Review

Contributions of GIDES Project for Sediment Disaster Early Warnings in Brazil

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The rapid growth of urban areas and their inadequate expansion on slopes and flood plains made sediment disasters more frequent in Brazil. After the succession of disasters that caused major damage between 2008 and 2011, the Brazilian government reformulated its strategy and policies related to disaster risk management. Within this strategy, the Brazilian government has proposed a cooperation agreement with the Government of Japan, resulting in GIDES Project, which has as its main objective the strengthening of the national strategy for natural disaster risk management. Regarding actions related to the monitoring and early warning of sediment disasters, three Brazilian Municipalities were chosen as Pilot Implementations for GIDES, aiming to allow the discussion of new methodologies, adapting content and language of the alerts, the establishment of shared and unified information flows and records, and the establishment of common protocols, in experimental scale. This article aims to draw the major aspects in Brazilian risk management context, outline the main challenges faced so far and the Project's contribution perspectives for the improvement of sediment disaster risk management in Brazil, especially on issues related to monitoring and early warning.

Key words: sediment disaster, risk management, early warning, GIDES Project

1. INTRODUCTION

Brazil is the largest country in Latin America, both in area (8,515,767.049 km²) and population (projected to 206 million in 2016) and plays an important role as an emerging power on the world stage [Nieto, 2012 ; Cooper & Flames, 2013 ; IBGE, 2016].

Pressured by rapid population growth, by migration to services provided areas and by the inefficiency of government regulation and control of land use, many Brazilian cities (especially those near the coast) grew in a disorderly manner, occupying areas of slopes and floodplains and suffering the consequences of geodynamic and hydrological disasters.

According to 2010 Brazilian Census, 84.4% of the

population is urban [IBGE, 2010] and in the last decade, the geodynamic and hydrological disasters in Brazil resulted in a loss of about 4.69 billion dollars, affecting more than 6.5 million people and killing over two thousand [EM-DAT data, Guha-Sapir et al., 2016]. Among these, there was the January 2011 disaster in the mountainous region of Rio de Janeiro state, in which a variety of geodynamic processes (slides, rockfalls and debris flows), combined with flashfloods in deep valleys, caused the death/disappearance of over a thousand people.

The 2011 disaster showed the need for reformulation of disaster reduction strategies in Brazil and its repercussions awoke several actions toward risk management improvement in the country, among them

the creation of new organizations, the strengthening of existing civil defense bodies, investment in research and technology, changes in legislation, creation/improvement of interagency protocols and exchange of experiences between institutions and researchers from other countries, including Japan. Within this strategy, in 2012 the Brazilian government proposed a cooperation agreement with the Government of Japan, resulting in GIDES Project (The Project for Strengthening National Strategy of Integrated Natural Disaster Risk Management), on demand of the Brazilian Ministry of Cities (MCid), in cooperation with other three Brazilian Ministries: the Ministry of National Integration (MI), the Ministry of Science, Technology, Innovation and Communication (MCTIC) and the Ministry of Mines and Energy (MME).

The authors of this article participated actively in the planning process and implementation of GIDES Project's activities, as members of the execution team by MCTIC, since 2012. From 2014 to the project closure, the first and third authors accompanied the project as external participants (from the academy); the second author belonged to the execution team until 2017 and the fourth author continues integrating the team that is responsible for the Project (through the National Center for Monitoring and Early Warnings of Natural Disasters, CEMADEN). During this period (2012-2017), it was possible to participate in technical discussions and inter-institutional working groups involving various actors from the Brazilian Civil Defense and Protection System. It was also possible to attend technical meetings with academy members and exchange experiences with Brazilian and Japanese researchers and professionals.

This article aims to outline the main challenges faced so far and the Project's contribution perspectives for the improvement of sediment disaster risk management in Brazil, especially on issues related to monitoring and early warning.

2. SEDIMENT DISASTER HISTORY IN BRAZIL

In Brazil, sediment disasters are very common and, although an efficient official registration system for occurrences has not yet been established, many works have investigated important events that help in the retrieval of historical data of such occurrences [Jones, 1973; Kanji *et al.*, 2005; Kanji *et al.*, 2008; Coelho Netto *et al.*, 2009; Lacerda, 2007; Avelar *et al.*, 2011]. Nogueira [2002] and Macedo & Martins [2015], are some of the authors who worked to summarize the main events of sediment disasters in Brazil, starting from Civil Defense database, compilation of scientific work and from other data sources. Considering the

data from these two studies, one can find that between 1928 and April 2015, sediment disasters have made at least 6,079 fatal victims in Brazil. It should be noted that many small occurrences are not registered and that deaths from great tragedies are not always accounted properly, so it is estimated that this number is probably higher.

Historically, the improvement of Brazilian Government's disaster risk management actions was driven by the occurrence of major disasters. The relationship between risk management and disaster occurrences is evident when one looks at the history of Brazilian law applied to the issue. This reactive behavior of Brazilian legislation has been shown by Cartagena [2015] and UFSC [2012]. In 1960, after successive landslides in Santos (1956 and 1959), which resulted in the death of 69 people [Nogueira, 2002], but mainly in response to the impacts of successive droughts in the Northeast, Law No. 3742 was enacted, establishing that the Federal Government should assist the states and municipalities in cases of public disasters triggered by natural factors.

At the end of the 1960 s, the major disasters that occurred in 1966 in Rio de Janeiro city (100 deaths), and in 1967 in the city of Caraguatatuba (120 deaths) and Serra das Araras (about 1,200 deaths) [Nogueira, 2002], caused several actions by the Federal Government, among these: Decree No. 64568 of 1969, which created the working group for drafting the permanent defense plan against public calamities; Decree-Law No. 950 of 1969, which established the Special Fund for Public Calamities and Decree No. 67347 of 1970, laying down guidelines for defense against public calamities and creating the Task Force for Public Calamities Affairs. This last decree provided that the response to public calamities, should be made from the cooperation between local, state and federal agencies, starting always from the municipality, followed by state and finally, by the federal government. The disasters mentioned above and the laws that succeeded them also ended up stimulating the creation of state and municipal civil defense bodies.

At the end of 1980 s, Decree No. 97274 of 1988 established the National Civil Defense System, which was the first to attribute prevention actions to civil defense agencies [Alves *et al.*, 2011]. Legislation on the civil defense system was successively modified to be improved and also to conform to United Nations resolutions, such as during the 1990 s (the International Decade for Natural Disaster Reduction), when in 1995 came the National Civil Defense Policy [Almeida, 2015]. With the evolution of the Brazilian Civil Defense System in the 2000 s, new apparatus have been created, such as the Civil Defense Community Groups (NUDECs), the National Center

for Risk and Disaster Management (CENAD), among others [Almeida, *op. cit.*].

More recently, in a short period of time, the tragedies of Santa Catarina in 2008 (floods and sediment disaster), Alagoas and Pernambuco (floods) in 2010, and in the mountainous region of Rio de Janeiro state in 2011 (flashfloods and sediment disaster), succeeded causing huge losses and generating great national commotion. In response to these calamities, in 2012 the federal government then restructured the entire National Civil Defense System through the National Protection and Civil Defense Policy-PNPDEC (Law No. 12.608), which is now called the National System for Protection and Civil Defense-SINPDEC and allocated massive funds to practical actions through the National Plan for Risk Management and Response to Natural Disasters-PNGRD.

The actions mentioned above pointed not only the reintegration of disaster related issues on the government agenda, but especially the growing importance given to disaster prevention and risk reduction through the implementation of public policies. Although many instruments addressed in PNPDEC have not yet been regulated and despite the lack of studies on the effectiveness of the investments announced by PNGRD (what makes its analysis difficult to be made at this moment), significant advances have been observed in this new phase of policies on disaster risk reduction. Among these is the restructuring of CENAD, the creation of CEMADEN, the identification and mapping of the country's main risk areas by the Brazilian Geological Survey (CPRM) and also by state and municipal agencies. These actions made possible establishing a monitoring and early warning system for disaster risks in Brazil, working 24 hours a day, 7 days a week, in order that public bodies of SINPDEC (municipal, state and federal) started to work in a more integrated way.

Specifically within the framework of CEMADEN, we highlight the increase of investment in Brazil's observational system from 2011 to 2015, with the installation of about 2,800 pluviometers, 9 meteorological radars, equipment for the analysis of sediment disaster risks, besides having created a technical staff that thinks continuously the national early warning system.

3. BRAZILIAN ARRANGEMENT FOR SEDIMENT DISASTER RISK MANAGEMENT

The Federative Pact is a legal framework established by the Brazilian Federal Constitution which establishes a relative institutional autonomy among the federative

entities (federal, state and municipal government). This is a fundamental aspect that requires considering the peculiarities, capabilities and necessities of each federative entity, which can be significantly diverse from each other. This way, the effectiveness of the sediment disaster risk management system depends on the integration of three subsystems that are interconnected by the Federative Pact and can be associated with the conceptual model proposed in **Fig. 1**: Land Use Management (LMS), Monitoring and Early Warning (MWS), and Civil Defense (CDS). As one can see, the Land Use Management Subsystem (LMS) is comprised of MCid/CPRM (Federal level), Urbanistic State Offices (State level) and Urbanistic Municipal Offices (Municipal level), that must work harmonically together through susceptibility/risk mapping, land use regulation, monitoring and control, considering disaster risk reduction general aspects.

The Monitoring and Warning Subsystem (MWS) comprises CEMADEN (Federal level), Monitoring and Warning State Offices (State level) and Monitoring and Warning Municipal Offices (Municipal level), who have the mission to work in an integrated manner in order to achieve effective results in monitoring risk areas and issuing socionatural disasters warnings in a coherent/effective way.

The Civil Defense Subsystem (CDS) plays a decisive role in Brazilian risk management system, being represented at the Federal level by CENAD/SEDEC, at State level by State Civil Defense bodies and at Municipal level by Municipal Civil Defense bodies.

It is noteworthy that the operational limits for each institution may not be restricted by the subsystem circuit described in **Fig. 1**. For example, a Municipal Civil Defense body may contact CEMADEN to acquire more information about a warning received from CENAD (currently there is a protocol that prohibits CEMADEN to issue warnings direct to the municipalities, in order that just CENAD can do it).

In the proposed model, institutions of all federative levels are connected by the white external circle illustrated in **Fig. 1**. At this integrated supra-institutional level other players can also participate (community and academia, for example), and knowledge and data can be shared properly, allowing dynamic communication, well defined protocols and integrated operations. This should be also an innovation-based model, where research, development and technology are aligned to the main aim of population defense and protection.

The processes of the Monitoring and Early Warning subsystem and its integration with other subsystems can be viewed in the proposed flow chart in **Fig. 2**, where those processes that represent a direct impact on

Fig. 1 Proposed model of the expected Brazilian integrated risk management system for sediment disasters.

monitoring and early warning axis are highlighted in yellow. In the center, there is the PDCA cycle (Plan, Do, Check, Act) that needs to be incorporated into the whole system, enabling a continuous improvement (Kaizen) on civil defense and protection operations.

4. THE HOLE OF CEMADEN

Since the beginning of its operationalization, by the end of 2011, CEMADEN has oriented its monitoring and issuance of alerts based on rainfall thresholds proposed by other risk management instruments such as the Civil Defense Preventive Plan of São Paulo State (PPDC), in operation since the 1980s [Mendes *et al.*, 2015], as well as in existing alert systems such as AlertaRio, which have been operational since the 1990s [d'Orsi *et al.*, 1997; Calvello *et al.*, 2015]. However, due to the rapid increase of municipalities to be monitored (from 56 in 2011 to 274 in 2012 and to 958 in 2017), CEMADEN's incipient organization and its observational network, coupled with the lack of a

consistent disaster database at the time, made it difficult to obtain mass movements thresholds for the various Brazilian localities and realities. This situation forced the center to seek alternative ways to monitor these areas and to propose, in a qualitative way, criteria for issuing alerts.

In 2012, a management model was implemented based on the feedback of issued alerts analysis (information gathered from CENAD, State and Municipal Civil Defenses and from the media), taking into account the occurrence or not of mass movements associated with alerts. The rules of this new analysis, Alerts x Feedback Clipping, performed only for 'high' and 'very high' warning levels, helped to determine the precipitation critical values (or thresholds) used for mass movement alerts. Initially, the rules were proposed according to risk scenarios for the municipality of Nova Friburgo, in the state of Rio de Janeiro [Ogura *et al.*, 2012]. That analysis considered the rain gauge stations as references and within a radius of 3 km from them, the locations that could be

Fig. 2 Relation between monitoring and early warning processes (highlighted in yellow) and the other subsystems that comprise the proposed risk management system for sediment disasters.

affected by a given meteorological event. Based on the alert level, it was expected that a certain type of event would occur and consequently a certain number of risk areas that could be affected by the process (**Table 1**).

Over time and with the continuous increase of the municipalities to be monitored, CEMADEN reduced efforts to maintain this type of analysis and began to adopt the thresholds that are being proposed by State or Municipal institutions, as in the case of Rio de Janeiro State, where the State Geological Service (DRM) has been proposing thresholds based on the relationship between rainfall and landslides observed during rainy periods [DRM, 2013, 2016, 2017].

The plan is based on the establishment of regional precipitation values that can lead to the occurrence of mass movements for four regions of the state: Mountainous region ; Metropolitan ; North, Northwest

and Paraíba Valley ; and Green Coast. However, this is not the reality in most of the Brazilian territory, where specific studies on rainfall thresholds that cause landslides are scarce.

Therefore, given the particularity of each region, in the case of mass movements, different rainfall values can trigger the issuance of alerts at different levels: moderate, high and very high. The resultant product, that is, the emission of the alert, is obtained by the association of observed precipitation, the weather forecast, the type of geodynamic process (landslides, debris flows and block falls) and the vulnerability of the areas at risk (represented by the number of exposed people, for example), configuring the risk scenario (**Fig. 3**).

The transmission of the alert is determined by the CEMADEN-CENAD protocol, endorsed by the Decree

Table 1 Proposal of a risk scenario for the municipality of Nova Friburgo, Rio de Janeiro State. Source : CEMADEN, 2012.

Risk Scenario	Triggering Rainfall	Processes Involved	Reference Stations	Spatial Distribution of Precipitation (Station x Locations)
Moderate (event with high frequency of occurrence and low potential of destruction, usually with fatalities of the order of units of victims). Areas at risk: 311	Rainfall in the order of 80mm to 120mm / 72h + Continuous rainfall forecast	Rock Falls Punctual and induced landslides	Conselheiro Paulino	Riograndina, Maria Tereza, Três Irmãos, Floresta, Alta Floresta, Conselheiro Paulino, São Geraldo, Ruy Sanglard, Ouro Preto, Córrego Dantas, Lazareto, Amparo, Jardimlândia
			Suspiro	Duas Pedras, Córrego Dantas, Ruy Sanglard, Jardim Paraíso, Chácara do Paraíso, Village, Centro, Ouro Preto, Sítio São João, Córrego Dantas, Cordoeira, Lazareto, Amparo, Vila Nova
			Olaria	Centro, Olaria, Barroso, Cordoeiro
			Ypu	Centro, Village, Cordoeiro, Sítio Pai João, Amparo, Barroso, Olaria
			Venda das Pedras	Nova Friburgo, Córrego Dantas, Campo do Coelho, Conquista, Três Cachoeiras
High (event with average frequency of occurrence and high relative potential of destruction, usually dozens of victims) Areas at risk: 350	Rainfall in the order of 150mm / 72h + Continuous rainfall forecast	Diverse processes involving rocks (falls topples, slides, etc.) Significant number of landslides on cut and fill slopes and sparse landslides on natural slopes.	Conselheiro Paulino	Riograndina, Maria Tereza, Três Irmãos, Floresta, Alta Floresta, Conselheiro Paulino, São Geraldo, Ruy Sanglard, Ouro Preto, Córrego Dantas, Lazareto, Amparo, Jardimlândia
			Suspiro	Duas Pedras, Córrego Dantas, Ruy Sanglard, Jardim Paraíso, Chácara do Paraíso, Village, Centro, Ouro Preto, Sítio São João, Córrego Dantas, Cordoeiro, Lazareto, Amparo, Vila Nova
			Olaria	Centro, Olaria, Barroso, Cordoeiro
			Ypu	Centro, Village, Cordoeiro, Sítio Pai João, Amparo, Barroso, Olaria
			Venda das Pedras	Nova Friburgo, Córrego Dantas, Campo do Coelho, Conquista, Três Cachoeiras
Very high (event with low frequency of occurrence and very high relative potential of destruction, usually dozens of victims). Areas ate risk: 359	Very high acumulated rainfall, more than 200mm in 72h.	Generalized landslides. Mud and debris flows. Rock fall, topple and slides. Generalized landslides with very high risk of fatalities (hundreds) and damages.	Conselheiro Paulino	Riograndina, Maria Tereza, Três Irmãos, Floresta, Alta Floresta, Conselheiro Paulino, São Geraldo, Ruy Sanglard, Ouro Preto, Córrego Dantas, Lazareto, Amparo, Jardimlândia
			Suspiro	Duas Pedras, Córrego Dantas, Ruy Sanglard, Jardim Paraíso, Chácara do Paraíso, Village, Centro, Ouro Preto, Sítio São João, Córrego Dantas, Cordoeiro, Lazareto, Amparo, Vila Nova
			Olaria	Centro, Olaria, Barroso, Cordoeiro
			Ypu	Centro, Village, Cordoeiro, Sítio Pai João, Amparo, Barroso, Olaria
			Venda das Pedras	Nova Friburgo, Córrego Dantas, Campo do Coelho, Conquista, Três Cachoeiras

No. 149, of December 18, 2013, based on article 4, section VIII, where “CEMADEN will issue natural disaster alerts for CENAD”, which will retransmit it for State and Municipal Civil Defenses, assisting the National System of Civil Defense (**Fig. 4**).

Since the institutional arrangement under GIDES Project in mid-2013, actions on different fronts within CEMADEN have been proposed and debated throughout the technical meetings involving different project partners, mainly between CENAD, CPRM and State and Municipal Civil Defenses. Among these actions we can make explicit the improvement and automation of the warnings issued by CEMADEN, alteration in the transmission flow of alerts, as well as the strengthening of risk management (prevention) by the Municipal Civil Defenses.

Approaches illustrated in **Figs. 1, 2, 3** and **4** can be integrated in a timeline, a valuable tool that allows to understand how observational data, landslide events, interinstitutional operations and communications interact dynamically in time, **Fig. 5** shows the timeline of the rainfall event of March 17th 2013, in the Municipality of Petropolis, located at the mountainous Region of Rio de Janeiro State.

The timeline observation allows a better understanding of the complexity of actions taken

during the monitoring and realizes the dynamism following the alert level changes, the close communication between CEMADEN and CENAD, the different sources of information used in monitoring and the variety of sources of feedbacks.

From **Fig. 5** one can note that the timeline reflects the monitoring activities taken by CEMADEN and CEMADEN-CENAD protocol in action. The monitoring actions aim to contribute at anticipating actions taken by Municipal and State Civil Defenses, indicating a possibility of occurrence of a certain phenomenon, in this case, flashfloods and mass movements. During the meteorological monitoring and based on the feedbacks obtained from CENAD, CEMADEN's situation room searches to understand the risk scenario, analyzing the accumulated rainfall and/or river water levels data, associated to meteorological forecast. In this context, the Situation Room informs CENAD, indicating a possibility of raising or lowering the alert level.

5. CONTRIBUTIONS OF GIDES PROJECT TO MONITORING AND WARNING OF SEDIMENT DISASTERS

It can be said that GIDES Project had the following

Fig. 3 Flowchart reporting the chain of alert issuance by CEMADEN. Source : CEMADEN, 2017.

Note:

1. In accordance with the protocol, the entire natural disaster risk alert issued by CEMADEN should be sent to CENAD, in order to constitute a basic subsidy for taking preventive actions for civil protection (1).
2. In the case of processes monitored by soil/rock displacement (creep and falling of blocks), only the option (2)

Legend: SCD: State civil defense; MCD: Municipal civil defense

Fig. 4 Flowchart demonstrating the chain of alert transmission. Source : CEMADEN, 2017.

tripod as operating strategy : technical, organizational and articulation, with the following function :

- **Technical aspects.** The exchange of knowledge is put into practice mainly through the visit of Japanese sediment disasters experts in Brazil and also through visits of Brazilian experts to Japan. During the project, technical meetings were held in Brazil (around 40 meetings), when the Project team had the opportunity to discuss specific content of thematic areas with guests from other institutions and

academic community.

- **Organizational aspects .** Institutional strengthening requires an understanding of how SINPDEC works in its institutional arrangements and policies, so that the starting point was mapping the processes, activities and responsibilities of different institutions that make up the system at Federal, State and Municipal levels. These activities were handled by Japanese experts, who carried out detailed research visits in major institutions, identifying points for

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Note: There is no confirmation of the times of occurrences so far, Civil Defense agents are on the field.

Fig. 5 Timeline of the rainfall event on March 17 th, 2013, in the Municipality of Petrópolis. Source : CEMADEN, 2013.

improvement in both intra and inter-institutional matters. It is noteworthy that the mapping at State and Municipal levels was carried out only in the States and Municipalities involved in the Pilot Projects.

- **Articulation aspects.** Given the political and institutional complexity of GIDES's issues, as well as the various interests involved, it was necessary to build trusting relationships with each participating institution and seek for political support directly in the Presidency, which monitored the Project through the Civil House ministry during the initial phase. Thus, the Japanese team successfully managed to mobilize all the necessary actors who have joined formal working groups to cross the evolved ministries.

5.1 Pilot Projects

Pilot Projects were a key aspect to the success of GIDES because they provided places for experimentation and improvement of methods, techniques and procedures related to sediment disaster risk management, and enabled the development and maturation of complex inter-institutional processes involving integrated operations. In fact, the Pilot Projects represented a test phase to detect the viability of actions and procedures agreed in the Project, through a supervised and controlled application in specific Municipalities.

For pilot implementation they were selected three Municipalities considered representative of the most significant disaster risk scenarios of the country and, therefore, presented Municipal Civil Defense bodies capable of facilitating the implementation of the actions planned in the Project scope. After a preliminary phase of selection and joint validation with the counterparts, the municipalities selected were Petrópolis and Nova Friburgo (both located in Rio de Janeiro's State mountainous region) and the municipality of Blumenau (located in the State of Santa Catarina). These municipalities were significantly affected by the megadisaster at the mountainous region of Rio de Janeiro in 2011 and the disaster at Itajaí's Valley in 2008, respectively.

5.2 Activities planned for the Project

The Project was designed into four groups of activities to be carried out over four years (2013-2017), arranged according to the outputs intended by the project.

Concerning the assignment of responsibilities, each output was under the coordination of one ministry (in brackets), but the other ministries mentioned also participate in the activities of the related output :

- OUTPUT 1 : Strengthen capacity of risk

assessment on sediment disaster including hazard identification, vulnerability analysis, and risk evaluation and mapping (MI, MCid, MCTIC) ;

- OUTPUT 2 : Strengthen capacity of planning and implementation of risk reduction measures for sediment disaster (MCid, MI) ;
- OUTPUT 3 : Improve protocol of early warning, disseminating risk information and method of correct disaster data (MCTIC, MI) ;
- OUTPUT 4 : Improve system of monitoring and prevention on sediment disaster mitigation (MCTIC, MI).

Specifically on issues related to monitoring and early warning for sediment disasters, the expected activities, results and products can be seen in table 2. Among other activities, they were carried out to date eight technical meetings on monitoring and alert issuing, whose main objective was to promote discussions in order to prepare the 'Technical manual for preparation, transmission and use of landslides risk alerts'. This document, among other purposes, aims at establishing the main guidelines to be followed in the Pilot Projects on this subject.

The manuals to be produced within the Project's scope also serve to equalize the technical understanding between the counterparts and their respective bodies, so that the terminologies and concepts can be used in the same manner by all components of SINPDEC.

6. ANALYSIS OF GIDES ACTIVITIES, FOCUSING ON MONITORING AND EARLY WARNING

The Japanese system of monitoring and early warning has been gradually introduced by Japanese technicians during their mission in Brazil and also through training visits made by Brazilian experts in Japan. The exchange of information has allowed understanding up to what points Brazil can use the Japanese experience to improve the national system.

The Japanese monitoring system, described by *Osanai et al.* [2010] is relatively complex and is a result of many years of research on the mechanisms of the physical processes that govern sediment disaster in that country ; it also includes a huge amount of monitoring instruments. It is noteworthy that the point is not about importing the Japanese model, but rather to understand how Brazil can enhance its system from the adaptation of the best practices of Japanese models.

Other points that have been highlighted in the Project's discussions are the occurrences registration (process of the Civil Defense subsystem) and the risk mapping (process of the Land Use Management subsystem), which have a strong impact on monitoring and early warning operations.

Some mapping techniques have been learned and discussed, aiming not only to produce better maps, but also to disseminate correctly the information contained in these documents, directed to risk professionals and the population at risk. *Uchida et al.* [2009] reviewed

Table 2 Expected activities, results and products from GIDES Project for the Monitoring and Early Warning axis. Source : Adapted from JICA, 2013.

Proposed activities	Expected results	Expected outputs
Selecting one or two risk areas in each municipality to the pilot application.	Critical Curves calculation in order to increase objectivity in the joint decision process of issuing alerts.	Technical manual for preparation, transmission and use of landslides risk alerts.
Following the Japanese methodology adapted to establish standard critical lines ¹ for sediment disaster early warning at pilot sites.	Establishment of common protocols directed to sediment disaster monitoring and early warning.	
Application of joint protocols (Federal, State and Municipal levels) aiming to a unified Alert Issuing.	Establishment of shared and unified information flows and records. Adapting content and language of the alerts aiming a broad understanding of the whole network involved in sediment disaster forecasting process.	

¹ Lines used for issuing alerts, based on rainfall indices

the hazard map production process applied to sediment disasters in Japan and showed how the Japanese law was able to induce in a systemic way the production of hazard maps in the country.

GIDES Project's activities have enabled the involved counterparts to better understand the functioning of other institutions that are part of the project, both in the same government level, as at other levels. This fact is an enormous step towards the strengthening of SINPDEC.

From the better understanding of the functions, operational details, products and especially the difficulties faced by each institution, the other components of SINPDEC began to better understand their role and how they can improve their operation in an integrated way. In addition to the exchange of experience and adjustments in the procedures between Brazilian counterparts, the lessons learned from Japanese experiences helped understanding how the Brazilian system can enhance its effectiveness in a global way. In that sense, the discussions that took place during the project showed that there is a need to improve the integration between CEMADEN, CENAD, State and Municipal Civil Defenses, in order to anticipate the transmission of alerts to the population at risk. One of the project's main products, the 'Technical manual for preparation, transmission and use of landslides risk alerts' is very important for all institutions involved in disaster risk management since it represents an initial milestone in the attempt to strengthen and unify the national early warning system. The manual provides important definitions about early warning systems, their components and responsibilities. On the monitoring, they were presented methods currently used by CEMADEN and others ones that should be used in the future with the system evolution. It was also discussed the way alarms are triggered, criteria on which they are based, definition of alert levels and protocol of actions to be taken. It is very important, as the manual itself suggests, that this publication be evaluated by the SNPDC bodies and that it be improved over time. As a consequence of the handbook, it is expected that legislation and agreements between institutions should be established so that the suggested communication protocols are followed. In this way, the municipal civil defenses are expected to receive the information more quickly, to take action in advance and to return the necessary information so that the situation is controlled also at the Federal and State levels.

7. CONCLUSION

In more general terms one can think about the advances needed to improve the disaster risk

management system in Brazil, starting from transversal axes to all outputs of GIDES Project. For example, the establishment of a continuous flow of information is essential to a successful integrated operation. In another example, regarding mapping issues, the existing mapping information should be not only adequately forwarded to the right recipients, but also should be previously discussed among the bodies at SINPDEC and the communities at risk.

The information in the maps must be communicated to the population at risk using accessible language in order that it can be understood that the final result depends on several physical and social factors and also that the methodology used in the maps preparation carries a certain amount of subjectivity. Finally it is important to be aware that the final outcome of the maps, understood as the space distribution of risk, may vary in time.

Risk maps should be updated to incorporate information gathered by municipal stakeholders (including communities at risk), establishing a two-way information process.

Regarding the monitoring and early warning activities, the information flow should be thought steadily, considering the following phases :

- **The understanding of risk scenarios**, when the focus is in comprehending different types and magnitudes of hazards and the consequences to the system at risk (before an occurrence) ;
- **Attention to an imminent disaster**, when the offices at different levels must communicate to each other in a precise way and guarantee that the necessary information is delivered to the possibly affected communities ;
- In **post-disaster**, monitoring offices should receive back information about the damage extension. This **feedback** is very important to evaluate the monitoring and early warning system. Therefore, the information should be accurate and equalized between the different institutions involved.

After a careful analysis, one can conclude that despite the progress of legislation and public policies related to disaster risk management in Brazil, many advances are still needed for them to be effective and to reach the main goal : to reduce losses due to sediment disasters. Among the main advances needed, some specific points are highlighted here :

- Implementation of an integrated information system between the institutions that comprise SINPDEC, specially carrying out the register of occurrences and its respective triggering events ;
- Integration of civil society in SINPDEC, inducing the creation of communitarian monitoring

systems and or stimulate the creation and operation of Community Groups for Civil Defense and Protection (NUPDECs) ;

- Increase social participation in disaster risk reduction actions ;
- Setting up legal and normative mechanisms that ensure the operational integration between the different levels of government, considering the peculiarities at different levels of public administration and especially of Civil Defense organizations in Brazil ;
- Strengthening of municipal Civil Defense should be thought by means of achievable goals in the medium to long term, providing sufficient staff and resources ;
- Analysis and evaluation of the effectiveness of public policies for disaster risk reduction so that they can be revised and improved continuously ;
- Since some initiatives do not last long (for lack of funds or discontinuity in the public administration), mechanisms should be designed to ensure the continuity of policies focused on sediment disaster risk reduction.

Part of those advances depends on the regulation of instruments provided in PNPDEC, and another part depends on the efforts of SINPDEC members in implementing these instruments.

It is well known that the strengthening of the disaster risk reduction strategy carried through GIDES Project can help both the construction of these legal instruments, as its implementation, once they depend on the proper interinstitutional functioning of SINPDEC bodies.

It is also worth noting that the creation of a forum for communication and discussion between the institutions of SINPDEC, universities and civil society could help at pointing possible ways and approaches for sediment disaster risk management in Brazil, even after the completion of GIDES Project.

ACKNOWLEDGMENT: The authors thank the member institutions and professionals from GIDES Project, especially the Japanese team, for the aggrandizing opportunity of working and learning together.

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Received : 8 July, 2016

Accepted : 13 December, 2018