater emphasis be placed on providing support for equipment maintenance to keep stations running.
- Encouraging smaller-scale projects with two-or-three partners would lead to more manageable research questions and more frequent publications (although this must be balanced carefully to ensure that all nodes benefit from network activities).

Network governance and integration:

- Develop a more formalised structure for the network in order to acquire funding as a network and to formalise cooperation with other networks.
- Develop measures to include younger scientist and technicians in decision-making.
- A gender representative within executive committee that discusses with gender representatives at the different nodes possible strategies to encourage more women to join the field of geophysics and to continue in the field of seismology.

2. Introduction

2.1 Regional Seismo-tectonic Context

ESARSWG member countries lie along the East Africa Rift System and associated secondary fault systems. The East African Rift is a divergent plate boundary which is extending at a rate of 5mm/yr in Ethiopia reducing to less than 1 mm/yr in southern Mozambique. The rift system changes significantly in character and morphology along its length. Rather than forming a single simple structure the rift consists of multiple distinct branches separating relatively stable regions. Recent seismicity clusters along these branches, but regionally large earthquakes have occurred away from these recognised rift segments (e.g. the 2015 Mw6.5 Central Kalahari earthquake in Botswana). The largest earthquakes which have occurred in recent years are the Mw7 2006 Macheze earthquake in Mozambique and the Mw7.2 1990 Juba earthquake in South Sudan. Both of these events were large enough to cause very considerable damage and they occurred on faults which had not previously been identified as major sources of seismic hazard (indeed the causative fault of the Juba event is still to be definitively identified). This emphasises the need for data gathering and seismic hazard modelling. The extension rate of the rift system is relatively low (compared to other plate boundary zones), however this means that the repeat time between large events on a single structure is likely to be on the order of hundreds or even thousands of years. As a consequence there is often no known historical record of large events on faults which nevertheless pose significant seismic hazard. The rapid recent development of the region has resulted in much higher potential population exposure to individual large events. It has been globally recognised that sustainable development requires resilience to geohazards, such as earthquakes, to be incorporated into national development plans in a responsible data-driven way.
In comparison to most continental plate boundaries the region is sparsely instrumented. The level of instrumentation is also inhomogeneous with large areas completely uncovered at a local, and even national, level. This leads to varying magnitude completeness levels across the region and adds to the location uncertainty for smaller events in some regions. In addition to the small number of permanent stations, intended to report for reasonably long time periods, a number of temporary networks have been deployed across the region. These networks are generally deployed for a few months to 3 years as part of a major international research projects. These projects are generally designed to collect data to monitor volcanic processes or to constrain crustal and lithosphere-scale structure rather than to facilitate seismic hazard assessment. A detailed and homogeneous seismic catalogue is one important input to an accurate seismic hazard assessment. Other important inputs include detailed fault maps, geodetic estimates of fault loading rates, a historical catalogue, paleoseismic studies of active faults, accurate local attenuation relationships, and detailed maps of local site characteristics which can amplify the effects of ground shaking. All of these inputs require significant technical skills and some require access to expensive technical equipment.

2.2 Aim and structure of the evaluation

This evaluation has the aim to assess the development of the ESARSWG-network since the inception of ISP funding in the late 1990s: “The purpose of this evaluation is to analyse and assess functionality, developments,

and impact of the ESARSWG network and its activities since the start of ISP support in 1997. This is to provide ESARSWG and ISP with indications of the progress and development of the Network, and to provide input and recommendations on improvements and future directions." (ToR, p. 3) More specifically, the ToR spell out that the evaluation has the aim to to analyse and assess the relevance, efficiency, effectiveness, impact and sustainability of the network and its nodes in relation to ESARSWG's own set goals and objectives (ibd). Commissioning an evaluation is in line with IPS's 'Results based Approach' in order to shed light on achieved goals of its long-term support and to improve its program and funding mechanisms (see ISP Strategy 2013-2017).

After introducing the report with regard to its topical relevance for geosciences, the aims of the evaluation and the methods applied, the report is structured in three parts: First, we outline ISP's and the network's rationales and objectives to achieve a heuristic starting point for the evaluation. The rationales help to understand ESARSWG's own set goals and objectives over the course of its existence. These and the funding framework of ISP are the objectives against which the current status quo are assessed. This section (3) also contains a review of the network's structure and governance mechanisms, which shape its working [ToR: 1-3, 18] [1].

In the following section (4) we assess the three particular objectives of the network: its training-aims of technicians and researchers [ToR: 12, 15-16]; its research efforts, which comprise data collection, catalogue compilation, data processing and research publication [ToR: 5-8, 10-11, 18]; and finally the knowledge transfer towards governments and international networks [4, 13-17, 19, 20]. While the research-part affects, among others, the question of research quality, the transfer-part sheds light on the network's broader relevance and impact. We conclude all three assessments with specific recommendations that can inform future strategies and planning both of the network and of ISP.

The final section (5) contains a ranking of challenges and a list of key recommendations we consider necessary to work towards the network's continuous relevance and sustainability. This complies with the task spelled out in the ToR to identify " the main bottlenecks for increased networking in earthquakes monitoring" and to suggest measures to address the bottlenecks [ToR: 21]. We use part of the follow-up survey to show what network members consider as the most pressing challenges and complement these impressions with key recommendations, including financial sustainability [Tor: 22].

2.3 Methodology

The ex-post evaluation is based on desk-studies, interviews with participants from nodes and on interviews with stakeholders from selected nodes and funders, and on a survey to respond to the key questions of ISP (relevance, effectivity and efficiency, impact, and sustainability). The evaluation itself has two dimensions: a descriptive-analytical and a formative dimension. Throughout its process, the team followed a simplified log-frame model, containing the objectives of ISP and of network-members, the planned and pursued activities over the funded years and its outcomes. However, the evaluation team will go beyond the simplified framework and will include reported obstacles that prevented the implementation of activities in the past. The emerging model helped us evaluators to arrive at a conclusion for further network activities that can achieve higher levels of sustainability.

The descriptive-analytical dimension

A thorough desk-review of available data from ISP formed the basis of interviews and selected site visits. Most quantitative indicators (persons, instrumentation, publications, cooperation) were drawn from the self-evaluations and the annual reports. We also identified a lack of data as a limitation. Furthermore, we tentatively

[1] The numbers indicate to which specific questions of the Terms of References (ToR) we respond to. See Appendix 2 for the complete list of questions.

use data from UNESCO and other science policy-sources to make sense of specific national and regional challenges and opportunities. However, UNESCO-data shows gaps and often refers only to the last available data from many years ago with only few updated information. Given the opportunity to attend the general meeting in October 2019, all present representatives of nodes were interviewed with the aim to gather further information about the historical and recent development of nodes, national challenges and opportunities and regional networking in training, instruments and research. Additionally, the interviews aimed at gathering the contact information of other team members. Furthermore, we held one meeting with the responsible ISP-directors for the Physics-Department, Carla Puglia and Ernst van Groningen in December 2019. Further personal as well as written interviews were conducted with members of the ISP-physics reference group in January and February 2020 to receive further insights on the evaluation process and selection of proposals from the network. Perspectives were also obtained from selected international researchers. These perspectives helped to get a better understanding of the scientific field of all nodes and their international collaborators and competitors. To arrive at more specific insights into the working conditions of network members, we decided to visit four nodes. These visits helped us to gain a broader understanding of the collection, research and training environment, including obtaining an impression of the used instrumentation. Being in these countries also allowed us to interview stakeholders such as government and university experts, users of seismographic data and national funders. Interviews with stakeholders also helped to assess the network's national and regional relevance and opportunities for further impact and sustainability. Uganda (UG) was set as the country that hosted the general meeting. The other selected countries were Mozambique (MZ), Tanzania (TZ) and Ethiopia (ET). The sampling is justified because of the historical position as founding member of UG, ET, and TZ and the more recent member Mozambique. Moreover, the sampling is following the challenges collected from the self-evaluations. While Ethiopia seems to give a more self-contained impression, Tanzania shows a higher degree of international outreach. Additionally, the four nodes give insights in the network's different participants: while in UG and MZ analysts are from government organisations, they stem from universities in ET and TZ. This reflects the participation of both groups in the network. Contrary to our plan to conduct a first survey among all staff beyond node-coordinators, including as well alumni, we adapted our plans during the evaluation due to the availability of staff-interviews at the nodes. All staff-members were, however, invited to the survey based on our conclusions, where we gave the opportunity to raise further points. Since we were not able to achieve more information about network-alumni we did not follow up on integrating them into our research.

The formative dimension

While all collected information helps to describe the network's progress and current state, the evaluation has an overall formative effect in the sense that its results will be used to inform future grant applications and ISP's assessment. To assure that our interviews and data-interpretation captured the most significant achievements, challenges and led us to formulating fitting recommendations, we decided to present our preliminary results to the network's members in form of a follow-up survey. During the survey, its items have informed all invited participants about our preliminary results and indirectly about issues that were brought up in other interviews and self-evaluations. The survey-participation was voluntary and confidentiality as well as anonymity was assured to all respondents. In this survey we presented positive developments and challenges we identified as well as recommendations we propose with this evaluation according to the ToR [see questionnaire in Appendix 1.3.]. Participants had the opportunity to comment on our summaries. Furthermore, we offered the option to rank the importance of challenges according to participant's views. The results are integrated into our analysis below. All node-coordinators were asked to forward the invitation to their staff-members to increase the participation. The survey was open for participation from March 15 to April 6, 2020 and received 11 full and 1 partial responses. We used the German survey provider SoSciSurvey to conduct the follow-up survey (https://www.soscisurvey.de/).

3. The network's rationales, history and governance

The network brings together a heterogeneous group of researchers, analysts and technicians, who aim to collaborate to achieve in-depth seismic information on earthquakes, and to use these data to inform governments and other stakeholders in their efforts of hazard management. However, the network also works in a region of heterogeneous countries with different science policies, research and training capacities and research and development (R&D) priorities. This diversity forms the context of the network's historical development and current work. Context-variables such as general training capacities in higher education (including, for instance, the number of female students in the geosciences), availability of public and private sources for R&D or the number of researchers per country need to be kept in mind to understand the objectives and strategies of ISP and ESARSWG.

We want to shortly illustrate the network's context with reference to funding of R&D in all nine countries, although the often-consulted data from UNESCO remains fragmentary. Data on gross domestic expenditure on R&D (GERD) reflects the dominance of government and foreign funding sources, with the business, higher education, private non-profit-sectors contributing only smaller parts. [1] All countries of the network share a high amount of foreign sources as contributions to their research capacities and studies, which range from 19.1 percent in Ethiopia (2017) to 52.4 percent in Uganda (2014). In international comparison, African countries tend to have an underfunded science and technology sector in relative and in absolute terms.

Table 3.1: GERD as Percentage of GDP and Sources of GERD (latest available data)

Country (year)	ER (2017)	ET	KE (2010)	MW	MZ (2015)	UG (2014)	TZ (2013)	ZA (2008)	ZW
GERD as % of GDP	0,27	n/d	0,79	n/d	0,34	0,17	0,51	0,28	n/d
Sources of GERD-Funding									
Business	1,51	n/d	4,34	n/d	0,47	3,41	0,08	3,23	n/d
Government	73,39	n/d	25,96	n/d	43,49	37,89	57,53	94,83	n/d
Higher Education	3,13	n/d	19,02	n/d	13,32	2,31	0,33	n/d	n/d
Private non-profit	1,45	n/d	3,53	n/d	3,02 (2010)	6,05	0,05	0,322	n/d
Foreign sources	19.1	n/d	47.1	n/d	39.9	52.4	42.0	1,6	n/d

The data suggests that if the national governments (and businesses) are not stepping up their commitment to R&D (e.g. [1]) - their scientists will remain looking for foreign sources to sustain their work within the country. At the same time, the continuous limited national and regional funding sources offer less opportunities of acquiring funding locally.

[1] Data here reflects the latest available data. A longitudinal study would reveal changes in amounts of GERD and in spending patterns of sectors. For most of the 6 countries with data one can see decreases by businesses and private non-profit organisations spending after the global 2008 financial crisis.

3.1 ISP and ESARSWG rationales

ISP rationales

The ISP supports diverse research networks in low-income countries with a specific focus on the basic sciences, including the geosciences. Many institutional and network funding comprise technical capacity development and postgraduate training through the long-term support of infrastructure, research and training. The overall goal is to strengthen domestic research capacities within the basic sciences and to foster its use for development aims [2]. ISP implements its support through different funding formats: research groups, universities, and regional and interdisciplinary research networks.
The network-rationale is to create instances of scientific cooperation and complementary activities, sharing equipment and expertise of postgraduates across borders. Among the expected outcomes for low-income countries are more postgraduates, who produce and use quality research results in the world as a whole and produce relevant development-related research in particular (ibid). Funding for research groups and networks can overlap, encouraging the groups to cooperate more intensely and developing research that cannot be done by individual researchers.
The main funder of ISP is the Swedish Development Agency (SIDA) that shapes the framework of supporting research and training in low-income countries. Other funders are Uppsala University and Stockholm University. ISP acknowledges in-kind support, but admits that it has yet to be accounted for financially [2]. Hence, participating collaborators in low-income countries contribute to the network's support and maintenance.
Due to its large government funder ISP hence refers to the priorities of the Swedish government. Changes of Sweden's development policy during the last decade has led some network nodes to lose access to direct funding (Tanzania) or not to be eligible for direct research group funding (Mozambique). This can lead to limitations with funding postgraduate education and maintaining instrumentation. A lack of funding for all nodes has led to the development that some network nodes have to raise funds through other sources to remain functional within the network. ESARSWG members currently funded by ISP as research groups are at Addis Ababa University, University of Nairobi and National University of Science and Technology in Zimbabwe.
The ESARSWG-network differs from other ISP-funded networks insofar as it does not comprise training for MSc and PhD and does not put a strong emphasis on research activities per se (see sec. 3.2.). The directors of the IPS Physics department as well as members of the reference group acknowledge this development. Given the close relationship between the training for MSc and PhD and publications, the absence of training as well as the different primary aim of the network (coordination) helps to explain the low number of publications. However, ISP encourages to include training and publication into future applications.

ESARSWG rationales

The ESARSWG-network was founded with the objective to collaboratively generate data on seismic events along the East African Rift System (see 1.1 and 2.2). The overall objective according to the 2016 grant application is: "Networking in earthquakes monitoring in the ESARSWG region to mitigate seismic hazard while capacity building in the region in both manpower and equipment" (ToR). In line with ISP's long-term objectives the specific aims for the period of 2017-2019 were:

- compilation and exchange of national bulletins and annual network bulletins
- training of seismogram analysts and technicians
- production of regional attenuation relations
- calculation and determination of seismic hazards for the ESARSWG region.

Earlier objectives included the increase of station coverage in all participating countries and to conduct collaborative research on the basis of data collection. One of the earliest objectives was to train technicians and analysts to produce data from analogue instrumentation. The network has hence not significantly changed its objectives of the course of its 25 years existence.

3.2 Network History

The east african network developed in 1988 funded by UNESCO and the University of Uppsala. In 1990 UNESCO funded stations in Uganda, Tanzania and Kenya. Additional countries joined in 1992. ESARSWG was established during a training workshop for the SEISAN earthquake analysis software at the University of Dar es Salaam in September 1993 with 8 countries. The result of the workshop was a publication in BSSA, a regional seismic hazard map as part of the Global Seismic Hazard Assessment Program (GSHAP). ISP has been funding the network since 1997. The Moçambican node joined in 2008. The goal of the network is data sharing, compilation of bulletins and catalogues and capacity building of earthquake research scientists, technicians and analysts through workshops.
Since its inception the network has gone through different stages. While there were not stations in the beginning the regional seismic network developed with the donation from UNESCO, but did not yet have the analysis capacity. This changed with the use of Seisan. It followed a gradual station densification and the different nodes changed at different times from analogue to digital stations. Only some nodes have now gradually moved to real time stations. Some network members are also investigating the use of SEISCOMP3 software.

Country	Joined ESARSWG	Coordinating Node	Personnel: PhD/other Ac./ Supp.	No. of Women	Operational Stations (remote/real time)	Based at	Current Node Coordinator
Ethiopia	1993	2005	2/8/0	1	0/8	Addis Ababa University	Atalay Ayele (PhD)
Eritrea	1993		1/3/1	1	3/1	Eritrea Institute of Technology	Ghebrebrhan Ogubazghi (PhD)
Kenya	1993		No submission			University of Nairobi	Gladys Kianji (PhD)
Malawi	1993		0/2/10	3	11/0	Geological Survey with Catholic University of Malawi	Lostina S. Chapola (MSc)
Mozambique	2007/8	–	0/6/2	0		National Institute of Mines	Helio Filemone Inguane (MSc)
Tanzania	1993		3/2/1	0	11/0	University of Dar es Salaam with Geological Survey, Dodoma	Richard Wambura Ferdinand (PhD)
Uganda	1993	2015-2020	1/4/3	1	5/0	Directorate of Geological Survey and Mines	Fred Alex Tugume (PhD)
Zambia	1993		0/5/7	4	5/1	Ministry of Mines and Minerals Development	Daniel Mutamina (MSc)
Zimbabwe	1993	2008-09, 2012-16	2/3/2	1		National University of Science and Technology with Meteorological Services Department (GOETZ OBSERVATORY)	KwangariMarimira (MSc)

3.3 Network Structure and Personnel (including Gender)

The network nodes are run either by geology departments of public universities or the national geological surveys. In some countries the university and government departments cooperate formally, in others there is an informal division of labour. In some countries the location of the node changed with the personnel in charge. In Malawi and Zimbabwe there are strong informal and personnel ties between the organisation. While the node is situated at the National University of Science and Technology in Zimbabwe the attending analyst was an employee of the geological survey. The head of the Malawian node is a lecturer at the Catholic University, but worked at the geological survey for many years. In the case of Tanzania, the department at the University of Dar es Salaam and the Geological Survey in Dodoma both form part of the node. In general the roles and tasks of university departments and geological surveys differ strongly. Tasks of geological surveys include monitoring seismicity, creating geological maps and advising the government in geological affairs. As government departments they have a larger staff of technicians and analysts. The role of university departments is to train undergraduate and graduate students and to conduct geological or geophysics research. While it is difficult for university departments to employ technicians and seismogram analysts to monitor and maintain seismological stations, geological surveys often lack the capacity to conduct research. The two types of organisations can

complement each other, while universities are better positioned to conduct research and postgraduate capacity building, geological surveys have more options to budget for technicians and analysts and to provide funding for the maintenance of equipment. In reality, however, the funding and maintenance of equipment through public funding is one of the major problems and a large group of the nodes. Since graduates of geological study programs oftentimes work at geological surveys and employees of the survey either return to academia or attend courses and university departments there is a regular exchange and overlap of personnel between the two organisations irrespective of formal agreements. This also means that in cases of low capacity in research or monitoring both types of organisations can support each other to achieve their common goals. The collaboration among the nodes is not impacted by the difference between government agencies and universities. In some of the countries where the node is located at a geological survey, the university departments lack a division and study programmes for geophysics and seismology. Some researchers noted therefore that cooperation with countries with small geology departments and no contact person. In general the funds for meetings remain crucial for collaboration across borders, including meetings with potential students.
The personnel at the nodes are mainly seismologists, seismogram analysts and technicians. The majority of nodes have at least one employee with a PhD. In the following table we have listed the number of personnel in different categories according to degree and the representation of women at each node. According to the self-assessment questionnaires there are no women employed at two nodes, while the rate of women at the remaining 7 nodes varies between 10 to 30%. Only two of the node coordinators in the network are women. These two lecturers and a young female technician were the only women attending the general meeting of roughly twenty participants. There is no ESARSWG wide strategy for tackling gender inequality in the network, despite ISP's strategic focus on gender equality. Gender sensitive recruiting would be the job of the different node institutions. The lack of gender representation is acknowledged at each institution, but no solutions were formulated. This is no particular problem of the network or the geosciences, but of basic sciences in general. So far there seems to be little awareness among the male network members concerning the reasons for the lack of gender representation among students and staff and how to retain women technicians, analysts and scientists in the field.

Table 3.2: Survey-response: Summary recommendations: institutionalise a gender related strategy by naming a gender and/or diversity secretary in the executive committee and the coordinating node

	Frequency	Percentage	Valid Percentage
Neutral	2	16,7	18,2
I agree	2	16,7	18,2
I fully agree	7	58,3	63,6
Total	11	91,7	100,0
I don't know	1	8,3	
Total	12	100,0	

Recommendations

1. Enquiry into the factors that lead to the poor representation of women in the network and develop gender-related strategies based on the findings.

2. A gender representative within executive committee that discusses with gender representatives at the different nodes possible strategies to encourage more women to join the field of geophysics and to continue in the field of seismology.

3. The network and individual nodes should expand outreach activities to target especially girls and young women.

4. In cases where the nodes are situated at government agencies with universities that lack geophysics programmes, one suggestion to facilitate the cooperation within the network would be to establish partnerships between the universities in all member states and to incorporate universities in, e.g. Mozambique and Zambia in the postgraduate capacity building (e.g. through sandwich programmes and co-supervision).

3.4 Network Governance and Communication

ESARSWG is an informal scientific network that does not have a formal legal status. The node coordinators of the member countries form the General Meeting, which is responsible for the overall policy. The General Meeting elects the members of the Executive Committee, which executes its policies, for a term of four years. Members are the Chairperson, Vice-Chairperson, Secretary and the Treasurer. They hold regular planning meetings to develop plans for the implementation of the network's activities and are free to involve node coordinators who are not formal members of the Executive Committee. The node coordinators are currently working on a constitution to formalise their relationship and to be better equipped to raise funds from their respective governments. Still they would have to deal with the differing regulations in the member countries. There are some overlaps in aims between ESARSWG and other international organisations such as the Africa Array project as well as the African Seismological Commission. This offers the opportunity for regular exchange. Apart from that the collaboration and exchange among the nodes is more of an ad-hoc nature. In case of an damaging event, they contact colleagues from neighbouring countries in order to locate the event. In that sense, the funding of ISP has a great impact, because it ensures the connection among the node members. By exchanging information about events, they can provide more accurate information to their respective stakeholders in government and society. However, there are also challenges with respect to the planning and communication. For example, the network does sometimes not plan workshops and gatherings in advance. The date and place for the general meeting in October 2019 was only set and communicated one month in advance. By that time, some of the network members had already made their plans for field visits and conference attendances. In addition, a lot of younger members perceive that the communication is only taking place between the older long term members/node coordinators and that newcomers are not properly introduced to the network's history, past activities and achievements. Regular communication can be difficult, because some network members are unresponsive via whatsapp or email. ESARSWG does not have its own website and lacks a regional data repository. Furthermore, some nodes feel excluded when not being elected as head of network - giving sentiment of exclusion and lack of ownership within the network.

Recommendations

1. Develop a more formalised structure for the network.

2. Set up a website for the network and a communication platform to share information.

3. Set up a regional data centre that can be accessed by network members.

4. Set up a Whatsapp group to facilitate communication among younger members.

5. Set up a yearly plan for activities, so that members can block the time of the workshops in advance.

6. Include technicians in the network meetings, so they can exchange knowledge and information.

7. Develop measures to include younger scientist and technicians in decision-making.

4. Results

4.1 Training

There are two training streams within the network. The main stream is operational in nature (connected to the routine processing of seismic data and catalogue creation). Originally training in station deployment and data analysis using SEISAN (a software package often used for seismological research) was provided through the network. At first scientists from Europe provided direction through a workshop in 1993, but capacity quickly developed to allow regional training, generally tied to bulletin production workshops. This training typically lasts for one or two weeks and continues to the present. It is consistently praised by participants at all levels in the network. A number of nodes report significant problems in retaining trained staff at both analyst and seismologist level necessitating an ongoing training program to retain capacity. Most nodes have at least one skilled analyst with expertise in SEISAN. Many nodes, particularly university nodes, have a small number of trained analysts. Without the regional network there is a danger of capacity being lost with individuals leaving the node through retirement, death, or career change. The regional repository of knowledge at network level is one of the main strengths of the organisation. If funding were stopped it would likely quickly result in a significant loss of capacity in at least some nodes. When a gap in expertise develops (there is a period with no experienced SEISAN user at a node) then some participants suggested that a slightly longer training period may be beneficial. It is also important that the network keeps up with global trends in seismic monitoring. The network should consider adopting new software (such as SEISCOMP3) and new technologies (such as real-time stations) and incorporate these into their training program as appropriate.
The second training stream is at MSc and PhD level. At the beginning of the network a number of participants received PhD training in Sweden. They have gone on to have distinguished scientific careers and some have been retained by the network providing significant regional capacity. Training then switched to the regional level. A number of participants received MSc training in the Ethiopian node (although this only operated for a limited period of time and for a small number of students). This program (ISP-funded scholarships for degrees in Ethiopia) is not currently active. A number of countries have also trained (and are training) PhD and MSc students locally. The current model is problematic in countries which lack an academic institution with professors with a high level of seismology expertise. Some countries also have a limited amount of seismological data which could prevent local research projects at PhD level. There are also considerable problems in obtaining funding for postgraduate stipends in some countries. In other countries, especially those involved in major international research projects which generate large amounts of data, there has been steady local and international training of MSc and PhD-level geophysicists. The unevenness of capacity for higher-degree level training is a challenge that is recognised by the network (see table below), and strategies should be adopted to mitigate this.

Once trained there is a major challenge in retaining individuals with higher degrees. The local salaries available are not competitive compared to those offered by global seismological organisations (such as the ISC and the CTBTO) and so a number of graduates have moved abroad. Other regional organisations such as the Council for Geoscience in South Africa have also attracted network members. Members have also left for industry-related jobs. The fact that network members have taken up roles in prestigious international organisations should be (and is) a significant source of pride for the network, but it poses problems for regional capacity

Table 4.1: Survey responses: Summary of Challenges: There are disparities in number of PhD-holding staff between the nodes.

	Frequency	Percentage	Valid Percentage
I agree	5	41,7	45,5
I fully agree	6	50,0	54,5
Total	11	91,7	100,0
I don't know	1	8,3	
Total	12	100,0	

development. Individuals who have chosen to remain part of the research network report being motivated by the love of their country and their love of science. Some analysts mentioned that the travel and networking aspect of their jobs was part of their motivation. It therefore seems that the network is playing an indirect role in the retention of trained staff. Brain drain will remain a major challenge for the foreseeable future, underscoring the need for the ongoing training of as many individuals as possible.
There is less network-based training available for technicians, and the maintenance of stations is a serious problem at some nodes. It is possible that more technical training could help to keep stations running for longer. The fact that each node operates different instruments, and that modern instruments usually require component replacement rather than ad hoc repair does limit the utility of regional technical training. More informal direct contact may help to improve technical experience and capacity. Where network maintenance is a particular difficulty, node visits by regional or international technical experts may help to build capacity. As new technologies, such as real-time data collection, spread through the network initial training on the new equipment may be beneficial (see table 4.3.).

Table 4.2: Survey-response: Summary of challenges: building a pipe-line of skilled technicians is a considerable challenge.

	Frequency	Percentage	Valid Percentage
I don't agree	1	8,3	9,1
Neutral	2	16,7	18,2
I agree	2	16,7	18,2
I fully agree	6	50,0	54,5
Total	11	91,7	100,0
Not answered	1	8,3	
Total	12	100,0	

The development of new premises for the IGSSA in Addis Ababa with significant government investment presents a possible opportunity for the network. The university has excellent research and training capacity and will have a research institute with cutting edge facilities in the next two years. The staff and institution also have the ambition to provide a regional training resource. In previous programmes the University has provided support by, for instance, waiving fees for foreign students.
The combination of large quantities of data available in many nodes (especially with geological surveys) and a number of experts in various fields (especially within University nodes) represent a significant resource on which to build postgraduate theses. Co-supervision of research students across the network could lead to improved training and increased capacity.

Table 4.3: Summary recommendations: provide minor network funding to foster the regional exchange of skilled technicians for trouble-shooting and training.

	Frequency	Percentage	Valid Percentage
Neutral	1	8,3	9,1
I agree	1	8,3	9,1
I fully agree	9	75,0	81,8
Total	11	91,7	100,0
Not answered	1	8,3	
Total	12	100,0	

Recommendations

1. The workshop-based analyst training program should continue, longer (1 month) visits to a highly capacitated node could be considered if a major lack of capacity develops at a node.
2. Informal direct contact between both analysts and technicians (by for instance WhatsApp groups) should be encouraged (See Sec. 2.4.)
3. Avenues for funding of regional postgraduate studentships should be explored, especially for nodes with a lack of PhD-holders within the subject. Sandwich courses between Addis Ababa and local institutions may be a useful and cost-effective model.
4. There are a number of possible options for funding such an initiative: A) Increased network funding, B) Where institutions in member countries receive direct ISP funding some of this could be allocated to bring or send members of the network for sandwich-course visits, C) Other external funding opportunities, including government programs could be considered.

4.2 Research

Data Collection

Data collection capacity varies greatly across the network. This is the most important challenge faced by the network as it directly impacts their ability to achieve their primary goals in some member states. Training, bulletin creation and seismic hazard analysis are all compromised unless at least some data is generated. Capacity varies from 9 stations with significant real-time data transmission capabilities (with additional stations operated by international networks) to countries with long periods of no data collection. Three nodes did not bring data to the most recent catalogue creation workshop. The reasons for a lack of data collection are complex and vary from node to node. They include:

- The lack of operational instruments. In some cases this is because there has been no funding to replace obsolete analogue instruments, but in others it is due to difficulties in repairing, maintaining and safeguarding deployed stations.
- An inability to fund trips to existing stations to service them and collect the data (this is particularly a problem for university-based nodes where such routine activities are typically not funded by local government).
- Unresponsive procurement processes and excessive delays in the release of funds which can greatly delay operational tasks.

Table 4.4: Survey-response: Summary of positive findings: long period of data creation is an important achievement of the network

	Frequency	Percentage	Valid Percentage
Neutral	1	8,3	9,1
I agree	2	16,7	18,2
I fully agree	8	66,7	72,7
Total	11	91,7	100,0
Not answered	1	8,3	
	12	100,0	

A number of national and network-level interventions are required to improve the situation. Support for station servicing and repair could help some countries maintain a minimum data collection capacity. This could take the form of the sharing of technical expertise, limited funding for repairs and replacements (although it is recognised that at the current funding level the ability to replace instruments is very limited) and basic maintenance field trips.

During the next funding cycle it would make sense for all member countries to commit to providing data from at least one station to catalogue creation workshops. For this to be feasible the network would need to focus funding on countries which currently lack the capacity to meet this commitment. This could take the form of a one-off purchase of a single broadband seismometer for countries which have no operational instruments or limited funding for travel and parts to support station maintenance. There are also a number of advantages to operating real-time networks, especially in countries where site visits to remote stations only occur very occasionally and during disaster response. A number of nodes have real-time instruments installed, and depending on the existing instrumentation some stations may be upgraded at relatively low costs. Where possible new stations should incorporate this technology and the network should consider how they can support this transition.

Ultimately sustainability requires governmental investment for equipment maintenance and operation. The situation is better in some nodes than others, but all require additional support. A number of interviewees noted that additional government funding is only likely after a major regional or local event. A necessary precondition for such additional funding is that governments perceive there to be a credible body of expertise to invest in. The ESARSWG network is already greatly helping to promote this perception at a number of nodes.

Larger one-off funding injections are also needed to replace, expand and upgrade instrument networks. It is likely that this will only be possible by combining increased local government investment, aggressively pursuing international funding opportunities and, where possible, obtaining equipment donations at the close of collaborative projects with international research groups. Where such donations are obtained by individual node members the network may play a role in providing technical support to ensure that they are being operated optimally. A long term goal could be the development of a network equipment pool to support countries with restricted national networks and for rapid deployment after a future major event. It must be acknowledged though that there are significant logistical obstacles to transporting bulky and expensive equipment across borders.

Catalogue Creation

Catalogue creation is one of the core activities of the network. This work is done at annual meetings hosted on a rotational basis. At these meetings representatives from all nodes bring processed phase data, which should have been created throughout the year, and this data is combined and analysed to produce the catalogue. The host node will be best represented at the meeting and bears the primary responsibility for catalogue creation

in that year (though members of all nodes contribute their expertise during the process). These meetings are usually also combined with training workshops. There are both advantages and disadvantages to this model. Regular rotation is made difficult due to the differing transport associated with different host countries. There are reports that differing capacity at different nodes have led to annual variations in catalogue quality. There is no technical reason why it is necessary to gather for these meetings - a catalogue could be created using phase data sent electronically. However the creation of seismic catalogues is a very particular type of scientific exercise. The nature of the problem requires data to be shared across international boundaries, and so these exercises require a strong element of scientific diplomacy. This is particularly so because the repositories of these data are often government institutions with strict and bureaucratic data policies. In addition, within the regional context, there is the need to pool expertise and training to maintain critical skill capacity at all nodes. In this context physical gatherings are an essential part of ensuring all participants experience co-ownership of the catalogue, and incentivising the data production and sharing necessary for the catalogue to continue. The COVID-19 emergency is an obvious short-term challenge to this model, and the group is encouraged to experiment with an e-meeting this year to allow catalogue creation and training to continue. It would be wise to try to replicate as far as possible the interpersonal interaction of the normal catalogue creation meetings as possible into this activity (rather than expecting nodes to simply email phase data to a single coordinating node). In the long run regular in-person meetings are likely required for the effective continuation of the project.
The catalogue is a valuable product of the network, as is the phase data generated to create it. Both of these are fed to the ISC which uses this information to generate their highly regarded global catalogue. Such global catalogues require regional and national data collection capacity to be effective. The network should consider how to make their own catalogue more visible internationally. They should consider making it more accessible online and perform studies on its completeness and accuracy for publication in scientific journals. This would be an example of a possible valuable joint research project.

Data Sharing

There is general agreement that the sharing of data is a major success of the network. Universally network members report rapid international data-sharing in the event of a damaging or strongly felt earthquake. This has the benefit of potentially providing much more accurate epicentral locations to government stakeholders (disaster management centres, usually situated in the office of the prime minister). Due to the loss of local communication links in the event of a damaging earthquake such information is of great value in mobilising emergency personnel and can lead to significant reductions in fatalities. Stakeholders indicated satisfaction with the timeliness and quality of the information that has been provided by network members over the last few years. It should be noted that the sparsity of real-time data, especially in some countries, mean that there must be significant uncertainties in the locations provided in this way.

Table 4.5: Survey-response: Summary of positive findings: sharing of data among the network members is working well.

	Frequency	Percentage	Valid Percentage
I agree somewhat	2	16,7	18,2
I agree	6	50,0	54,5
I fully agree	3	25,0	27,3
Total	11	91,7	100,0
Not answered	1	8,3	
Total	12	100,0	

The catalogue itself is an important outcome of data sharing within the group. As more real-time stations go online it will be possible for automated real-time data sharing (rather than waiting for the catalogue-creation meetings) to take place either through a regional data centre or, more easily, through an existing international data centre such as IRIS. Globally there has been an important trend towards open data within seismology. This allows data collected for one purpose (such as earthquake monitoring by a national network) to be used for other purposes (such as whole-earth tomography, or the investigation of the core-mantle boundary) which are only possible with large global datasets. Increasingly it is viewed as best practice to contribute data to the global community. There is a careful balance which is needed here as well-resourced research institutes in Europe or America can use data to scoop regional researchers who may take longer to complete projects due to the local context (for example the number of researchers or the infrastructure capacity). The network should carefully consider if their data policies need to change to balance the benefits to global science, and research projects they have no plans to complete themselves, while also giving themselves the opportunity to complete research projects using the data they have collected. One option might be an embargo period of 3-5 years after which waveform data is made available. This is a complex issue and rather than making a specific recommendation, we urge the network to consider it carefully internally.

Joint Research Projects

It is acknowledged that the focus of the network is on long term monitoring and catalogue creation (which can lead to journal publications, but do not have to) rather than the creation of large numbers of research publications. They can have a significant impact by feeding into building codes and other government publications which are not very visible in 'academic' bibliographic analyses. Scientists at government institutes have other work responsibilities that take precedence over the time consuming process of writing journal articles. Where major international projects have aligned with the networks core priorities they have successfully contributed to these projects. This includes the regional participation in the GSHAP (Global Seismic Hazard Assessment Program) during the late 1990s, the GEM (Global Earthquake Model) program and the creation of the seismotectonic map of Africa during the 2010s.
In addition to this participation on global projects there was a journal publication associated with the SEISAN workshop at the beginning of the network which made the case for the utility of a regional catalogue. There has also been a bilateral research project between the Malawian and Tanzanian nodes using refraction seismology to investigate the Karonga region. One of the reasons for the comparative lack of 'ESARSWG' publications is the focus on looking for research opportunities that all members can participate in, rather than using the network to promote smaller-scale multilateral projects (with perhaps two or three partners) such as the Karonga project.

Table 4.6: Survey-response: Summary of challenges: there is a need to install mechanisms to encourage collaborative journal publication.

	Frequency	Percentage	Valid Percentage
I agree	2	16,7	16,7
I fully agree	10	83,3	83,3
Total	12	100,0	100,0

Where international projects have arisen which do lend themselves to large-scale multilateral regional participation the group has used these opportunities. It should also be noted that while there have not been many group publications, individual nodes within the network have very prolific publication records with publications produced with both local and international co-authors. It is likely that the capacity generated and sustained by the network has contributed indirectly to these studies, but it is difficult to measure this contribution.

Given the nature of the network and it's priorities we do not believe the relative lack of publications should be viewed as a failure. That said there are clear opportunities for this aspect of the network to be developed, to encourage both network-wide research projects and smaller scale regional research projects within the group. These opportunities include:

- A retrospective analysis of the catalogue accompanied by a publication to facilitate the use of the catalogue by the broader research community.
- A number of the government surveys are the repositories of large amounts of useful geophysical data which is not easily available to the scientific community. There are often analyses that these data can be used for which do not align with the principal priorities of these institutions. The close relationship between research-active survey and academic scientists is one of the unique and positive aspects of the network. It would be wise to explore the possibility of collaborative work on these datasets, perhaps in the context of the regional exchange of postgraduate students.
- Encouraging smaller-scale projects with two-or-three partners would lead to more manageable research questions and more frequent publications (although this must be balanced carefully to ensure that all nodes benefit from network activities).
- The network has made steps to broaden from a narrow focus on seismology to a more holistic view of seismic hazard assessment. As the network moves more towards performing or improving seismic hazard analysis it is important the evidence from other fields are incorporated into these assessments. It would be useful for the network to identify gaps in datasets available at individual nodes (for example detailed fault databases, geodetic data, perhaps even paleoseismic data) and to collaborate on filling these gaps. There are a number of excellent scientists associated with individual nodes who may not currently be integrated into the network who could help with this. It should be emphasised that these activities will be principally aided by the networking possibilities afforded by ESARSWG meetings rather than significant direct research funding. The activities associated with collecting and processing data from the seismic catalogue should remain the primary focus.
- The network should also consider how it can collaborate more formally in the immediate aftermath of significant earthquakes to aid with the immediate characterisation of the event, and to advance the scientific understanding of the hazard posed by the region.
- In the longer term it may also be useful to build relationships with engineers and social scientists to gain a broader view on this inherently interdisciplinary work. This could begin by inviting suitable local scientists to network meetings.

Seismic Hazard Assessment

The state of seismic hazard assessment varies greatly across the different nodes, but there is no doubt that the project has greatly improved it throughout the network. The catalogue data is a key input into seismic hazard assessments and the participation of the network in projects such as GSHAP and GEM creates a solid base on which to build. In some countries the hazard assessments are now quite old and an update would be immediately useful. In other countries nodes have recently recalculated their seismic hazard assessment, and in some cases are involved in detailed micro-zonation projects. One of the advantages of the network is the close direct links to governments at most nodes and so seismic hazard assessments can have considerable local impact once completed. In addition the recent experience in conducting these exercises at some nodes has created capacity that may be helpful for other members. While the situation varies significantly, all nodes could usefully improve their hazard assessments, especially through basic research aimed at providing new raw data to inform these estimates. In recent network funding proposals there has been increased focus on the creation

of hazard assessments, and aims have included the generation of a new regional attenuation model. This is one of the most difficult areas of research required for hazard assessment requiring expensive equipment (strong motion sensors) and appropriately placed events to calibrate the relationship. Creating a new attenuation relationship is a vital piece of research; but for now it will likely remain a long-term goal to work towards. It would be helpful if the group held a meeting (perhaps associated with a hazard collection workshop) to identify the current state of the various data inputs required for a seismic hazard assessment in all member countries, identified gaps, and embarked on (ideally collaborative) research projects aimed at filling these. It is encouraged that these do not focus solely on seismology, but also the creation of fault maps, geodetic information and historical seismicity, and that the pool of collaborators be widened to include other experts within node institutions.

Recommendations

1. Provide network support to allow all members to contribute a minimum of one station, preferable real-time, to the network. Given funding constraints this support should be focussed on nations which are struggling to provide any data to the collective, rather than be regarded as a 'right' for all members. In some cases this support may need to take the form of equipment purchase, but it could also involve funding from other sources.

2. Greater emphasis be placed on providing support for equipment maintenance to keep stations running.

4.3 Knowledge transfer and collaborations

The data collected and compiled in the catalogue are used in multiple ways to contribute to the needs of international academe, the region and the respective network countries. The network members share their data with IRIS and ISC and therefore insure that it can be used by the international scientific community. Beyond the collaboration and support by ISP, individual nodes collaborate with other international networks in the area of data collection and joint research projects. During the course of the past 30 years nodes in some countries have had access to (temporary) stations provided by UNESCO, USGS, CTBTO, GFZ Potsdam, GTZ and Africa Array. They have also been involved in collaborative research projects like seismotectonic map of Africa, GSHAP, GEM (see 3.2). Many nodes have collaborations with universities in Europe and America. However, in some cases western scientists do not focus on collaborative relationships, but use the network members' expertise to extract information to be analysed abroad. In some cases, instrumentation was left after the conclusion of a project, but no capacity building with respect to the maintenance was provided.
Scientists of ESARSWG provide information – sometimes collaboratively – to government officials in the case of earthquakes, advise officials concerning disaster risk management and preparedness as well as seismic hazard maps and provide data for building codes. In some countries governments have become more aware due to recent seismic events, but are very slow in implementing changes based on the provided information. Scientists also offer their expertise to private companies (insurance companies, construction companies) concerning insurance claims with respect to mining, for construction sites of dams and stadiums etc with site specific assessments. These consulting services also enable them to generate revenue to fund their activities.
Finally, they are also engaged in outreach activities by providing information to the public during fairs and exhibitions, create public awareness among school children and offer information by giving interviews on TV and writing newspaper articles.

5. Pressing challenges and key recommendations

5.1 Challenge-ranking from the survey

Participants of the follow-up survey were asked to rank the identified challenges according to their perspectives from 1 to 9.. In addition to the network's objectives and mechanisms, this ranking allows the current members to reconsider their priorities for future applications. Moreover, we as evaluators received valuable feedback after the interviews and self-evaluations on the challenges we identified.
All participants chose to rank the challenges. The following table illustrates the results. To facilitate the illustration the diverse responses were grouped: responses to rank 1 to 3 are summarized under group 1 ("very pressing"), to rank 4-6 under group 2 ("somewhat pressing") and to rank 7-9 under group 3 ("not pressing").

Table 5.1: Clusters of Challenge-Ranking

Challenge	Responses	Group 1	Group 2	Group 3
Disparities in equipment availability	12	9	1	2
Disparities in number of PhD	12	5	4	3
Equipment maintenance through site visits	12	5	4	3
Building a pipeline of skilled researchers	12	4	5	3
Building a pipeline of skilled technicians	12	3	2	7
Acquiring funding from other than ISP	12	2	8	2
The underrepresentation of women in the nodes and the network	12	2	3	7
Need to install mechanisms to encourage collaborative journal publications	12	3	2	7

The table suggests that disparities in equipment availability are considered as the most pressing issue by most respondents. A majority of nine find disparities in PhD-trained staff and equipment maintenance most pressing to somewhat pressing. Skilled researchers are important but a majority says it is only somewhat or not pressing. The skill-training of technicians is considered to be somewhat and by a large number as not pressing. Eight respondents consider acquiring and diversifying funding sources as somewhat pressing. A majority finds that the representation of women in the network and in nodes is not a pressing or only somewhat pressing issue, equally the challenge to encourage collaborative journal publications.
Other issues not listed for the ranking but added in open answer-fields by respondents include staff retention (twice), linking with government and government awareness (twice) as well as more transparency in the network's governance (twice) (see section 3.) These issues were not included in the ranking but seem to have an equal high status of pressing challenges for some respondents.

5.2 Key recommendations

The following non-hierarchical recommendations draw from the challenge-ranking and the assessment presented in section four of this report. All following key recommendations complement each other and could lead to higher levels of sustainability for the network:

- Acquiring and diversifying funding/support for either training and staff retention, research (including instrumental capacities) and knowledge transfer forms a prerequisite and consequence for the sustainability of ESARSWG. It should be further developed to support the long-term objectives of the network and to create new momentum for international collaboration. It should hence be attributed a higher position in the ranking of challenges.
  Some governments of the network have already applied for international funding to strengthen the nodes and its capacities (MZ), others plan to build new centres and include geophysics (ET, TZ). These initiatives could be starting points to strengthen the network. ISP and the review panel could be helpful in connecting the network to further potential supporters. Other modes could be learned from similar networks (e.g. MSSEESA), who have institutionalised and formalised their relationship and which installed membership fees.

- PhD-training and technician training will be crucial to increase the capacity in seismology and geophysics. Given the limited number of M.Sc. and PhD-programs in the region, the network could work towards international scholarships and regional placements (e.g. in Ethiopia) as well aim to form a training agreement with a higher degree of formality. Mobility of former students and researchers within the network proves that it can be feasible also in the future. Regional and international mobility of network members is also more likely to increase the visibility of ESARSWG in scientific and policy networks. Moreover, a formalised network is also more likely to be perceived as a group by potential funders and supporters.

- The network should participate in the general efforts to include more women researchers and technicians in their midst. A network and node-level strategy and an assigned post on the board seem necessary for this. The gender-issue should receive a higher priority for the network.

- To contribute to knowledge-transfer and science communication, more bilateral and multilateral research and publications would be desirable.
  The network provides a formidable starting point for this due to its regional coverage and its transdisciplinary composition of government institutes and university departments. Research and moreover publications can also have the effect of more visibility in scientific and policy networks and lead to more interactions with other regional and international seismological networks. Moreover, power publications underline the growing importance of research that is responding to local needs at the intersection of science and development.

Table 5.2: Survey-response: Summary recommendations: increase collective fundraising efforts by formalising the network status at the national government level and engaging international funders as a group.

	Frequency	Percentage	Valid Percentage
Neutral	1	8,3	8,3
I fully agree	11	91,7	91,7
Total	12	100,0	100,0

5.3 Conclusion

ESARSWG is a network that serves the collaborative seismological data collection and analysis for the countries in the African rift system. The 9 nodes of the network meet regularly for catalogue creation and the compilation of a bulletin which they share with the global seismological community. Each node has since and before inception

run a national network of seismological stations and also have access to stations run by other international and regional organisations. In the past thirty years they have used the data they collected and analysed to inform national governments in the case of seismic events, provided information for disaster risk management officials in their respective countries and have raised awareness about seismicity in the region. They have also pursued other geophysics research and used it to provide information to government agencies, societal stakeholders and industry.

ESARSWG's rationale and objectives are still valid and relevant for the region, Their activities (data collection and analysis) and outputs (catalogues and bulletins) provide vital information to national hazard maps, building codes and general awareness around seismicity. Furthermore, they contribute to global knowledge on geophysics in general and seismology in particular.

The network achieved the goal of compiling and exchanging national bulletins and annual network bulletin. However, the quality of the bulletins varies given that the responsibility for the compilation and catalogue creation changes. Furthermore, some nodes have a lack of operational stations, lack the funding for station maintenance or for accessing the data at remote stations. Therefore not all nodes bring data to the compilation workshops. While ESARSWG was over the years successful in training seismogram analysts and technicians, the retention of staff poses a major problem. In addition, the two week catalogue creation and training workshops are perceived to be too short. The capacity and relevant data-sets to accurately calculate and determine seismic hazards varies from country to country. Therefore not all of the objectives were achieved. One major factor that influences the extent of achievement in the named areas lies in the different levels of capacity, instrumentation and funding in the 9 node countries although it is partially mitigated by exchange within the network.

As a result of ISP funding network members benefited from strengthened ties among each other that helped to inform government and the public in case of events. They also benefited from capacity building and training. The funding of network meetings, training and to a lesser extent equipment have not only benefited ESARSWG but also the member countries in the area of disaster risk management and public awareness.

So far there are no funding opportunities that could replace ISP's funding. Currently the network is trying to formalise its structures and develop a constitution in order to better address regional countries for increased funding. Some node countries enquired opportunities of funding and collaboration with Chinese institutions, which has not yet materialised. The greatest barrier to sustainable funding is still the lack of adequate funding from regional governments, intercontinental organisations and science granting councils. These are avenues that should be pursued in the long term.

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[2] International Science Programme. International Science Programme, Uppsala University, Sweden: Strategic Plan 2013 - 2017.

Appendix 1: Interviews

List of conducted oral and written Interviews

Table 5.3: Oral and written interviews

Month	Name	Affiliation
October 2019	Dr Richard Wambura Ferdinand	Geology Department, University of Dar Es Salaam (TZ)
	Dr Glady Kanji	University of Nairobi (KE)
	Dr Atalay Ayele	IGSSA, Addis Ababa University (ET)
	Heliu Inguane	National Institute of Mines (MZ)
	Dr Ghebrebrhan Ogubazghi	Erirtrea Institute of Technology
	Dr Fred Tugume	Comissioner Geological Survey (UG)
	Lostina S. Chapola	Catholic University of Malawi and Malawi Geological Survey
	Zachary Baguma	Director Geological Survey and Mines (UG)
	Mazibuko Chintu	Seismographic Analyst, Geological Survey (ZM)
	N.N.	Representative from Zimbabwe
	Jimmy Ogwang	Disaster preparedness officer, Prime Minister's Office (UG)
	Moses Matovu	Structural Engineer, Makerere University (UG)
	Nabbosa Betty	Public Works Assistant Commissioner (UG)
	N.N.	Former Node Leader (UG)
	Betty Nabbosa Kajumba	Assistant Commissioner Structural/Civil Engineering, Ministry of Works and Transport, UG
	Sisay Alemayehu	IGSSA, Seismology and Earthquake Geo-technical Engineering Unit, ET
	Sisay Alemayehu	IGSSA, Seismology and Earthquake Geo-technical Engineering Unit, ET
	Dr. E.E. Mshiu	Head of Geology Department, University of Dar Es Salaam, TZ
	Peter S. Machimbya	Lecturers/Seismologists/Analysts, Geology Department, University of Dar Es Salaam, TZ
	Dr. Gabriel D. Mulibo	
	Khalfan Mtelela	
	Dr. Harun Makandi	Geospatial Researcher, COSTECH, TZ
	Emmanuel Nko	Ag. Director Knowledge Management, COSTECH, TZ
November 2019	Belarmino Massingue	Head of Petroleum Geology Department, Universidade Eduardo Mondlane, MZ
	Dr. Joao A. Mugabe	Seismologist, Lecturer Petroleum Geology Department
	Dr. Fatima Chaufere	Geologist, Instituto Nacional de Minas, MZ
	Viriato Samboco	Technician, Instituto Nacional de Minas, MZ
	António José Beleza	National Institute for Disaster Management, MZ
	Adriano S. Sênvano	Director General, Instituto Nacional de Minas, MZ
	V Manihica	Director Geological Survey, Instituto Nacional de Minas
	Claire Lynga	Senior Research Advisor, Embassy of Sweden, MZ
	Marcia Guambe	UN Habitat, MZ
	Wild do Rosário	UN Habitat, MZ
December 2019	Prof. Carla Puglia	Director ISPP, SE
	Prof. Ernst von Groningen	Former Director ISPP, SE
February 2020	Prof. Ewa Wäckelgård	Members of Reference Group ISPP, SE
	Prof. Magnus Willander	
	Prof. Roland Roberts (written response)	
	Prof. Krishna Garg (written response)	

Main Questionnaire for semi-structured interviews

Introduction: Thank you for participating in this interview. In this interview we will ask you questions with respect to history and organizational structure, relevance, research focus and quality, efficiency, effectiveness and impact, collaboration and sustainability of Esarswg and the individual nodes. We want to focus on the strength and weaknesses in these different areas.

History and Organizational Structure:
What has changed since you organization joined ESARSWG?
How would you assess how the network is run, how decisions are made, conferences are oganised, resources are allocated?
What are the strengths and weaknesses of the governance structure and communication?
What is the gender representation in the network? What kind of gender related strategies do you have?

Research focus and quality:
Beyond seismology, what are the other areas of geophysics research within the network? And, in which way could the network be expanded to address other types of geophysical research?
Are other types of geophysics research incorporated and used for seismic hazard or related topics?
How does the data collection work? What is the nature of your network and is it operational? And how does the data get shared with the other members of ESARSWG?

Effectiveness and impact:
How has the research policy at your organisation benefited by the network? Has it improved the quality of research? How has ESARSWG affected your research?
To what extent has the catalogue been used to inform seismic hazard assessment within your country? What else is the catalogue and bulletin used for?
What is from your perspective the impact of ESARSWG with respect to capacity building of technicians and analysts?
Do you find it difficult to retain people once they are trained?
What kind of impact did ESARSWG and the nodes have on national policies and practices in the region?

Relevance:
Do you produce national annual bulletins?
What could the network contribute to help the situation with the stations?
In what way did ESARSWG contribute to the enhancement of research capacity, capacity building in general and the level of equipment? In what way is the training provided by the network beneficial?
Do you have examples of the data you are providing affecting policies?

Collaboration:
What kind of institution do you represent?
What kind of links do you entertain with universities / geologocial surveys in your country or internationally?
Does it influence the cooperation of the different nodes depending on whether they are at universities or at geological surveys?
Do you collaborate with the other members of ESARSWG on research? Do you publish research?
Are the results of collaborative research projects published in journals?

Sustainability:
What are other sources of funds you have access to? How could you improve the sustainability?
Do you have a plan for sustainability concerning networking manpower equipment capacity building as well as

dissemination of information?

Is there something left that is very important to this subject matter that we forgot to ask?

Thank you very much

Survey responses

Comments

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Frequencystabelle

Summary of positive findings: sharing of data among the network members is working well.

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	I agree somewhat	2	16,7	18,2	18,2
	I agree	6	50,0	54,5	72,7
	I fully agree	3	25,0	27,3	100,0
	Total	11	91,7	100,0	
Missing	Not answered	1	8,3		
Total		12	100,0		

Summary of positive findings: long period of data creation is an important achievement of the network.

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	Neutral	1	8,3	9,1	9,1
	I agree	2	16,7	18,2	27,3
	I fully agree	8	66,7	72,7	100,0
	Total	11	91,7	100,0	
Missing	Not answered	1	8,3		
Total		12	100,0		

Summary of positive findings: capacity to communicate findings to national governments is adequate.

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	I don`t agree at all	2	16,7	20,0	20,0
	I agree somewhat	2	16,7	20,0	40,0
	Neutral	3	25,0	30,0	70,0
	I agree	3	25,0	30,0	100,0
	Total	10	83,3	100,0	
Missing	Not answered	1	8,3		
	I don`t know	1	8,3		
	Total	2	16,7		
Total		12	100,0		

Summary of positive findings: findings are adequately transmitted to national disaster management centers.

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	I don`t agree at all	1	8,3	8,3	8,3
	I agree somewhat	5	41,7	41,7	50,0
	Neutral	1	8,3	8,3	58,3
	I agree	5	41,7	41,7	100,0
	Total	12	100,0	100,0	

Summary of positive findings: resources are well used to facilitate regional scientific networking.

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	I don`t agree at all	2	16,7	16,7	16,7
	I agree somewhat	2	16,7	16,7	33,3
	Neutral	3	25,0	25,0	58,3
	I agree	2	16,7	16,7	75,0
	I fully agree	3	25,0	25,0	100,0
	Total	12	100,0	100,0	

Summary of positive findings: training at Technician level is working well.

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	I don`t agree at all	1	8,3	8,3	8,3
	I agree somewhat	3	25,0	25,0	33,3
	I agree	5	41,7	41,7	75,0
	I fully agree	3	25,0	25,0	100,0
	Total	12	100,0	100,0	

Summary of positive findings: diversity of skills within the network nodes is expanding.

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	I don`t agree at all	2	16,7	18,2	18,2
	I agree somewhat	2	16,7	18,2	36,4
	I agree	5	41,7	45,5	81,8
	I fully agree	2	16,7	18,2	100,0
	Total	11	91,7	100,0	
Missing	I don`t know	1	8,3		
Total		12	100,0		

Open response section: [01]

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid		3	25,0	25,0	25,0
	- Number of Scientists in the discipline of the network is improving - Scientists in the region collaborate with international researchers which is promoting research in the network but is not to the level required	1	8,3	8,3	33,3
	Active fault mapping done in 2010 in Rukwa and Karonga.	1	8,3	8,3	41,7
	Active fault mapping in the Rukwa-Karonga area in 2010	1	8,3	8,3	50,0
	Sharing research experience. Sharing culture. 	1	8,3	8,3	58,3

	Some research papers have been published utilising data from the Regional Networks. 	1	8,3	8,3	66,7
	The fact that the network has survived for more than 25 years and has maintained a platform for regional discussion forum in itself is a major achievement.	1	8,3	8,3	75,0
	The network has been instrumental in building capacity in Geosciences/Seismology in many countries, with a lot of students in the region using the data collated by the network for their Phd and MSc Theses. Some of these graduates have since been engaged by their local universities as lecturers and have gone to introduce Geosciences related programs at these universities.	1	8,3	8,3	83,3
	Training at PHD level in geophysics including seismology: I do not agree- because this has preferentially been done only for University agencies and not to the Geological Survey Departments.	1	8,3	8,3	91,7
	Training of most scientists available at the moment in the region was through exposure to ESARSWG	1	8,3	8,3	100,0
	Total	12	100,0	100,0	

Summary of challenges: there are disparities in number of PhD-holding staff between the nodes.

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	I agree	5	41,7	45,5	45,5
	I fully agree	6	50,0	54,5	100,0
	Total	11	91,7	100,0	
Missing	I don`t know	1	8,3		
Total		12	100,0		

Summary of challenges: there are disparities in equipment availability.

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	I don`t agree	1	8,3	9,1	9,1

	I agree	2	16,7	18,2	27,3
	I fully agree	8	66,7	72,7	100,0
	Total	11	91,7	100,0	
Missing	I don`t know	1	8,3		
Total		12	100,0		

Summary of challenges: equipment maintenance is hampered by lengthy procurement processes at our organization.

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	Neutral	2	16,7	16,7	16,7
	I agree	3	25,0	25,0	41,7
	I fully agree	7	58,3	58,3	100,0
	Total	12	100,0	100,0	

Summary of challenges: equipment maintenance is hampered by inadequate funding for site visits.

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	I agree	2	16,7	16,7	16,7
	I fully agree	10	83,3	83,3	100,0
	Total	12	100,0	100,0	

Summary of challenges: there is a need to install mechanisms to encourage collaborative journal publication.

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	Neutral	1	8,3	8,3	8,3
	I agree	2	16,7	16,7	25,0
	I fully agree	9	75,0	75,0	100,0
	Total	12	100,0	100,0	

Summary of challenges: building a pipe-line of skilled researchers is a considerable challenge.

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	I don`t agree	1	8,3	8,3	8,3
	I agree	4	33,3	33,3	41,7
	I fully agree	7	58,3	58,3	100,0
	Total	12	100,0	100,0	

Summary of challenges: building a pipe-line of skilled technicians is a considerable challenge.

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	I don`t agree	1	8,3	9,1	9,1
	Neutral	2	16,7	18,2	27,3
	I agree	2	16,7	18,2	45,5
	I fully agree	6	50,0	54,5	100,0
	Total	11	91,7	100,0	
Missing	Not answered	1	8,3		
Total		12	100,0		

Summary of challenges: aquiring funding from other than ISP as a network is a challenge and influences the sustainabi...

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	Neutral	1	8,3	8,3	8,3
	I agree	1	8,3	8,3	16,7
	I fully agree	10	83,3	83,3	100,0
	Total	12	100,0	100,0	

Summary of challenges: the underrepresentation of women in the nodes and the network as a whole remains a challenge.

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	I don`t agree at all	1	8,3	8,3	8,3
	I don`t agree	1	8,3	8,3	16,7
	Neutral	1	8,3	8,3	25,0
	I agree	3	25,0	25,0	50,0
	I fully agree	6	50,0	50,0	100,0
	Total	12	100,0	100,0	

Open response section: [01]

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid		4	33,3	33,3	33,3
	- Challenges of retaining trained man power - Least awareness on the importance of the discipline by the regional governments - Inefficient infrastructure of the node countries like electricity and internet connection 	1	8,3	8,3	41,7
	Countries in which PHD geophysics programs are not avialable in the respective Universities need to be considered for full scholarship offers to Universities that can offer such programs because it is not possible to undertake sandwich programs.	1	8,3	8,3	50,0
	Good data archival systems to avoid data loss	1	8,3	8,3	58,3

I am not sure about the priority list I made... I donation know if we should consider which is the most challenging among them or if we should instead list which priorities the network should take in consideration. The latter is reflected in my list.	1	8,3	8,3	66,7
In my opinion the grouping lacks transparency in its dealings especially the executive which is reluctant to accommodate new faces but would rather like to circulate positions among same members. Views of other members ok outside the executive are hardly taken on board. Lack of opening up more research activities apart from seismological bulletin compilation in order to advance scientific research in the region	1	8,3	8,3	75,0
Low commitments of governments to the efforts being made.	1	8,3	8,3	83,3
Staff retention, the network has lost a lot of its membership who have moved abroad for greener pastures.	1	8,3	8,3	91,7
Transparency and accountability on the activities of the group The positions should be extended to new faces rather than circulating within the same members If there is funding for maintenance of equipment, that must flow down straight to the line network operator unlike the previous scenario where such help done by node members.	1	8,3	8,3	100,0
Total	12	100,0	100,0	

Summary recommendations: establish a common framework for its PhD-training (e.g. sandwich degrees, a regional doctora...

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	Neutral	3	25,0	25,0	25,0
	I agree	3	25,0	25,0	50,0
	I fully agree	6	50,0	50,0	100,0
	Total	12	100,0	100,0	

Summary recommendations: support single station acquisitions for countries with no network (e.g. through investment f...

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	I agree	3	25,0	25,0	25,0
	I fully agree	9	75,0	75,0	100,0
	Total	12	100,0	100,0	

Summary recommendations: provide minor network funding to foster the regional exchange of skilled technicians for tro...

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	Neutral	1	8,3	9,1	9,1
	I agree	1	8,3	9,1	18,2
	I fully agree	9	75,0	81,8	100,0
	Total	11	91,7	100,0	
Missing	Not answered	1	8,3		
Total		12	100,0		

Summary recommendations: have a roving maintenance expert.

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	I don`t agree	1	8,3	9,1	9,1
	Neutral	1	8,3	9,1	18,2
	I agree	2	16,7	18,2	36,4
	I fully agree	7	58,3	63,6	100,0
	Total	11	91,7	100,0	
Missing	I don`t know	1	8,3		
Total		12	100,0		

Summary recommendations: put greater emphasis on bilateral research, including small grants for visits to work on pub...

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	I agree	4	33,3	33,3	33,3
	I fully agree	8	66,7	66,7	100,0
	Total	12	100,0	100,0	

Summary recommendations: publish one or more review/summary publication on the network catalogue.

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	Neutral	1	8,3	8,3	8,3
	I agree	2	16,7	16,7	25,0
	I fully agree	9	75,0	75,0	100,0
	Total	12	100,0	100,0	

Summary recommendations: increase collective fundraising efforts by formalizing the network status at the national go...

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	Neutral	1	8,3	8,3	8,3
	I fully agree	11	91,7	91,7	100,0
	Total	12	100,0	100,0	

Summary recommendations: start/increase its engagement of higher education and science related divisions of regional ...

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	Neutral	1	8,3	8,3	8,3
	I agree	1	8,3	8,3	16,7
	I fully agree	10	83,3	83,3	100,0
	Total	12	100,0	100,0	

Summary recommendations: institutionalize a gender related strategy by naming a gender and/ or diversity secretary in ...

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	Neutral	2	16,7	18,2	18,2
	I agree	2	16,7	18,2	36,4
	I fully agree	7	58,3	63,6	100,0
	Total	11	91,7	100,0	
Missing	I don`t know	1	8,3		
Total		12	100,0		

Open response section: [01]

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid		7	58,3	58,3	58,3
	Based on this evaluation, ISP should empower those centres with better capacity to get involved in training and research visits when necessary.	1	8,3	8,3	66,7
	Despite short comings in the group, it is important to emphasize the importance of ISP support to the Group, as its mere existence brings a number less visible benefits for seismology in the region.	1	8,3	8,3	75,0

	I agree actually on every points. The problem is that some of this expected or wished actions are not considered in the network statements right now. they are still valuable suggestions for a real change in better...	1	8,3	8,3	83,3
	None.	1	8,3	8,3	91,7
	PHD training at International level unlike regional doctorial schools only	1	8,3	8,3	100,0
	Total	12	100,0	100,0	

Consent

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	Yes, I agree	12	100,0	100,0	100,0

Alter (Kategorien, 5 Jahre)

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	35 to 39 years old	4	33,3	36,4	36,4
	45 to 49 years old	2	16,7	18,2	54,5
	50 to 54 years old	2	16,7	18,2	72,7
	55 to 59 years old	2	16,7	18,2	90,9
	65 years or older	1	8,3	9,1	100,0
	Total	11	91,7	100,0	
Missing	System	1	8,3		
Total		12	100,0		

Land (weltweit, in de+en)

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	Ethiopia	2	16,7	18,2	18,2
	Zimbabwe	3	25,0	27,3	45,5
	Eritrea	1	8,3	9,1	54,5
	Malawi	2	16,7	18,2	72,7
	Mozambique	1	8,3	9,1	81,8
	Other	2	16,7	18,2	100,0
	Total	11	91,7	100,0	
Missing	System	1	8,3		
Total		12	100,0		

Beschäftigung

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	I am a lecturer/researcher at university	3	25,0	27,3	27,3
	I am a professor at university	3	25,0	27,3	54,5

	I am a administrator/researcher at a non-university public institution	2	16,7	18,2	72,7
	I am a technician at a non-university public institution	1	8,3	9,1	81,8
	Other:	2	16,7	18,2	100,0
	Total	11	91,7	100,0	
Missing	System	1	8,3		
Total		12	100,0		

Beschäftigung: Other

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid		10	83,3	83,3	83,3
	seismic Analyst	1	8,3	8,3	91,7
	Senior Geophysicist/Geological Survey Department	1	8,3	8,3	100,0
	Total	12	100,0	100,0	

Anmerkungen (offen): [01]

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid		4	33,3	33,3	33,3
	I beg to be excused for not asking other members of our group to participate in the survey. Due to the current virus, schools are closed and movement is highly restricted. I have done strong efforts to be able to do it myself.	1	8,3	8,3	41,7
	I think every thing has been raised. No further comment.	1	8,3	8,3	50,0
	I think the questioner is excellent as it has included almost all relevant items.	1	8,3	8,3	58,3
	i think the questionnaire is very comprehensive and in my view it covers all the areas that need to be addressed.	1	8,3	8,3	66,7
	The questionnaire is clear to me	1	8,3	8,3	75,0

	The questionnaire is okey. My only comment will be that-- I feel the management of ESARSWG has been curtiled by the so called old-guds who selffishly implement decisions for the rest and thus leaving us new comers without a sense of belonging. This has led to some institutions (Universities) obtaining more equipment than others and also training more PHD holders under ISP than Geological Surveys. I also feel there has to be a balance in the executive commitee to have representation from both the Geological Surveys and Universities unlike the way it is now where University members dominate.	1	8,3	8,3	83,3
	The questionnaire was clear.	1	8,3	8,3	91,7
	Very good, I had only little problem for the first part...	1	8,3	8,3	100,0
	Total	12	100,0	100,0	

gender

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	Female	3	25,0	27,3	27,3
	Male	8	66,7	72,7	100,0
	Total	11	91,7	100,0	
Missing	System	1	8,3		
Total		12	100,0		

ranking challenges: Disparities in number of PhD-holding staff between the nodes.

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	Rank 1	2	16,7	16,7	16,7
	Rank 2	1	8,3	8,3	25,0
	Rank 4	2	16,7	16,7	41,7
	Rank 5	2	16,7	16,7	58,3
	Rank 6	2	16,7	16,7	75,0
	Rank 8	2	16,7	16,7	91,7
	Rank 9	1	8,3	8,3	100,0
	Total	12	100,0	100,0	

ranking challenges: Disparities in equipment availability.

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	Rank 1	3	25,0	25,0	25,0
	Rank 2	4	33,3	33,3	58,3
	Rank 3	2	16,7	16,7	75,0
	Rank 6	1	8,3	8,3	83,3
	Rank 7	1	8,3	8,3	91,7
	Rank 9	1	8,3	8,3	100,0
	Total	12	100,0	100,0	

ranking challenges: Equipment maintenance through lengthy procurement processes at our organization.

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	Rank 1	2	16,7	16,7	16,7
	Rank 2	4	33,3	33,3	50,0
	Rank 3	1	8,3	8,3	58,3
	Rank 6	2	16,7	16,7	75,0
	Rank 7	1	8,3	8,3	83,3
	Rank 8	2	16,7	16,7	100,0
	Total	12	100,0	100,0	

ranking challenges: Equipment maintenance through site visits.

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	Rank 2	2	16,7	16,7	16,7
	Rank 3	3	25,0	25,0	41,7
	Rank 4	3	25,0	25,0	66,7
	Rank 5	1	8,3	8,3	75,0
	Rank 9	3	25,0	25,0	100,0
	Total	12	100,0	100,0	

ranking challenges: Need to install mechanisms to encourage collaborative journal publication.

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	Rank 3	1	8,3	8,3	8,3
	Rank 4	2	16,7	16,7	25,0
	Rank 5	1	8,3	8,3	33,3
	Rank 6	2	16,7	16,7	50,0
	Rank 7	3	25,0	25,0	75,0
	Rank 8	2	16,7	16,7	91,7
	Rank 9	1	8,3	8,3	100,0
	Total	12	100,0	100,0	

ranking challenges: Building a pipe-line of skilled researchers.

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	Rank 1	2	16,7	16,7	16,7
	Rank 3	2	16,7	16,7	33,3
	Rank 5	3	25,0	25,0	58,3

	Rank 6	2	16,7	16,7	75,0
	Rank 7	1	8,3	8,3	83,3
	Rank 8	2	16,7	16,7	100,0
	Total	12	100,0	100,0	

ranking challenges: Building a pipe-line of skilled technicians.

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	Rank 2	1	8,3	8,3	8,3
	Rank 3	2	16,7	16,7	25,0
	Rank 4	1	8,3	8,3	33,3
	Rank 5	1	8,3	8,3	41,7
	Rank 7	4	33,3	33,3	75,0
	Rank 8	2	16,7	16,7	91,7
	Rank 9	1	8,3	8,3	100,0
	Total	12	100,0	100,0	

ranking challenges: Aquiring funding from other than ISP as a network.

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	Rank 1	2	16,7	16,7	16,7
	Rank 4	3	25,0	25,0	41,7
	Rank 5	3	25,0	25,0	66,7
	Rank 6	2	16,7	16,7	83,3
	Rank 7	2	16,7	16,7	100,0
	Total	12	100,0	100,0	

ranking challenges: The underrepresentation of women in the nodes and the network as a whole.

		Frequency	Percentage	Valid Percentage	Accumulated Percentage
Valid	Rank 1	1	8,3	8,3	8,3
	Rank 3	1	8,3	8,3	16,7
	Rank 4	1	8,3	8,3	25,0
	Rank 5	1	8,3	8,3	33,3
	Rank 6	1	8,3	8,3	41,7
	Rank 8	2	16,7	16,7	58,3
	Rank 9	5	41,7	41,7	100,0
	Total	12	100,0	100,0	

Appendix 2: Terms of References

UPPSALA
UNIVERSITET

International Science Programme (ISP)

Terms of Reference

ESARSWG Evaluation

Contents

1. BACKGROUND

1.1 Information about ISP

International Science Programme (ISP) at Uppsala University assists low-income countries to build and strengthen their domestic research capacity and postgraduate education in the basic sciences – chemistry, mathematics and physics. ISP provides support to research groups and regional scientific networks at universities and institutes in Africa, Asia and Latin America. ISP consists of three subprograms:

- International Programme in the Physical Sciences (IPPS), from 1961,
- International Programme in the Chemical Sciences (IPICS), from 1970,
- International Programme in the Mathematical Sciences (IPMS), from 2002.

ISP has supported scientific regional networks since the early 1980's. The reason for supporting regional scientific networks is that regional cooperation generates scientific cooperation and complementary activities, gives access to advanced equipment, and contributes the human capital needed for good postgraduate education.

ISP's main donor is the Swedish Government through the International Development Cooperation Agency (Sida). For more information visit: www.isp.uu.se

1.2 Information about ESARSWG:

The East and Southern African Seismological Working Group (ESARSWG) consist of scientists or groups of scientists located at either universities or governmental agencies in nine countries along the East African Rift: Eritrea, Ethiopia, Kenya, Uganda, Tanzania, Malawi, Mozambique, Zambia and Zimbabwe (see Appendix 1). The overall coordinating node of the Network is presently based at the Uganda Geological Survey in Entebbe. The coordination assignment rotates between the nodes every 4 years. The network members meet for the executive committee planning once for each project period. On average, they meet twice a year to prepare the regional bulletin and to conduct training workshops.

The Network was formed in 1993, and has been supported by ISP since 1997. Initially the network included members from Uganda, Kenya, Tanzania, Zambia, Zimbabwe, Malawi, and Ethiopia. Later Eritrea and Mozambique joined. The formation of the network was a response to damaging earthquakes that have occurred and will continue to occur in the ESARSWG region, causing loss of lives and properties worth millions of US Dollars. Therefore, it is important for Governments in ESARSWG region to put in place policies and regulations before developing new infrastructures. The availability of the accurate seismic hazard assessment models provided by the ESARSWG network are paramount for planning purposes.

The main objective of ESARSWG, as stated in the 2016 application to ISP:

"Networking in earthquakes monitoring in the ESARSWG region to mitigate seismic hazard while capacity building in the region in both manpower and equipment".

The specific objectives for 2017–2019 are:

- *To compile and exchange national monthly earthquake bulletins and annual ESARSWG bulletins.*

- *To train seismogram analysts for the National Data centers.*
- *To train technicians on real-time seismograph facilities and data analysis. To compile a regional Earthquake Catalogue for input to the regional seismic hazard calculations.*
- *To produce a regional attenuation relation suitable for hazard calculations.*
- *To calculate and determine seismic hazard for the ESARSWG region.*

The Network started with training of tehnicians on how to install and operate seismic stations. A majority of the stations by then were mostly single component analogue recording on paper. Workshops and training were held on rotation basis within member countries. Participants would carry the paper records to workshops and get trained on how to read and interpret records. Thereafter periodic seismic data bulletins were produced. Over the years analogue seismic stations have been replaced by digital stations. Moreover, some of the stations in the region are made to be real-time stations, which eventually changed the capacity of analyze data and deliver results.

It should be noted that ESARSWG has no common post-graduate educational programs (MSc and PhD), in contrast with the other networks supported by IPPS. However, several of the individual network nodes run such programs.

2. EVALUATION PURPOSE AND SCOPE

2.1 Purpose

The purpose of this evaluation is to analyze and assess functionality, developments, and impact of the ESARSWG network and its activities since the start of ISP support in 1997. This to provide ESARSWG and ISP with indications of the progress and development of the Network, and to provide input and recommendations on improvements and future directions.

2.2 Scope

The evaluation should cover the period **1997-2018**[1] and focus on how ESARSWG functions, its activities and progress. The scope of the evaluation is to analyze and assess the relevance, efficiency, effectiveness, impact, and sustainability of the ESARSWG network and its nodes **in relation to ESARSWG's stated main and specific objectives** (as listed under section 1.2).

3. THE EVALUATION ASSIGNMENT

The evaluation should ultimately result in:

1) **An overview of how ESARSWG functions, its activities and progress** from 1997 until today, by answering the stated questions in section 3.1. In general, it should provide a brief history and organizational overview of the network and account for how far ESARSWG has come in achieving its stated specific goals and objectives. It should result in an assessment of the network's overall relevance, efficiency, impact, collaboration and sustainability. Strengths and weaknesses of each of these aspects should be clearly outlined.

[1] Most of the data available covers 2008-2018, and will therefore be the period of focus. However, developments since the start should be considered.

2) **Recommendations and improvements** (long- and short-term) to ESARSWG and to ISP, respectively, on future directions of the network and its activities, including outputs, outcomes and impact (3.2).

3.1 Overview of ESARSWG, its activities and progress

The following headings and questions should be addressed in the evaluation report:

History and organizational structure

1) Provide a short historical overview of the ESARSWG network, its activities and its development.

2) Provide an overview of the organizational structure and governance of the network - including communication, decision-making processes and planning and implementation of activities. The main strengths and weaknesses of the organizational structure should be outlined.

3) How is the gender representation within the network? What are the strategies to work with gender related issues, if any?

Relevance

4) Are the ESARSWG network objectives and activities consistent with the needs and priorities of the network regions, countries and node institutions?

Research focus and quality

5) How are the major areas of geophysics research represented within the network? If certain research areas are missing or weak, how could the network cooperation improve this situation?

6) Describe and assess the seismological data collection and sharing at node and network level.

7) How is the ESARSWG network contributing to the seismology research field, number and quality wise? How has the **research quality** evolved since the beginning of the ESARSWG network?

8) How is the research conducted in terms of joint projects, joint publications and joint contributions to scientific conferences?

Efficiency

9) Comment on the efficiency of the ESARSWG and its activities, i.e. are the outcomes of the network reasonable given what has been put in in terms of funding and time? Comment on the facilitating/hindering factors. [2]

Effectiveness and impact

10) To what extent and how has the ESARSWG network contributed to increase the geophysical research capacity in the network countries and at the node institutions?

11) To what extent has the program been successful in delivering outputs such as described in the specific objectives?

12) Assess and exemplify how the ESARSWG has contributed to increase capacity building of manpower and equipment in earthquake monitoring and seismic hazard mitigation in the region. How can these be improved?

13) Assess the quality, the reach and the impact of earthquake bulletins and regional earthquake catalogues. Are they actively used by researchers in the network and/or by others? How could their use be improved?

14) Has the calculation and determination of seismic hazards carried out by the network benefited the region in any way? Exemplify.

15) To what extent and how has the ESARSWG network contributed to the needs and priorities of training of technicians and seismograph analysists in the network countries?

16) Are the trained seismogram analysts and technicians from the network contributing to the region? How? Please provide qualitative examples is possible.

17) Have ESARSWG and its participants had any impact on policies and practices in the node countries and/or region in any way? Exemplify.

Collaboration

18) Describe and analyze how the nodes cooperate and influence each other and others in the region, also considering that the network includes different kind of nodes, i.e. governmental agencies and academy.

19) To what extent does the network collaborate with other seismic networks in the region or internationally (data sharing, access to seismic stations, etc)?

20) Describe any other collaboration with stakeholders outside the network, like public institutions, industry and civil society.

21) What are the main bottlenecks for increased networking in earthquakes monitoring in the ESARSWG region to mitigate seismic hazard while building capacity in the region in both manpower and equipment*?* How can they best be addressed?

[2] NOTE! This question regards an overall analysis of the network's efficiency and do not concern financial management or audit, since these are carried out and checked regularly and separately.

Sustainability

22) Describe the current planning for sustainability concerning networking, manpower and equipment capacity building as well as dissemination of information in the network and at the node institutions.

23) Describe the network's and nodes' efforts and ability to attract sufficient financial support, other than from ISP, to finance network and node activities. How has it developed over time? What will happen if ISP will phase out its support?

3.2 Recommendations and improvements

The evaluation should result in recommendations on the future direction of the network and on improvements of its activities including outputs, outcomes and impact.

The recommendations should be based on the findings and headings in 3.1 *Overview of ESARSWG, its activities and progress*. The recommendations should be directed both to ESARSWG and to ISP.

4. METHODOLOGY

The evaluation team should provide ISP with an overview of methodology and proposed time schedule for the evaluation. ISP will assist if requested.

The evaluation should include both preparatory desk studies and field visits to chosen node institutions. In addition, the evaluation team will be able to meet with members from all the nodes at a Steering Committee meeting, to be organized by the Network sometime during May-August (TBD). Moreover, interviews could/may be held with the following stakeholders involved in the Network activities:

- The overall ESARSWG Network Coordinator
- Node Coordinators
- Staff members at the node institutions involved in the Network
- Relevant people in management at node intuitions
- Seismogram analysts
- Technicians
- Director and Deputy Director of the Physics Program (IPPS) at ISP
- The IPPS reference group members
- Sida representatives
- Other stakeholders the evaluation team find relevant

Interviews should be at least semi-structured, but templates might be adapted to the interviewed category.

5. TIMEFRAME, REPORTING & COST COVERAGE

5.1 Timeframe and reporting

- **Start and end.** The assignment of the evaluation team will start **in April 2019** and be completed **by end of December 2019,** if nothing else is agreed upon.
- **Inception report.** The evaluation team should provide ISP with an inception report including a preparatory desk study answering relevant questions of the ToR, methodology and feasibility of the ToR given the time and resources by **May 2019.** (Separate instructions for the inception report will be provided).
- **Field visits.** As planned in the inception report and agreed upon with the network, should preferable be carried out in one trip in conncetion to a network meeting if feasible.
- **Draft report.** A draft of the evaluation report should be sent to ISP for commenting by **November 2019. and presented to ISP and the network (via skype or in person).**
- **Final Report.** The revised, finalized version of the evaluation report should be sent to ISP in **December 2019**.

5.2 Cost coverage

ISP will provide fuly cover the costs incurred by the evaluation team during the field visits.In addition, members of the evaluation team will each receive net honorarium of 1,500 USD plus travel allowance, according to Swedish rules and regulations.

NOTE: Only flights in economy class are reimbursed.

6. AVAILABLE DOCUMENTS

ISP will provide the evaluation team with the necessary documents to carry out the desk study and evaluation. In addition, the evaluation team will be provided with **self-evaluation forms** from network the nodes.

Appendix 1

List of the members of the ESARSWG network.

Eritrea Node
Name of Institute: Department of Earth Sciences, Eritrea Institute of Technololgy
Location: Asmara, Eritrea
Node coordinator: Woldeghebriel Ghenzebu
Email: wgenzebu@gmail.com

Ethiopia Node
Name of Institute: Institute of Geophysics Space Science and Astronomy, Addis Ababa University
Location: Addis Ababa, Ethiopia
Node coordinator: Atalay Ayele
Email: atalay.ayele@aau.edu.et
Phone: +251 911401332

Kenya Node
Name of Institute: Geology/Seismology and Applied Geophysics, University of Nairobi
Location: Nairobi, Kenya
Node coordinator: Gladys Kianji,
Email: kianji@yahoo.com
Phone: +254722756598

Malawi Node
Name of Institute: Catholic University of Malawi & Malawi Geological Survey,
Location: LImbe, Malawi
Node coordinator: Lostina Chapola
Email: chapolalostina@yahoo.com, chapolalostina@gmail.com
Phone: +265888352245

Mozambique Node
Name of Institute: Mozambique Geological Survey and University Eduardo Mondlane
Location: Maputo, Mozambique
Node coordinator: Paulino Feitio
Email: pfeitio@hotmail.com
Phone:

Tanzania Node
Name of Institute: Department of geology, University of Dar es Salaam
Location: Dar es Salaam,Tanzania
Node coordinator: Richard Wambura Ferdinard
Email: rf@udsm.ac.tz, rf@uccmail.co.tz
Phone:

Coordinating Institution: Uganda Node
Name of Institute: Uganda Geological Survey
Location: Entebbe, Uganda
Node coordinator: Dr. Fred Tugume
Email: fred.tugume@gmail.com
Phone: +256 772 471131

Zambia Node
Institute name: Zambia Geological Survey
Location: Lusaka, Zambia
Node coordinator: Francis Tchilongolah (???)
Email: : bandatchilo@gmail.com (???)
Phone

Zimbabwe node
Name of Institute: Dept, of Physics, National University of Science and Technology
Location: Bulawayo, Zimbabwe
Node coordinator: Dumisani John Hlatywayo
Email: djhlatywayo@gmail.com
Phone: +263773738136