Natural Hazard Risk Maps for Public Use in Rural Areas in Northern Tajikistan

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Abstract

The mountainous landscape of Tajikistan and its harsh climatic conditions, combined with intensive land-use, has resulted in an environment that is significantly prone to natural hazards. For many rural villages the primary natural hazard risks are mass-movements such as landslides, avalanches, rock fall, and floods. These movements routinely destroy infrastructure, disrupt local economies, and take lives.

To minimize the impact of such natural hazards to Tajikistan`s vulnerable mountain societies, an important step is the management and dissemination of knowledge about high risk locations. Main purpose of the cartographical work of the here presented project was to produce a set of maps which are easy to understand, easy to produce and maintainable by local authorities.

For each village involved in the project, two maps were created. One map in bird-eye view that shows all the points of interests in case of an emergency, such as safe havens, mosques, radio communication, escape routes and alternative road connections. The other map in 3D view shows the possible hazard risk zones. These areas should not be used for further development and possibly be targeted by mitigation measures.

For the information regarding natural hazards to be formally integrated into current and future land-use planning (e.g. new roads, settlements, agriculture, etc.), dissemination and articulation of the information has to meet local needs. For experts of governmental and international organizations information can be presented using sophisticated tools and techniques such as thematic mapping and GIS. Such tools are not appropriate for local governments and communities in Tajikistan that have little or no experience with software and data presentation.

This project used satellite imagery from GoogleEarth overlaid with the findings of the risk assessments. GoogleEarth satellite imagery for the area of interest (Northern Tajikistan, and more specifically Zerafshan valley) provides images with a resolution better than 3 meters. This quality of imagery allows one to identify individual houses, streets and other important landscape features that are easily recognized by local populations. Additionally, the 3D capacity of GoogleEarth was used to create risk maps of the villages in a 3D view. The view was usually taken in a way that gives a natural impression of the villages similar to the perspective that one would have if looking from the opposite mountain side.

Using this kind of simplified mapping was readily accepted by the local population and authorities and received very positive feedbacks.

Keywords: mapping, natural disaster risk, cartography

1. Base information source

During an extensive disaster risk management project mainly conducted by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) in about 60 villages in the Zerafshan valley in Northern Tajikistan, assessments regarding the risk of natural hazards were conducted. The assessments focused on the existing risks of natural hazards on village level and an emergency plan in case of a natural hazard event. The collected information was compiled into three documents:

- Hazard information sheet (village level): Detailed information about the risk of natural hazards, such as type of risk, extent, localization and possible impact on the settlement.
- Emergency information sheet (village level): Detailed description of activities within the settlement in case of an emergency, such as safe havens and evacuation routes.
- Summary of hazard information and mitigation measure (district level): Listing of all the hazard risks and mitigation measures within the villages covered by the project per district.

The three documents which are basing on the assessments of GIZ were building the main source of information for the map production.

Additionally to the three documents, the responsible person for the cartographical realization was visiting each village. The additional visit of the villages by a natural hazard risk expert trained in cartography was allowing for a second independent opinion.

After the cross-check in the field, a consistency check between the field observations and the already existing written information was conducted. This consistency check was an iterative process between the organization responsible for the assessment and the one responsible for the cartography.

The combination of the primary assessments, the cross-check in the field and the consistency check in the office was an important factor in quality assurance and essential for the consistency among the different sources of information.

2. Map concept and cartography

Main purpose of the cartographical work was to produce a set of maps which are easy to understand, easy to produce and maintainable by local authorities. Regarding the high demand on technical knowledge and overhead, such as georeferencing, the use of GIS was considered as a not target oriented approach.

Instead of a GIS application a well known desktop publishing (DTP) software was chosen. The DTP software Adobe Illustrator was fulfilling all of the requirements of this project. The combination of GoogleEarth Professional and Adobe Illustrator proofed to be a simple and user-friendly combination.

Two maps per village are created to provide reader friendly maps. Each of the maps has a clear defined focus and set of symbols, namely:

- Hazard information map: The map shows the location of possible natural hazards and the type of hazards (mudflows, landslides, floods, avalanches, rock fall, groundwater), areas affected by a hazard, areas to be avoided regarding further development of the settlement and basic mitigation measures.
- Emergency information map: Indication of places with a high importance during an emergency such as safe havens, radio communication and medical facilities.

This map set accompanied by the information sheets, summarizes the most important information regarding disaster risk management in each village. All of the information (maps and information sheets) are provided only in Tajik language.

2.1 Software used

The Professional edition of GoogleEarth provides several additional features which were considered as useful for the project. The ability of exporting a chosen view on a village with a resolution of 4800 by 3368 pixel was the most important feature. The export of views in 2D and 3D in the mentioned resolution was used to save the imagery for the field work and the map production itself.

For the cartographical work the vector based DTP software Adobe Illustrator was chosen. The software can be seen as a standard in professional DTP and digital cartography. The rich possibilities of the manipulation of vector information and the extensive possibility of using transparency and color were only a few factors for choosing Illustrator for this project. In case of further use of GIS data or export of the existing data to a GIS, the plug-in MAPublisher[1] can be used. The plug-in allows the direct use of georeferenced data in Illustrator and extents the possibility of Illustrator towards a GIS with high quality graphical possibilities. Additionally the following aspects were also considered during the software evaluation:

- Direct storage of the maps as PDF documents.
- In case of offset printing a color separation is easy to apply and allow for a Computer-To-Plate (CTP) export.
- Availability of the software in Russian language.

Especially the possibility of using the plug-in MAPublisher and the so guaranteed connection to GIS was the main argument of selecting Illustrator. Other software packages, such as Corel Draw, do not provide this possibility.

2.2 Hazard information 3D map

Main purpose of the hazard information map is the presentation of hazardous areas within and around the villages. Central information of the map is the localization of possible natural hazard events such as mudflows, landslides, floods or avalanches. Additionally parts of the settlements which could be affected by a hazard are highlighted.

To simplify the map-reading 3D view was chosen. The chosen view shows the village from a familiar viewpoint. Often the view from a neighboring mountain side was chosen to represent the village in a way which could be known by the local inhabitants from their own experience. This recognition factor resulted in a high acceptance of the maps within the local authorities and inhabitants.

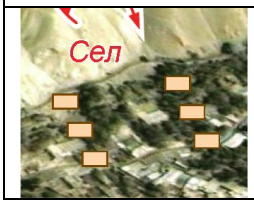
[1] MAPublisher produced by Avenza Systems Inc. (www.avenza.com/mapublisher)

Figure 1: Hazard information map in "3D view"

The content of the map is reduced to show only information which is relevant regarding the localization of possible hazards and the extent of a hazard event affecting the settlement. The map should be used as a tool for planning any further development of the settlement regarding the building of new houses, roads or official buildings. The information of areas under high risk should be used for defining areas to be abandoned or protected with adequate mitigation measures.

The following table summarizes the information shown in the map.

Table 1: Content of the hazard information map

Symbol	Description and cartographical remarks
	The symbol represents the location from where a mass movement may be released, with an indication of the potential direction of its flow path. A single symbol is used to represent all possible type of mass movements. This simplifies the reading of the map avoiding numerous different symbols. The type of hazard is indicated by a label. Both, the symbol and the label, are surrounded by a small white halo to separate them from the imagery. The symbols are distorted according to the terrain. This distortion supports the "3D effect" of the map and allows a more precise symbology of the localization of the hazard and flow path.
	Fuzzy indication of areas under risk within the settlements: As a symbol a group of houses was chosen. Due to the uncertainties of the area affected by a hazard, the use of a polygon was abandoned. Using fuzzy boundaries of possible affected areas is representing the uncertainties of the hazard extent in an obvious way.

Symbol	Description and cartographical remarks
	Fuzzy indication of areas where mitigation measures such as tree planting could prevent further erosion or release of hazards.
	Clear indication of areas which should not be used for any kind of activities. It is highly recommended not to use such areas for housing, business or agricultural use. In combination with adequate mitigation measures such areas could be re-used in mid- or long-term perspective. But this has to be continuously monitored.

2.3 Emergency information bird-eye view map

In case of a hazard event the information of places such as safe havens or places to obtain information must be made available for organizing rescue activities. The information where inhabitants of areas hit by a hazard have to go has to be pointed out in simple and understandable way. Providing this information beforehand of a hazard can safe many lives and simplifies the organization of rescue activities.

In the emergency information map a set of the most important places of interest (POI) in case of an emergency are pointed out. For simplifying the route finding a bird-eye view of the settlement was chosen. This perspective clearly shows the evacuation ways, roads and possible alternative roads in a non-distorted perspective. In most cases the map is oriented towards North (North at the top of the map). This map contains only information which could be relevant in case of an emergency.

Figure 2: Emergency information map in birds-eye view

All inhabitants should be able to read and understand the emergency map. For the case of “illiterate map readers” a simple and self-explaining way of symbology was chosen. The symbols should be memory triggers explaining their meaning without using the legend. Table 2~~Table 2~~ shows some examples of this self-explaining approach.

Instead of the use of abstract symbolic geometries, such as points, circles, triangular, images representing the POI were chosen.

Table 2: Examples of self-explaining symbols for Points-Of-Interest

Symbol	Description and cartographical remarks		Description and cartographical remarks
	School building.		Medical facilities, such as simple local medical help points or small hospitals.
	Mosque or religious buildings. Additionally to the localization, the local name is indicated.		Safe haven or central gathering point. Indicating where the inhabitants have to go in case of emergency.
	Central information point. At this localization all information regarding emergency planning is available. Instead of using the internationally known symbol “**i**” for **i**nformation an “A” is used. “A” stands for the Tajik word **А**хборотдихи (engl: information).		

Using the recognition factor of localizations within the satellite imagery, the symbols of the POI’s are not put directly on the location itself. Instead of this, the symbols are slightly displaced using an arrow pointing towards the location. The location is highlighted with a transparent red dot.

Table 3: Highlighting of Points-Of-Interest important in case of emergency

Symbol	Description and cartographical remarks
	Buildings or locations with a high importance in case of an emergency are highlighted by using a red circle. This includes places like Safe Havens or Central Gathering Points. A transparency of 50 % was used for the red dot. This transparency was selected based on a test series of transparencies (25 %, 50 % and 75 %). The chosen 50 % provided the best relationship between highlighting, transparency and color saturation using A3 color laser printer with coated paper (160 g/m^2).

Additionally existing roads, possible alternative roads and rivers and streams are shown using simple line symbols in different colors. Avoiding covering the information of the satellite imagery, the lines are also using a transparency of 50 %. The combination of 50 % transparency and a line width of 2 mm highlights the features in the imagery without covering it.

2.4 Update and maintenance of the maps

All of the maps and the original digital data will be handed out to the local authorities of the districts. To ensure the further development and maintenance of the maps within the

local authorities a training and support program will be established. The authorities will be equipped with one computer per district in combination with the software needed.

The Tajik NGO *CAMP Khuiston* which was elaborating all of the emergency and risk information maps will be responsible for the training of the local staff in the districts. The training of the staff will be conducted in three steps:

- Intensive training in the district offices using Illustrator, maintaining and updating of the maps.
- Refresher training after a certain time in the district offices.
- Service and backstopping during several month providing phone and on-site support for the district offices.

As a base for the training and support a Step-By-Step manual explaining how to use Illustrator and how to update specific layers of the maps will be elaborated.

Main aim of this approach in three steps in combination with a specific manual is a sustainable establishing of know-how and a mid- and long-term establishing of the maps and adjoining information sheets within the district authorities.

3. Conclusion

The reaction of the local authorities, head of villages and inhabitants of the settlements towards the GoogleEarth imagery approach of mapping was very positive. The positive factor of recognition of the settlements within the satellite imagery was attracting the audience to read and use the maps. In combination with the adjoining information sheets the maps can be used as a base for planning and emergency prevention activities on village and district level.

The use of GoogleEarth imagery in Illustrator within a Tajik organization without highly trained staff in GIS or other fields of computer science was very successful. The use of Illustrator is easier to learn than the use of GIS. Especially the relatively simple file handling and an intuitive way of drawing in Illustrator are important factors.

As in all cartographical projects a professionally edited content is crucial for the success of such a project. The amount of effort in cross-checking between written assessments, field notes and map drawings has to be considered as very high. Only with consistent information between written and graphical representation a cartographical product will be valuable.