INTEGRATED VOLCANO EARLY WARNING SYSTEMS: RECONCEPTUALIZING AS A COMPLEX ADAPTIVE SYSTEM OF COMMUNICATION NETWORKS

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1. DEVELOP INTEGRATED VOLCANO EARLY WARNING SYSTEMS

Volcano warning systems are a key part of volcano crisis management. However they are only effective to the extent that they are integrated, so that warnings consider:

- Multiple-hazards, cascading and concurrent events
- Multiple users, integrated into end-to-end people-centred networks

UN based models of warning systems use design focused on four key elements (see figure 1). However research has demonstrated that warnings can fail to link between the four key elements. Therefore warnings need to account for the factors shown in figure 2.

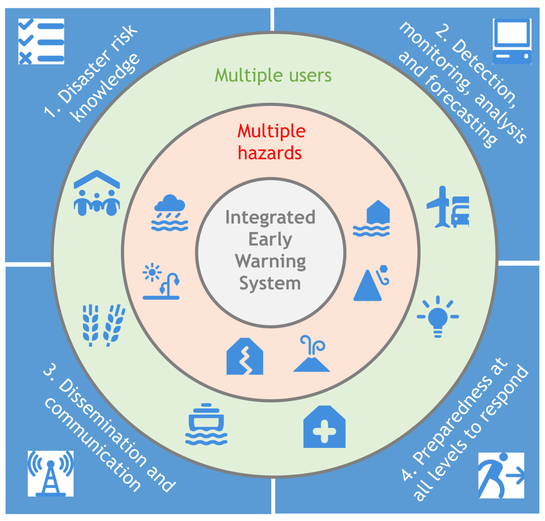

Figure 1: UN Model of EWS (UNDRR)

Figure 2. Factors to improve the linking of the four elements (Garcia & Fearnley, 2012, p.133)

- ➢ Integration is key, where the links between these different components facilitate action and connect internationally through to local levels
- ➢ Integration is required across the types of warnings required for different hazards and cascading effects, and for warnings at different timescales (see figure 3).

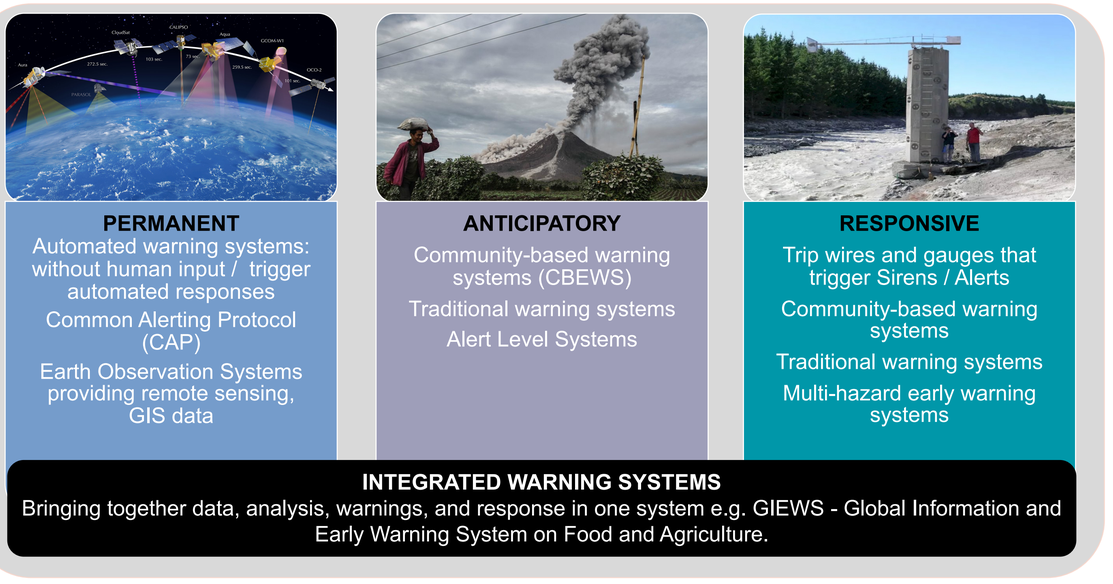

Figure 3. Different types of warnings are able to be issued dependent on the hazard, and timescales involved

3. STANDARDISATION OF WARNINGS NEEDS FLEXIBILITY

- Use standardisation of warnings and communication with caution, both the local and global need to work together
- By using simple flexible warnings design, local and national can be bridged

Issues	Local (Non-Standardised)	National (Standardised system)
Users' needs	Provides flexibility to local community but global users may be confused	Limits flexibility possible, but provides consistency and clarity to all
Communication Methods	Local interpretation likely to be more effective	Common terminology and understanding, but must be known
Decision Making	Gear decision on local needs, circumstances and knowledge	Descriptions provide guidelines / criteria, but implications may vary
Management	Local stakeholders develop close relationships	Streamlines communication within government agencies reducing confusion

Figure 5. The pros and cons of standardising ALS (adapted from Fearnley, 2012)

2. BUILD ROBUST COMMUNICATION NETWORKS FOR VOLCANIC HAZARDS & RISKS

Science and Technology Studies (STS) have established that silos make it difficult to achieve multi-directional communication between stakeholders where:

- Efforts are coordinated, and uncertainties are recognised and quantified
- Communications are unambiguous
- Responsibilities are clearly socially mandated

The problems stem from:

- The way that science communication works on an everyday basis
- Scientific credibility and how meaning is created and recreated
- Decision-making processes - it is important to understand how knowledge is created, and then understood by different stakeholders.

The effective ongoing use, value and deployment of knowledge across this interface depend on shared perceptions that the knowledge is:

- Scientifically credible
- Relevant to the needs of key users
- Legitimate, and that the processes through which it is generated and disseminated balance the interests and knowledge of all involved.

- ➢ These linked criteria contribute to building a complex adaptive system see figure 4

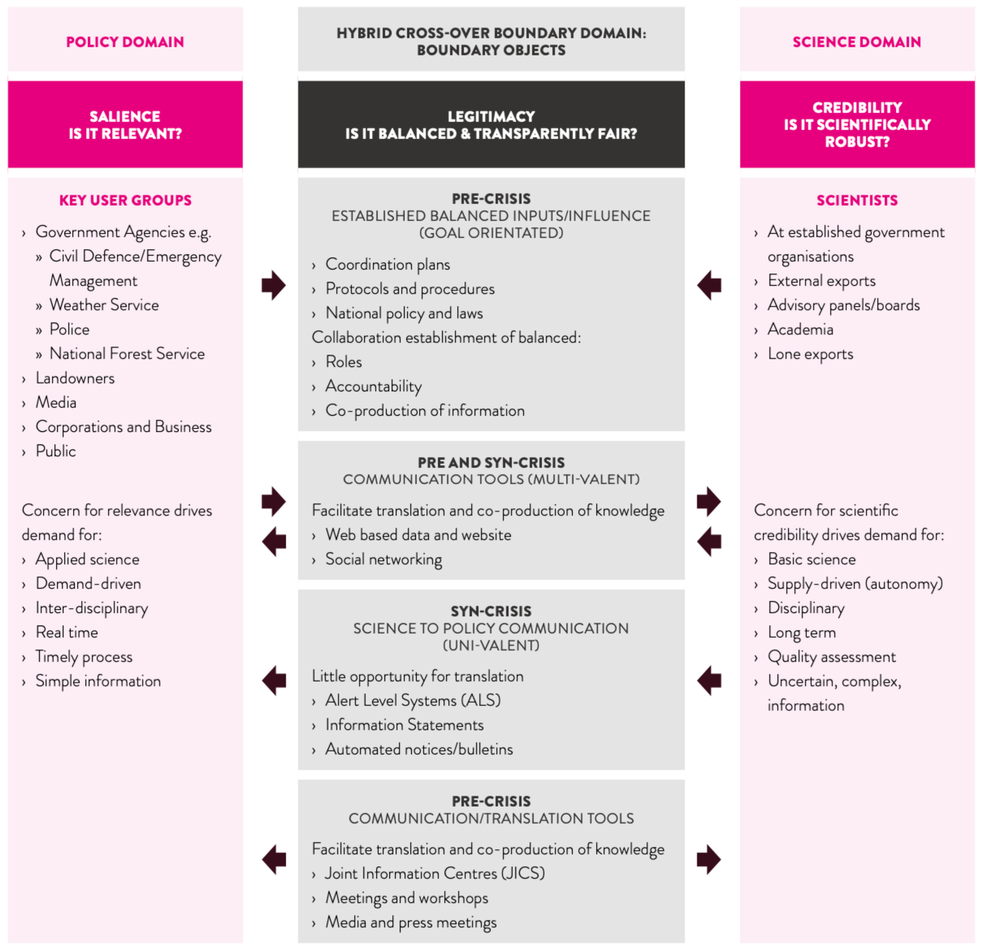

Figure 4. Mapping credibility, relevance and the generation of legitimacy to translate, communicate and mediate crisis information (adapted from Fearnley and Beaven, 2018, p. 11)

4. KEY FINDINGS: BUILD COMPLEX WARNINGS USING SIMPLICITY

Volcanic crises management requires collective consideration and understanding of how to act appropriately, both scientifically and socially, in the context of extreme uncertainty and complexity. To effect this shared understanding, a Volcano EWS must integrate everything from monitoring, the analysis and interpretation of the data, and establishing and analysing the risks, through to communicating information to stakeholders, and generating an effective response.

Process integration should include planning, cooperation, the execution of drills, education, and discussion; and using a wide range of communication tools such as alerts, bulletins, SMS messages, phone conversations, between all actors so that effective and timely decisions can be made.

When a Volcano EWS is reconceptualised in this way **as a complex adaptive system of communication networks,** it provides opportunities to work across silos, and hazards and expand the warning agenda to:

- ➢ Cut across vulnerabilities and contexts, hazards / threats globally to examine and share knowledge of warning designs, practices, and lessons identified
- ➢ Develop warnings that address the realities of vulnerabilities, hazards / threats, and anticipatory actions that range from local to international scale
- ➢ Develop simple systems to manage complexity. Too many differing systems can result in confusion resulting in a loss of trust or credibility (see figure 6)

Awareness Level	Meaning
Red	Urgent
Orange	Important
Green	Of Interest

Figure 6. Simplified Awareness Level to capture the complexities of volcanic warnings. Awareness levels trigger discussion via existing communication structures (as per figure 4) (taken from Fearnley, 2011)