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Pierre Lacroix  
*University of Geneva*

Rocío Escobar  
*University of Geneva*

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5D: A GIS-based Approach for Determining and Displaying the Degree of Operational Difficulty of Demining

Clearance operations highly depend on environmental, geographic and socioeconomic conditions. These conditions make demining easier, more difficult or nearly impossible. This article proposes an analytical method called 5D (Determining and Displaying the Degree of Operational Difficulty of Demining), which classifies degrees of difficulty as low, medium, high or extreme.

by Pierre Lacroix and Rocío Escobar (University of Geneva)

The Geneva International Centre for Humanitarian Demining is collaborating with the University of Geneva to explore the feasibility of displaying the impact of explosive remnants of war in contaminated countries through maps, without revealing the ERW’s exact locations. This project, Server for Explosives Remnants of War Information Systems, also aims to develop geographical information system tools and methods to identify where populations are most at risk. In addition, SERWIS endeavors to Determine and Display the Degree of Operational Difficulty of Demining (5D) on account of realistic and measurable terrain criteria, such as land cover, slope, distance to sensitive points of interest, distance to roads, hydrology, etc. By combining such geospatial datasets into a multi-criteria process at the macro level, this project is meant to refine the evaluation of a country or region’s demining capacity and help improve demining efficiency. Results provided by the model can act as a good starting point for operational teams that wish to prepare their intervention in the field. Decision-makers can use the model for determining the order in which contaminated areas are to be cleared and which tools should be used.

The article focuses on mechanical demining, and it is nearly impossible to determine the percentage of land that may be contaminated areas. By weighting various datasets, a new dataset is created and classified into four ordinal categories of demining difficulty: low, medium, high and extreme. The percentage of surface deemed contaminated can be obtained from this dataset, macro statistics can be obtained and used in a first step. This first step aims to present an analytical method—a map—for the evaluation and visualization of the degree of operational difficulty for demining contaminated areas. By weighting various datasets, a new dataset is created and classified into four ordinal categories of demining difficulty: low, medium, high and extreme. From this dataset, macro statistics can be obtained and used in a first step. This first step aims to determine the percentage of land that may be cleared in a region or a country, with a given technique and a specific level of operational difficulty. The percentage of surface deemed extreme to demine is also estimated. In a second step, the interpretation of information regarding operational difficulty may contribute to improving decision-making for the selection of the most suitable technique for a given area. This technique may affect the degree of difficulty in employing manual clearance methods, although to a lesser extent. Geographical data that can act as a direct or indirect indicator of the degree of difficulty are available for most of these factors. This paper focuses on mechanical demining, but does not present a future focus on other tools or methods. For each tool, developing a model of operational difficulty requires involving both geographers and experts on the tool in question. This enables the identification of appropriate layers of geographical data and the individual role of these layers in the model. For instance, a geographic layer on the ferromagnetic qualities of the soil might be a good input into a model indicating the difficulty of using metal detectors, but that same layer is likely not useful when estimating the difficulty of using animal detection. Only an expert on manual demining can determine which layers a geographer proposes are relevant for manual demining. These models are also likely to depend on the local environment. The factors that make manual demining difficult in one country are likely not exactly the same in another country.

The primary objective of this article is to present an analytical method—a map—for the evaluation and visualization of the degree of operational difficulty for demining contaminated areas. By weighting various datasets, a new dataset is created and classified into four ordinal categories of demining difficulty: low, medium, high and extreme. From this dataset, macro statistics can be obtained and used in a first step. This first step aims to determine the percentage of land that may be cleared in a region or a country, with a given technique and a specific level of operational difficulty. The percentage of surface deemed extreme to demine is also estimated. In a second step, the interpretation of information regarding operational difficulty may contribute to improving decision-making for the selection of the most suitable technique for a given area. This technique may affect the degree of difficulty in employing manual clearance methods, although to a lesser extent. Geographical data that can act as a direct or indirect indicator of the degree of difficulty are available for most of these factors. This paper focuses on mechanical demining, but does not present a future focus on other tools or methods. For each tool, developing a model of operational difficulty requires involving both geographers and experts on the tool in question. This enables the identification of appropriate layers of geographical data and the individual role of these layers in the model. For instance, a geographic layer on the ferromagnetic qualities of the soil might be a good input into a model indicating the difficulty of using metal detectors, but that same layer is likely not useful when estimating the difficulty of using animal detection. Only an expert on manual demining can determine which layers a geographer proposes are relevant for manual demining. These models are also likely to depend on the local environment. The factors that make manual demining difficult in one country are likely not exactly the same in another country.

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A model was developed in a geographical information system called ArcGIS®, inputted with datasets obtained from different sources and applied to the entirety of Mozambique. 1

This case study focuses on mechanical de-mining, on the basis of a fictive machine with medium class characteristics (length with flail approximately 4.7 m; working capacity approximately 8 m³/h in topsoil; 900 m³/h in sand; 840 m³/h in gravel) commonly used in many countries. The model does not aim to estimate financial cost, hence the use of the term operational difficulty. A cost assessment would require data collection and analysis on a local level, while the 3D model holds information about the location of different features such as airports, train stations, schools, hospitals, etc. In the mine action framework, POI are likely to facilitate activities, since they increase the access of demining resources to hazardous areas. 4

GlobCover. GlobCover is a global land cover map available for two periods, December 2004–June 2006 and January–December 2009. Data is missing for only 1% of total land area. GlobCover has been used in many fields of work (e.g., crop mapping, assessment of global forest cover and estimations of biomass burning emissions) and is easy to apply to a country like Mozambique. In the present case, this dataset was used to identify human activity such as farming and urban settlement. GlobCover is freely available online for noncommercial use at a 300 m resolution (Figures 1 and 2, pages S2–S3) in a raster format. Each pixel represents a 300 m x 300 m cell and holds a value indicating the category of land cover found at the position where it is located (see Figure 1, page S2). For instance, Category 14 corresponds to rain-fed croplands, Category 100 to sparse vegetation and Category 200 to bare areas (Figures 2 and 3, page S3). The data is in Tagged Image File Format (.tif), and the spatial reference is the World Geodetic System 1984 (WGS 1984).

The Global Lakes and Wetlands Database was used for noncommercial, scientific, conservation and educational purposes. 5 All these datasets are provided in vector format (polygons) and for typical scales of use ranging from 1:1,000,000 to 1:5,000,000. The GLWD can be used for noncommercial, scientific, conservation and educational purposes. 5

The Global Lakes and Wetlands Database was developed on the basis of seven digital maps and attribute datasets for lakes and wetlands. The Conservation Science Program of the World Wildlife Fund publishes it globally. Three different datasets can be used, depending on the level of detail required: large lakes and reservoirs (GLWD-1), smaller water bodies (GLWD-2) and wetlands (GLWD-3). For this case study, a combination of Level 1 and Level 2 was used to include lakes with an area > 50 sq km, reservoirs with a storage capacity > 0.5 cu km and smaller water bodies with a surface > 0.1 sq km. All these data sets are provided in vector format (polygons) and for typical scales of use ranging from 1:1,000,000 to 1:5,000,000. The GLWD can be used for noncommercial, scientific, conservation and educational purposes. 5

Figure 4. Overview of the model “Operational difficulty of demining.” Figure courtesy of the authors.
demining in Mozambique for a fictive demining machine with medium
capacity. The model can be identified by the letter F above a blue or a
green oval, offering the user the option specifying the value, before running the model. Administrative limits are placed into parameters, because they may influence operational difficulty of demining in different ways for different study areas.

The model is a powerful tool that can calculate in 30 minutes an operational difficulty layer of the entirety of Mozambique (about 800,000 sq km), with a 200 m resolution. In addition, the model is flexible, user-friendly and does not require advanced GIS skills from its users.
Mine Detection Rats: Effects of Repeated Extinction on Detection Accuracy

This article describes the performance of Giant African Pouched Rats where reinforcement (reward) or extinction (no reward) conditions affected landmine identification. Accuracy deteriorated quickly in the absence of reinforcement, suggesting that reinforcement is essential.

by Amanda Mahoney, Amy Durgin, Alan Poling [ Western Michigan University, APOPO ], Bart Weetjens, Christopher Cox, Tass Teweide, TekKimiti Gilbert [ APOPO ]

The mine detection rats in Mozambique work on training fields and actual minefields (operational sites). The training field comprises several 100 sq m, 200 sq m and 400 sq m boxes indicated by ropes along each side. Between zero and four deactivated landmines are buried within each box. The rats are attached to a rope (via a harness) held by two handlers on either side of the box. The rats walk across the box they are searching. When an indication response (passing and digging) occurs within 1 m of a landmine, the trainer clicks to signal reinforcement and food is delivered.

When the rats are used operationally, the location of mines (and other explosive remnants of war) is unknown prior to clearance operations. Therefore, knowing whether an indication response is correct (i.e., within 1 m of a mine) or incorrect is impossible. To avoid the possibility of reinforcing incorrect responses and thereby potentially reducing the rat’s subsequent detection accuracy, no reinforcers are delivered when the rats are used operationally.

In technical terms, the rats work under extinction (no reinforcement) conditions when used operationally and under differential reinforcement (food reinforcement for correct responses, no reinforcement for incorrect responses) conditions during training. Extinction inevitably weakens previously reinforced responses.

Figure courtesy of the authors.

Illustration of the experimental setup with one trainer and one rat.

All photos and figures courtesy of the authors.

As a result of almost 30 years of war, landmines are a devastating problem in Mozambique. According to a United Nations’ report, an estimated 20 people step on landmines every month in Mozambique and, due in part to lack of adequate health care, 60% of those people die. Since the mid-1990s, efforts have been made to clear Mozambique of landmines, but millions are believed to still contaminate the country. Anti-Persoonsmijnen Ontsnoping Product Ontwikkeling (Anti-Personnel Landmine Detection Product Development) started using Giant African Pouched Rats (Cricetomys gambianus) for landmine detection in Mozambique in 2007.

Details on how the rats are trained and used operationally are provided elsewhere.14 In brief, the rats are trained through operant conditioning in which food reinforces (rewards) appropriate indication responses (i.e., those that occur within 1 m of a mine). Incorrect indication responses are not reinforced. Training begins in a controlled laboratory setting and proceeds through a series of steps to a large training field.

An early evaluation conducted in 2005 in which seven rats searched 20,348.28 sq m of land in Mozambique indicated that their detection accuracy exceeded 95%. In a more recent evaluation, teams of two rats searched 93,400 sq m of land in Mozambique, revealing 41 mines. This area was then searched with metal detectors, revealing a 100% detection rate by the rats. Such findings suggest that pouched rats are accurately acceptable in detecting landmines and, as a result, they are used operationally in Mozambique.