Disastrous Predictions

Inaugural address

Victor Jetten

Professor of Earth Surface Systems Analysis

Monday 17 December 2007
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INTERNATIONAL INSTITUTE FOR GEO-INFORMATION SCIENCE
AND EARTH OBSERVATION

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Mr Rector, distinguished professors, dear colleagues, students, family and friends,

Increasing disasters?

Allow me to start this speech in a rather dry way with a definition of the term "disaster". The European Environmental Agency (2005) gives a helpful definition: "a serious disruption of the functioning of a community or society, causing widespread human, material or environmental losses, which exceed the ability of the affected community to cope using its own resources".

By the term "disaster", we usually mean a sudden catastrophic event of which we are helpless victims. This point of view is changing rapidly, whereby a disaster - such as the consequences of some hazardous event or process - is more and more seen as the result of unsustainable development practices. This makes disaster risk reduction and management an integral part of sustainable development. In its last report, the United Nations Development Programme (UNDP, 2007) recognises that disasters driven by climate change constitute one of the greatest threats to the Millennium Development Goals, because they directly affect a country's capacity to develop. I would like to make the distinction here between two types of disaster: first, the so-called sudden or rapid disasters, such as hurricanes, earthquakes and floods, which cause direct casualties and damage; second, the long-lasting and more diffuse so-called slow disasters, such as drought, erosion and soil degradation. As we will see during this speech, both the technical part of predicting these disasters and the response of society are different.

Disasters are often the result of natural processes that by themselves are not disastrous. For example, flooding in the Amazon basin happens regularly, is not disruptive in a negative sense, and is even necessary for the functioning of the ecosystems. It will only become a disaster when it involves human settlements. This harks back to the definition above, namely the ability of a society to cope. In other words, disaster reduction and management covers not only the hazardous processes but also the vulnerability, resilience and preparedness of society.

From the perspective of earth sciences, this mixing of cause and effect - the hazardous processes and the disastrous results - makes it difficult to gain a proper overview. In order to quantify disaster risk and damage, the International Strategy for Disaster

Reduction (ISDR) is compiling the statistics. Not surprisingly, in view of the major disasters of the last years and the media attention they have received, the number of lives affected and the economic losses are staggering. The tsunami disaster of Christmas 2004 triggered one of the largest aid efforts ever. After that, we had Hurricane Katrina in 2005, the earthquake in Pakistan in the same year, and several others. Together with the climate change discussion and the supposed links between the two, it seems we are entering a time of increasing disasters. Disaster statistics since 1900 have been compiled by the Emergency Disasters Database (EM-DAT). The disasters are separated according to origin (natural or man-made), and are further divided according to type of disaster (flood, hurricane, drought, etc.) and per region, continent and even country. Omitting epidemics and insect infestations and making a selection of the disasters related to ITC research, namely the hydro-meteorological and geo-technical disasters, the figures are impressive. Over the last 100 years, more than 22 million people have died, nearly 6 billion people have been affected in some way (injuries, health problems, homelessness), and the total damage is estimated at a staggering 1460 billion dollars. Should you think, however, that we cannot overcome the financial constraints, you have only to realise that until Dec 2007 the war in Iraq alone has cost the USA approximately 600 billion US dollars according to the Congressional Budget Office, which some say is a conservative estimate.

Earlier disasters may not have been well reported but, if we take a look at the trends over the last 30 years, we can see an increase in the number of disasters, and certainly an increase in damage. Hydro-meteorological disasters show a rising trend, geological disasters do not (see *Figure 1*). Those people warning of climate change would certainly see this as proof, but we have to be careful as we know, for example, that regions such as West Africa are influenced by the cyclic El Niño phenomenon. The nature of the definition of disaster makes it impossible to distinguish between cause and effect. The population is growing and, reportedly, half the world population is now urban. It is also a fact that many cities are in coastal zones or along rivers. These cities are therefore located in areas that are disaster-prone, and are often expanding into zones that carry even greater risks (badly protected floodplains, steep slopes, etc.). Moreover, municipal authorities may not have the necessary knowledge or the capacity to cope with disasters. At the same time, the UN Convention to Combat Desertification (UNCCD) and other organisations report that in rural areas the growth in population causes people to take marginal and unsuitable lands into production, with increased risks of crop failure due to drought, soil erosion, landslides and overgrazing by cattle. It could therefore be that the graphs simply reflect a larger and even more developed population at risk of disasters. In any case, it is clear that the problems as such are increasing.

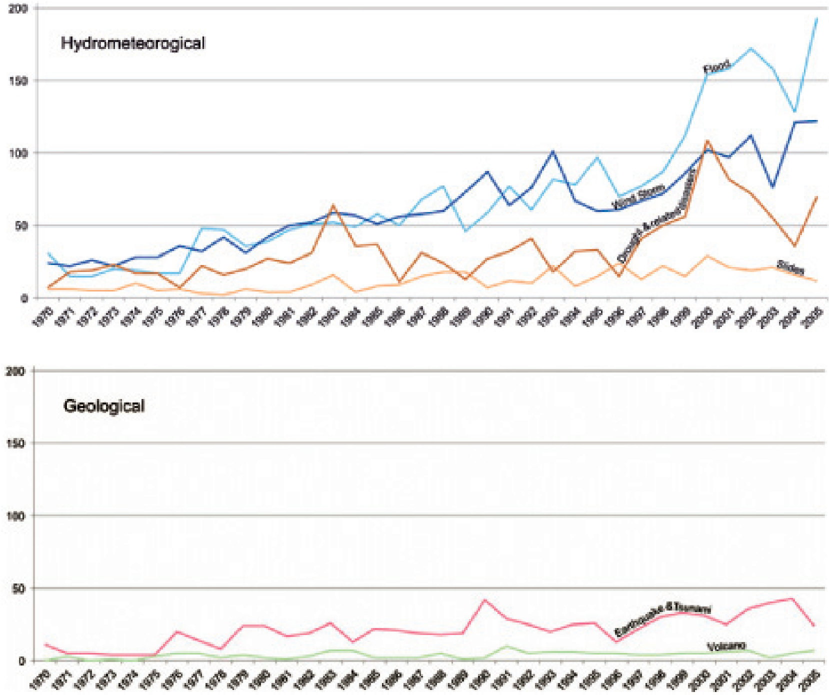

Figure 1 Trends in hydro-meteorological and geological disasters from 1970 to 2005 (source: ISDR, 2007; http://www.unisdr.org)

Disasters and climate change

It is impossible to speak about trends in disaster reduction and management without including climate change. The majority of hazards are meteorological and hydrological in origin, such as hurricanes, extreme rainfall and drought. These in their turn trigger hazards such as flash floods, landslides, erosion, ecosystem degradation and salinity problems. Under a rapidly changing climate, the trigger mechanisms and their spatial and temporal variability are likely to change. This will make it more difficult to predict when, where, and how frequently hazards and disasters will happen. Being trained as a physical geographer and having had my share of Pleistocene and Holocene history, I have to agree with Professor Kroonenberg's analysis that the climate has never been constant (Kroonenberg, 2006). In fact, it seems a bit short-sighted to think that the climate of the past century is somehow the norm, and that it represents a stable and long-term equilibrium. There is too much scientific evidence to the contrary. It may be that CO_2 levels are causing climate change, but whether we can influence the climate by changing CO_2 levels remains to be seen. The saying comes to mind that "to every complex problem there is a simple solution … and it's usually the wrong one". Nevertheless, I certainly welcome any development towards a more sustainable way of life on this planet.

Let me take a practical point of view with regard to disaster reduction and management. Many countries in the world are defining 2020 or 2050 development plans, and geoscientists and natural scientists have to come up with useful predictions to assist in this planning. Since disasters directly threaten development goals, disaster mitigation is included where needed in these plans. There is, however, considerable uncertainty regarding all these predictions, as the Intergovernmental Panel on Climate Change is the first to admit. The trends in temperature and precipitation according to different scenarios are fairly well established, at least on a continental scale. Unfortunately, these trends are geographical averages, and maps of climate change differ per model. There are large differences in the geographical patterns of predicted rainfall produced by the various models, especially in the tropics, where the climate system is highly non-linear. From a disaster reduction and management point of view, this is quite problematic.

In lesser developed countries (LDCs), cities, and maybe to an even greater extent rural areas, have only a limited capacity to respond to predicted changes, in terms of the technical capacity to plan ahead and the monetary capacity to realise adaptation and mitigation measures. It is therefore important to use this capacity wisely. So what, for instance, are the mitigation measures that we as disaster management scientists propose for dealing with droughts or floods? The type of climate change prediction that we need is actual weather patterns with rainfall intensities. Even if we know the changes in frequency of occurrence of an event, we will never know if it will happen tomorrow or in a hundred years' time. Therefore, we can only define scenarios in a "what-if" game. If you have a hazard of a given magnitude and it occurs in a specific location, we can to a certain extent predict the consequences.

International response

Since the Boxing day Tsunami in 2004, disasters have really caught the attention of the public at a global level, and UN organisations are formulating disaster risk reduction strategies at international and national levels. The UNDP is tasked with "stimulating the interest and actions needed to create comprehensive disaster preparedness plans, strategies and structures, and promoting disaster mitigation activities within the context of development planning and implementation". There are a host of organisations dealing with this at global and national levels. At international level there are for instance the UNDP Bureau for Crisis Prevention and Recovery (BCPR), the UN International Strategy for Disaster Reduction (ISDR), and the UNCCD - which was formed after the great Sahel disaster in the '70s. At national levels there are for instance agencies that deal with the results of tsunamis, hurricanes and earthquakes. Each new disaster triggers more political activity.

These institutions have developed a disaster risk reduction framework that aims to reduce or avoid the potential losses from hazards, ensure prompt and appropriate assistance to disaster victims, and achieve rapid and effective recovery (ADPC, 2005). The specific components of this framework are:

1 risk awareness and assessment, including hazard analysis and vulnerability/ capacity analysis
2 capacity building, including education, training, research and information
3 application of measures, including environmental management, land use and urban planning, protection of critical facilities, application of science and technology, partnership and networking, and financial instruments
4 early warning systems, including forecasting, dissemination of warnings, preparedness measures and response capacities
5 public commitment and institutional arrangements, including organisational frameworks, policy, legislation, stakeholder participation and community action.

Risk assessment and disaster management at ITC

ITC is active in several phases of this disaster risk reduction framework, and over the past years has developed a strong curriculum, both in the first phase, the analysis of hazards and risks, and in the capacity building and training phases. Developing expertise in the organisational and institutional aspects of disaster management is the subject of the second part of my speech. Let us first focus on the more technical aspects of hazard prediction and risk assessment and take a critical look at the state of the art.

In ITC's Department of Earth Sciences, we focus on geohazard processes that have hydro-meteorological triggers. We occasionally do other exotic risk assessments, such as those related to tsunamis, lahars, and glacial lake outbursts. Furthermore, we are currently involved actively in the Pakistan earthquake area, which gives us the opportunity to combine our departmental geophysical expertise with risk prediction research. Nevertheless, I cannot show everything that we do and will restrict myself to some examples of PhD research for the coming years.

Risk in this context is not only the probability that something will happen, it includes the possible damage that may occur (i.e. the vulnerability of the "elements at risk" and some expression of their value). A risk analysis of an area should give spatial planners a complete picture of possible threats and consequences and the knowledge they need to define mitigation and adaptation measures. Over the past years, the methodology for risk analysis has been successfully developed at ITC, and I would like to mention in particular the work of my colleague Cees van Westen in the SLARIM (Strengthening Local Authorities in Risk Management) project. This project gives planners a methodology for collecting and managing information for spatial multi-hazard risk assessment, and is based on case studies all over the world. The risk assessment methodology developed has become an integral part of our education curriculum, and is used in many places today. It has evolved from landslide risk assessment to a more generic method that can be used for many different types of hazard. Risk is determined by interpreting remote sensing images in combination with spatial landscape information and community-based information. Communities provide information on the hazard itself (frequency of occurrence, water depth, etc.), as well as on the damage and response.

Multi-hazard risk assessment and the incorporation of its results in planning activities and regional or national policies is not yet a run-of-the-mill exercise. From a technical point of view, we have to combine multiple hazards in an area with different mechanisms (e.g. landslides and floods as a result of a hurricane). Risk changes for hazards of different magnitude and frequencies, and there are upscaling problems when moving from the detailed process scale of site investigation to hazard and risk analysis for larger areas. From a socio-economic point of view, people and communities are not static. There is daily mobility between residential and work areas; there is growth and migration; there are changes in economic activities. In short, it is a highly dynamic problem where many choices have to be made before a risk analysis can be delivered.

Below, I will give you four examples of hazard and risk research at ITC's Department of Earth Sciences.

The basics: soil science

Behind all our research lies the basic need for landscape information. We need to understand processes and recognise the resulting changes they cause. And we need input data for our models. Much of that data comes from soil science. Soils are one of our greatest resources. They are non-renewable and subject to many threats, ranging from erosion to loss of fertility and salinisation. After Kyoto, air and water received considerable attention in terms of policies regarding air pollution and water scarcity, but soils were more or less overlooked. This caused a number of scientists in Europe to take action, which resulted in the drafting of the European Soil Thematic Strategy. This describes eight threats to soils and serves as a basis for future policy. Surprisingly enough, soils are not mapped in detail worldwide. We do not have a comprehensive picture of this resource. Many LDCs depend on the natural fertility of soils for their food production. They need soil maps as basic knowledge, but the inaccessibility of the terrain and the lack of resources prohibit national coverage by soil maps. As an answer to this, ITC soil scientists have worked for some time on the spatial prediction of soil types, and are involved in a renewed global effort to map soil properties. For example, using a combination of climatic data, satellite imagery for land use and land use change detection, and geomorphology derived from digital landscape data, they have successfully predicted soil types in Thailand. Next year, we will embark on a PhD research using more advanced statistical techniques to explore the possibilities of this type of resource mapping. Hopefully, this will lead to the availability of the practical soil information that forms the basis for many natural resources and land degradation studies.

One of the researches we are continuing in this respect involves the use of hyperspectral remote sensing to detect soil properties. The level of detail of spectral information from airborne and spaceborne sensors keeps increasing, and this continually opens up possibilities for acquiring information on the mineral composition of soils. Considerable expertise in earth sciences has been built up over the years at ITC, as well as with our colleagues at Utrecht University. Recently, an extensive salinity research was completed, showing advances in mapping soil salinity with hyperspectral remote sensing. We are continuing with this to discover how far we can map soil properties that will enable us to gather spatial information about land degradation processes directly, or map soil properties that can be used in spatial modelling.

Landslide hazards

The bulk of our geohazard research at ITC revolves around landslides. We study their distribution across the landscape, triggering processes, movement, and associated risk at various scales. The great difficulty lies in predicting where they might occur and what circumstances might trigger them. Landslides come in many forms and sizes and vary in their consequences: from damaging a house to burying whole villages. They are a result of slopes becoming unstable and starting to move. The triggering factors that cause this instability vary. Extreme rainfall and meltwater can cause the groundwater pressure in a slope to build up and decrease the resistance of the material to the point of failure. Landslides occur frequently in earthquake zones, where the propagation of waves near the surface causes a weakening of material and a higher risk of instability. Road and house construction that alters the shape of a slope may also act as a failure mechanism.

The state of the art in landslide research can be summarised as follows. The concepts and mechanisms behind different types of landslides are well known, so when a landslide has occurred, we can explain reasonably well, in hindsight, why it happened. Predicting when and where a landslide will happen is much more difficult. We can indicate danger zones and can guess what combination of hydro-meteorological and geological factors may trigger landslides, but, to achieve any precision or reliability, we need to have a considerable amount of data. In fact, an inventory of historic landslides in an area is the most important source for landslide risk assessment (this can be compared to the rainfall and environmental data in a threshold analysis). However, since many mountainous areas are inaccessible, we must base our analysis on aerial photo interpretation and satellite image analysis. This brings me to a number of researches that we have initiated in cooperation with the Indian National Remote Sensing Agency, Geological Surveys India, and the Indian Centre for Earth Science Studies. One of these studies focuses on improving methods of acquiring landslide data for the Himalayas and the Western Ghats in South India. Using object-oriented image analysis coupled with change detection of geomorphological shape parameters, we are exploring the possibility of automatically recognising landslides from high-resolution stereo Cartosat and Resourcesat images (see *Figure 2*). This involves detecting fresh and old landslides of different types and distinguishing these from other shapes in the image. We will also have to improve methods of shadow removal. If we can get a reliable sample of the landslides of the research areas in this way and an indication of their age, we will have a rapid method of building databases in difficult terrain. This will hopefully improve the predictive quality of our models.

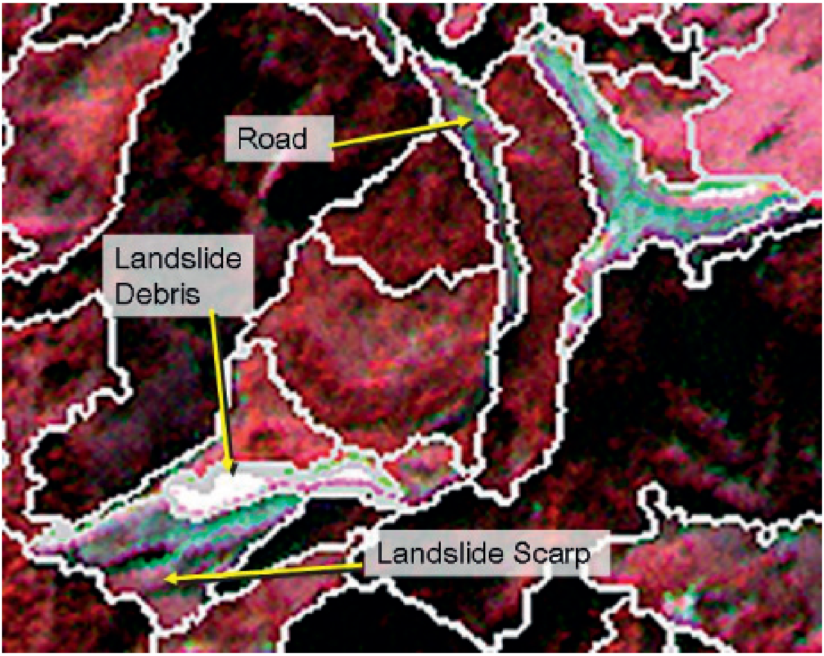

Figure 2 Example of a segmented Resourcesat-1 LISS-IV image (covering approximately 600x800 m of Himalayan terrain), showing the difficulty of recognising roads from landslide features

At the other end of the scale, some of our new research is dedicated to detailed modelling of the actual triggering processes and movement of slides. We are cooperating closely with our colleagues at Utrecht University, Professor Steven de Jong, Dr Theo van Asch and Dr Rens van Beek. Based on their work, we are simulating groundwater movement in steep areas to determine which slopes will be triggered by a given rainfall. The risk is not always confined to the failure areas, however. The film of the Conchita slide in California clearly shows the fluidity and speed of a landslide that turns into a debris flow. This means that the area at risk actually extends downslope. This is well known in two of our research areas: in Cuba and in the Western Ghats in India, where people live with this threat during the wet season each year. These two areas have an annual rainfall of more than 2000 mm, and both large landslides and smaller fast debris flows occur regularly. Thus, using a PCRaster model built by Dr Santiago Begueria of the University of Zaragoza, we are now trying to model the actual movement of the debris flow in order to improve our risk assessment. The simulations that I am showing you here are first attempts (see *Figure 3*). To parameterise the model, we need very detailed information on the hydrology and soil strength parameters of these areas, even the root strength of the vegetation. You can imagine that we do not have 3D information of this kind, although a vast amount of data is being collected in the test site in India with the help of the Centre for Earth Science Studies. There is, however, a way around this with inverse modelling. By using landslides that have been moving, and comparing the digital surfaces of the terrain before and after, we can in fact gain a very large validation dataset that shows the spatial extent of a slide and its thickness in many places. It is this combination of physically based modelling, GIS and the imagery of the geomorphological shapes that can help us to move forward.

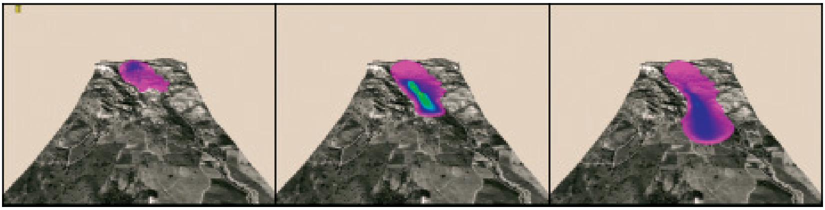

Figure 3 **Three time steps in a simulation of the 1963 landslide in Jagüeyes (Cuba). Using digital elevation models of before and after the slide and geophysical VES profiling, we can accurately simulate its movement (source: Castellanos (PhD), model by Begueria-Portugués and van Asch (in prep)).**

Land degradation and desertification

Desertification is a complex problem for many reasons. It can be seen as land degradation in dry areas and, as such, encompasses processes such as soil erosion, drought, salinisation and degradation of vegetation. However, areas subject to desertification may also experience flash floods, as rainfall comes more erratic but with higher intensities. Thus the slow and rapid disasters occur in an upstream-downstream fashion and are part of the same system. Since we work mainly in LDCs, where significant land use changes may occur through population growth, migration, etc., the coupling of upstream and downstream areas in hazard and risk analysis is one of our focus points.

Erosion hazard and risk

Apart from landslides, we are dealing with runoff and erosion in the hilly upstream areas. The main problem in runoff and erosion modelling (which has been present right from the beginning) is determining where water and sediment are generated in a catchment, i.e. the contributing areas. There are two reasons why we need to know this. First, if we know where erosion takes place and where runoff is generated, we can determine where conservation measures can be best applied, and which farmers to address. We need this information at a detailed scale because conservation measures are often field-level or farm-level measures. Second, different configurations of contributing areas give very different runoff signals, from long-lasting low-peak discharge to rapid high-peak discharge. This is important because downstream we have to deal with these discharge peaks in order to analyse which areas are being flooded, and even to design flood control measures.

Let us first take a look in some detail. From a series of tests that we organised in the past, it appears that we are not very good at predicting where water comes from. We are not even very good at predicting how much water is generated in a catchment. And the prediction of sediment delivery is even worse! In many studies, this is ignored because the predictions are not tested against reality. The input parameters for a model are constructed to the best of our ability and we then believe that the resulting simulations are good. Well, they are not! All the tests that we have done so far show that the predictive quality of models is moderate at best. In 1999, we compared predicted runoff totals and peaks in a test with seven physically based models used worldwide (Jetten et al., 1999). The only good simulations reported so far in literature are those that are thoroughly calibrated. Certainly, the uncalibrated use of models in an area should be avoided whenever possible. This is bad news for predictions in areas for which we have insufficient data. Many LDCs have good meteorological records, but often streamflow records include only the biggest river systems, not the upstream catchments. This situation is not much better in developed countries, where many monitoring activities have a lifespan of only three years, the average lifetime of a research project.

One of the main reasons for these moderate results is that runoff is a spatially accumulative process. In a model, we not only accumulate the estimated runoff, but also all the uncertainties associated with the prediction. Often the simplest models are considered best because they have only a few degrees of freedom. However, in erosion predictions this is relative, as even a simple runoff model with only a few variables accumulates runoff and its uncertainty over hundreds or thousands of spatial elements. The resulting discharge prediction in the upper reaches of a river system therefore has a large inherent uncertainty.

In my opinion, rather than estimating the water layer in each spatial element (which is in the order of millimetres) more precisely, the only way to limit this uncertainty is to determine more accurately which spatial elements are active and which are not. If we can determine that, for instance, only 20% of our catchment is active, we may have reduced the uncertainty considerably. We need a certain degree of physics in these models, but I am convinced that investing heavily in more physics does not help in making better predictions, whereas a better spatial representation of the process will. This is corroborated by the fact that the simplest runoff models seem to have the same predictive quality as the most physically based ones.

So how do we find out which elements are active? There are several options when we start integrating information of different origins and looking for information outside the model structure. First, a complex hydrograph can sometimes be disassembled into contributing parts that can be traced back to certain agricultural fields. We can then look at the agronomical information of these fields (crops, crop calendar, tillage activities) and select those fields that are likely to have runoff. Very often, this is a result of soil surface sealing caused by an interaction between rainfall and tillage practices. In other words, we limit the number of choices by including agricultural and soil structure knowledge. Second, it seems that this pattern does not change very much during the season, although we still have to investigate this more thoroughly. Since crop rotations are usually planned some time in advance, you may be able to predict better future runoff patterns. This of course gives a direct link to remote sensing, as using images to estimate land use and land cover is a standard procedure. Third, not only would we like to estimate runoff, we would also like to predict where erosion takes place. Our colleagues at the University of Leuven have proved that gullies often appear in the landscape in certain places and this can be determined by a simple digital terrain analysis. We have successfully coupled terrain analysis with predicting gully incisions and dimensions (*Figure 4*). A landscape sensitivity analysis identifies areas prone to gully incision; the erosion model is then applied to these areas to predict the size of the gullies and the amounts of erosion. This opens up new ways of research. Next year, we will embark on research coupling an analysis of high-resolution images with a spatial erosion model. We will investigate whether a pattern analysis from these images can identify the areas prone to runoff, with the model providing the quantification of the processes.

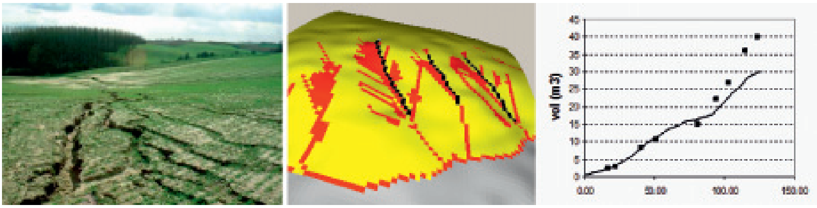

Figure 4 **Left to right: a rill system in Belgium (photo by Takken), predicted zone sensitive to incision in part of the catchment (red), and simulated gully volume (line) versus measured gully volume of one of the gullies (dots). The x-axis of the graph is the gully length in m (Jetten et al., 2006).**

Disaster management for slow hazards (of which erosion is an example) is different from that for the so-called rapid hazards and disasters. While the latter focuses more on protection, the prevention of damage, and emergency plans, the former focuses more on conservation and mitigation. The aim is to prevent the problem from even happening by implementing soil conservation measures. Dry periods cannot be avoided, but good land use practices can diminish their effects. However, since it is a slow and diffuse disaster, people are often unaware of it until it is too late. A few years of drought does not directly cause desertification, but it often brings to light the lack of resilience of an area that has been building up for some time. The same is true of erosion. In most places around the world, erosion is not seen as a problem because it is not directly linked to the livelihood of farmers. Whereas a bit of erosion may not decrease the yield, drought will decrease it straightaway. Thus desertification is not one process; it is an ensemble of processes that cause land degradation in dry areas where one problem hides the next. Desertification is certainly not a problem for only LDCs or for Africa in particular. It occurs extensively in the Mediterranean where, for example, groundwater is used at an alarming rate to grow crops that are unsuitable for that region. Fortunately, the technical part is well covered; land conservation measures have been well defined for many decades. They are also based on indigenous knowledge and fit closely with everyday farming practices. If we can do so much to mitigate desertification, why is it causing so many problems? I will try to answer this question in the second part of my speech. Let me first go literally from the hilly upstream area to the downstream urban floodplains.

Flood hazard and risk

Those of you who specialise in river basin research and flooding may ask yourselves whether the spatial configuration of runoff contributing areas plays a role at the river basin scale. Most likely it does not; short distance variability is levelled out and combined into a less variable discharge of large areas. Extreme weather events such as tropical storms produce so much water that spatial differences in a catchment are no longer important. Therefore, the effect of climate change on the floods of Western European rivers will be mainly direct changes in precipitation, snow melt and evaporation. Land use changes are not seen as major drivers of river discharge. However, this point of view is closely linked with (i) the level of development of the river basin and (ii) the size of the basin. The land use configuration in the large West European river basins is more or less fixed and no major changes are to be expected in the near future.

In tropical countries, however, rapid land use changes are taking place constantly as a result of population growth and urbanisation. Our research in Sri Lanka, Vietnam and Thailand shows that the conversion of forest to agricultural land and the subsequent conversion back to plantation forest as a result of conservation measures, may have a significant impact on the discharge and even on the flooding pattern downstream (see *Figure 5*). The relatively small rural catchment of 67 km^2 is directly upstream of the more urbanised floodplain. Combining the runoff model LISEM with the flood model SOBEK, we can clearly see the links between land use changes and downstream floods. These influence not only the height of the inundation, but also the inundation pattern and the associated areas at risk. The example here shows that an increase in forest area will decrease the flood risk to some extent. Although this seems logical, we have to be careful with these kinds of predictions. In 2005, the FAO and CIFOR published the report *Forests and Floods: Drowning in Fiction or Thriving on Facts?* This report questions the role of deforestation in increased flood risk. There are a few reasons for this apparent contradiction: (i) the buffering effect of a forest depends on the extent of the coverage, and large basins are never fully covered with forests; (ii) the antecedent rainfall in a monsoon climate may have saturated the system and filled the water buffering capacity; (iii) our models may be wrong. Many models are constructed and calibrated on the evidence of the normal behaviour of the river system. It may well be that the system behaves differently during a hurricane. We simply do not have the ground data to parameterise our models correctly for a hurricane: measuring systems malfunction and ground observations are impossible. We certainly know from our forests in Luxemburg, for instance, that there are many natural drainage paths that become active during rainstorms, and water is guided to the main river system very rapidly.

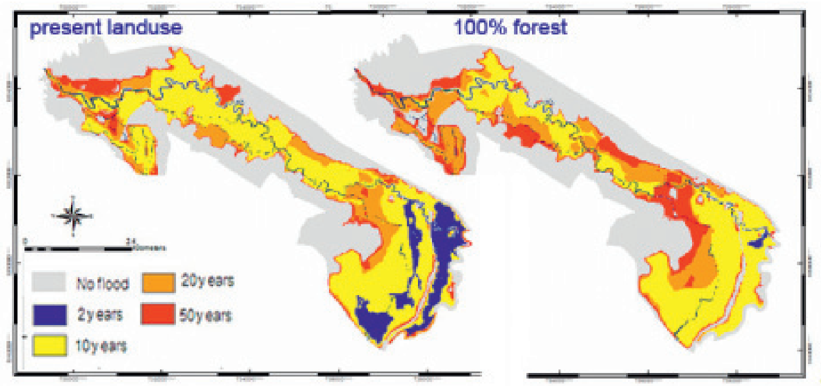

Figure 5 **Simulated flooded area downstream of the Nam Chun watershed (Thailand). The flooded area with a two-year frequency (blue) declines if the area is converted completely to forest, whereas the flooded area with a 10-year frequency and higher (sum of yellow and red areas) is still considerable. (Source: Prachansri, 2006).**

Disastrous predictions

This brings me to the title of my research: "Disastrous Predictions". Going back to the disaster risk reduction framework, the first phase is risk awareness and assessment, including hazard analysis and vulnerability/capacity analysis. How good are we at predicting hazards, with or without the added uncertainty of climate variability? Local governments in LDCs do not have an infinite capacity to cope with a vast range of possible disasters, so good predictions are important. Predicting immense disasters is not very helpful: it may trigger wrong actions and even work against finding solutions.

I have shown you that we can predict many things, but not always correctly or even with an acceptable degree of uncertainty. Let me focus on what we can do. The first role of predicting disasters is to give a likely scenario of *what* will happen, *when* it will happen, and *where* it will happen. We know what will happen, and are working on methods to extend that knowledge, for instance, in our automatic landslide inventory work and erosion predictions. Since we do not know the future weather, the question of when something will happen can be answered only in the form of probabilities. Unfortunately, frequency estimates have never been very precise, especially in areas where we do not have long-term meteorological records. This is because disaster frequency is not the same at all as rainfall frequency. What we have to provide the local administration with are estimates of the likely spatial extent of the problems. If something of a given magnitude occurs, where will it happen and how much damage will it do? I believe we can make some real progress here. Combining spatial models with direct and indirect earth observation information will hopefully increase the quality of disaster predictions considerably.

Governance of disasters

So far I have illustrated the need to give better predictions and improve our tools. This, however, is only half the problem. There appear to be gaps in communication between the phases of the disaster reduction management framework. On the one hand, there is the capability of analysing hazards and risk and creating scenarios of what may happen in a given situation; on the other hand, we have to apply mitigation and conservation measures, warn people, communicate the risk and even incorporate it into policies and planning. Bringing all this together and making it work is clearly a governance issue. I am happy that ITC has the expertise to attempt this, as the governance of disasters is one of the major problems. However, this is not the same for both "slow" and "rapid" disasters. As I mentioned in the beginning, not only are the driving processes behind these disasters different, but the response of the stakeholders is also different.

Desertification perception and awareness

Problem prevention, changing the attitude of land users, and promoting conservation measures are appropriate weapons in fighting disasters such as desertification. The UNCCD states that "… poverty forces the people who depend on land for their livelihoods to overexploit the land for food, energy, housing and source of income, and desertification is thus both the cause and consequence of poverty". This clearly shows that analysing desertification hazards and risk is not a purely technical issue. ITC is participating in the EU project DESIRE[1] (Desertification Mitigation and Remediation of Land) coordinated by ALTERRA. In this project, 28 countries are cooperating to test and implement land conservation measures in 19 sites throughout the world.

[1] http://www.desire-project.eu

A large part of this project is dedicated to communications with stakeholders, in most cases farmers. The Centre for Development and Environment (CDE) in Zurich and the International Soil Reference and Information Centre (ISRIC) in Wageningen have spearheaded the development of the WOCAT system, which is a comprehensive database of land conservation measures based on farmers' knowledge. WOCAT (World Overview of Conservation Approaches and Technologies) provides a structured way of creating awareness and acquiring stakeholder information and wishes regarding preferred conservation actions. It has long been recognised in desertification science that without participation little will happen. Erosion is not always seen as a problem, nor are the early signs of desertification. By the time these processes receive national and international attention, it is usually too late. Fortunately, the link can often be made through water conservation. Many erosion control measures are simultaneously water harvesting measures that may increase the yield. The small-scale measures have a good chance of success. There are many examples of large-scale irrigation projects where implementation disrupted the functioning of the local communities to such an extent that they had no chance of success. The role of the DESIRE project is to directly show the effects of conservation measures and scientifically prove their benefits - to promote acceptance, among other things. The conservation measures have to result in a direct benefit in order to be acceptable. Whereas people more clearly recognise the benefits of solutions for rapid disasters, the solutions for slow disasters are more diffuse and a matter of long-term planning.

Communicating flood risk

In terms of rapid disasters, efforts geared more to protection and adaptation, for example, through defences against high water levels of rivers and the sea, or through constructing buildings that can better withstand the effects of earthquakes. Although technically we can show what the effect of a hazard will be and who is at risk in a given situation, there are many risk scenarios that can be constructed. For example, the effect of floods can be analysed in a straightforward way using inundation models. An ITC research project in Naga City, the Philippines, has analysed the effect on the surrounding area of constructing an elevated shopping mall. The obstruction created by the shopping mall will force the water into an adjacent area, putting it at greater risk than is the case at present (Abdul Rahman, 2006). A more complex picture emerges when, in addition to water depth, factors such as the kinetic energy of the water and the speed of water level rise are included. For example, Alkema (2007) shows this in a multicriteria analysis of a dike breach in the *Land van Maas en Waal* in the

Netherlands (see *Figure 6*). Combining the speed of water level rise, the inundation depth and the flood propagation time from the point of entry, he has created an evacuation priority map. The result shows that flooding is far from being merely a reflection of the topography.

I am glad that these results have been published in several professional journals and newspapers in the Netherlands, and I support the current change in discussion and policy in our country from a simple 100% protection policy to a more realistic viewpoint on flood risk. Furthermore, we can add more dynamics of people's behaviour: where are people during the day? when are children at school? where are people in the evening? However, being able to do all this does not mean it is always useful, as the number of possibilities becomes too large. Which scenario to choose? In fact, risk assessment is not based only on technical modelling; it is a multidisciplinary exercise. Its usefulness comes from a proper dialogue between the technical institutes providing the hazard analysis, the vulnerable stakeholders, and the planners and policy makers who have to take every aspect into account.

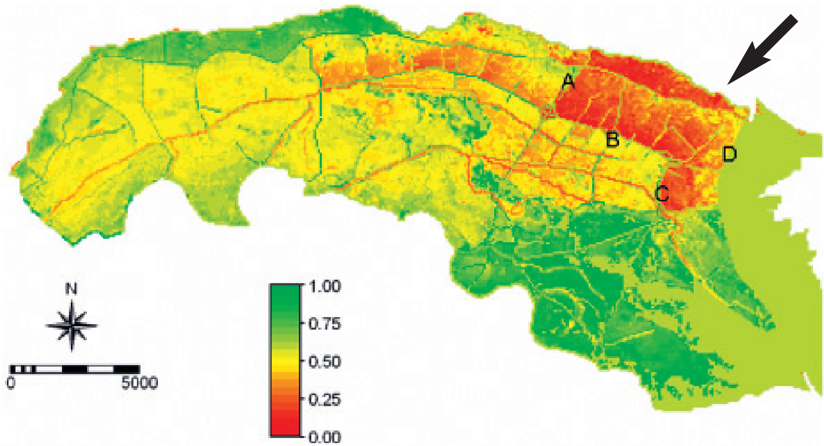

Figure 6 Evacuation priority map of a flood scenario in the *Land van Maas en Waal* for a given dike breach (arrow). The analysis is based on water depth, speed of water level rise and flood propagation speed. A = A50 (Arnhem-Den Bosch), B = A73 (Nijmegen-Venlo), C = noise barrier A73 in Nijmegen West, D = West-dijk, Maas-Waal Kanaal (Alkema, 2007).

Exporting Dutch knowledge?

The Dutch have a long tradition in disaster management when it comes to flooding by sea and rivers. Our response has always been seen as "the battle against water" and the striving for absolute protection. The general opinion seems to be that we can readily export this technical expertise and, indeed, Dutch engineering companies are active worldwide. Nevertheless, our thinking is changing. During the opening of the Twente Water Centre last week, Mark Dierikx from the Ministry of Transport, Public Works and Water Management explained that there had been major changes in the water policy of the Netherlands. We are moving from a top-down approach to a governance approach that tries to meet the requirements and wishes of all parties concerned.

I am glad that this is happening because otherwise there would be little expertise to export! In the 2003 Water Policy of the Asian Development Bank (ADB), it is stated that the policy of "total flood control" has been abandoned because it is impossible to ensure total control over the flood environment. The ADB admits that large and costly structural interventions have only contributed to giving people a false sense of security through "encouraged unimpeded development in areas where devastating floods will nevertheless inevitably occur" (ADPC, 2005). So perhaps our technical flood control expertise is no longer an export product. Our counterpart LDCs may not always have the technical or economic means to make plans a reality, but their ideas about disaster reduction and management certainly reflect our best knowledge. From my limited experience, I find that we are equal partners in this discussion. In fact, sometimes there is more flexibility in designing plans for situations in LDCs because there is much more direct experience of disasters. This has created a level of resilience and adaptation that we in the Netherlands no longer seem to have. I think that ITC with its worldwide network can play an important role in this dialogue.

Disaster reduction involves groups that have very different backgrounds and do not speak one another's language. Often the ball is in the court of the technical sciences, which are accused of hiding behind model complexities and mathematical language. Unfortunately, in spite of the fact that they are dealing with people, planning and policy experts also have their specialist jargon. Let us be careful not to adopt a language that will only remove us further from reality. I think the common language is images: a disaster risk made visible in a map will focus the mind wonderfully.

Summary

Let me summarise the two points that will spearhead our efforts in the coming years:

- Improve the spatial prediction of hazards:
  - integrate object-based and hyperspectral information from remote sensing images more closely with spatial models; this can considerably reduce the spatial uncertainty
  - focus less on predicting absolute values but more on correctly predicting the spatial patterns of hazards, particularly in relation to climate change.
  - investigate links between upstream and downstream drivers of hazards and disasters.
- Improve the link between the technical phases and the policy and planning phases of the disaster management framework:
  - translate technical results into useful results for all stakeholders
  - play a role in governance issues by providing disaster geo-information that will improve the dialogue and assist in defining acceptable disaster reduction measures.

A word of thanks

Permit me to end with a brief word of thanks to all our PhD students, those who are doing the actual work. I hope I will continue to learn a lot from you. Of course, thanks go to my new colleagues here at ITC for supporting me and making me welcome. Special thanks go to Professor Steven de Jong for his longstanding friendship and his continued support. May we continue to work together for many years to come. I would also like to thank Professor Freek van der Meer for giving me the space over the last two years to develop these ideas. May we too find interesting ways of doing some real earth science together. Thanks also go to my family, who are all professional photographers, painters and ceramists, and from whom I have inherited my love of landscapes and art. And last of all, a very big hug for my wife and daughter, who have settled in Enschede with such great enthusiasm.

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