Development of a damage and casualties tool for river floods in northern Thailand

J.K. Leenders, J. Wagemaker, A. Roelevink
HKV-consultants, P.O. Box 2120, Lelystad, The Netherlands

T.H.M Rientjes, G. Parodi
International Institute for Geo-Information Science and Earth Observation – ITC, P.O.Box 6, Enschede, The Netherlands

ABSTRACT: Understanding the economic damages resulting from a flood is of crucial importance to understand the impacts of floods on society. In this paper it is analyzed whether the dutch damage assessment and casualties tool is applicable in the 2T Kok river basin in northern Thailand for ex-ante decision making. The tool DACA-2T is under development, and gives insight in economical losses as a result of potential floods, taking into account the spatial distribution of damage categories, as well as the characteristics of potential flood scenarios that cause damage. The paper discusses the definition of appropriate flood scenarios to run the DACA-2T tool and the definition and set-up of the dataset that is the basis of DACA-2T. It is concluded that DACA-2T could serve as a tool for standardized assessments of damages and as such might serve to unify policies and protocols of damage assessments. Moreover the use of the DACA-2T tool can be of political and economic relevance since it gives decision-makers like governments, financiers and others a better grasp to evaluate decisions. By weighing the damages resulting from a potential flood, the tool could also be used to assess the costs and benefits of flood measures.

1 INTRODUCTION

For many people around the World and particularly in developing countries the dangers associated with river flooding are serious. Houses can be destroyed and land used for agricultural purposes can be affected. The impact of flooding on society can be dramatic as can be observed in the 2008 Myanmar typhoon for instance.

Countries like Vietnam, Cambodia, Laos, and Thailand in the Lower Mekong Basin (LMB) report yearly on flooding (see for example MRC annual flood reports of 2005 and 2006 (MRC,2006 and MRC, 2007). Particularly in 1996, 2000 and 2001, the effects of flooding in terms of human casualties, production loss, damage to infrastructure and private property were extensive (MRC, 2008). In the LMB-countries there is an ongoing debate and discussion on what to do to prevent or mitigate the negative impacts of flooding and how to adapt to it.

For such debate it is of crucial importance that an understanding on the impacts of flooding on society exists. The impact of a flood on society to a large extent depends on the vulnerability of society to flooding. Messner et al. (2007) describe that vulnerability is the degree to which some people, or classes of people, are more susceptible to, or suffer from a greater degree of harm from, some hazards than do other people or from other hazards. According to Penning en Rowsell (UNCHS, 2001) vulnerability is determined by:

- social economic variables (i.e. age profile of household, health status and/or mobility of household, savings of household, household income, cohesiveness of community, flood knowledge);
- property and infrastructure variables (i.e. susceptiblility of building contents to damage, susceptibility of building fabric, time taken to restore infrastructure, number of storeys, robustness of building fabric);
- flood characteristics (i.e. depth of flooding, duration of flooding, sediment concentration, sediment size, wave/wind action, velocity, pollution load of flood waters, rate of water rise during flooding onset);
- warning variables (i.e. whether a flood warning was received, warning time provided, advice content of warning); and
- response variables (i.e. time taken for assistance to arrive after or during event, amount of response available, response quality.

To understand vulnerability, assessments of flood effects on economic losses and casualties are a prerequisite Obviously flooding (here river flooding) is the main driver to damage. The type of floods, flow regimes and intervention strategies to mitigate on flood effects create differences in the damage extent. In addition, the extremeness of the flood event, as commonly expressed by a return period, influence the extent of the damage. More extreme floods cause more damage.

In hydrologic terms are river floods commonly characterized by the flood area extent, local water depths that change over the flooded area, flow velocities that also vary over the flood area and duration of the inundation. To assess the impact of a flood, also the localized rise of a flood, the timing of occurrence, the inflow of contaminants and debris from upstream areas must be considered. Messner et al (2007) Table 1 summarizes the flood characteristics that clearly affect flood damages.

Table 1. Summary of flood characteristics that effect flood damages (Messner et al., 2007).

Flood characteristic	Relevance
Area	Determines which elements at risk will be affected
Depth	Has perhaps the strongest influence on the amount of damage
Duration	Special influence on damages to building fabric
Velocity	Only high velocities will lead to increased damages: therefore mainly relevant in flash flood areas or areas near dike breaches
Rise rate	Influence on damage reducing effects of warnings and evacuation
Time of occurrence	Especially important for agricultural products
Contaminations	Contaminations and loads may increase damages significantly
Salt/-freshwater	Saltwater may increase damages; relevant in coastal areas

Research on damage assessment have mostly been carried out in western countries (e.g. USA (FEMA, 2007), Australia (Betts, 2002), UK, Australia, The Netherlands, Germany and the Czech Republic (Meyer & Messner, 2005). The Netherlands developed a tool for damage assessment that can be used for ex-ante examination of flood risk and to evaluate the change in expected damage if measures were taken. It assesses possible damages and risks in case a flood situation as based on a specified scenario would occur. Tools as such serve to support decision makers to value on flood mitigation and prevention measures. When such approach is applied to other regions it must be accounted for that different considerations may arise with different decision makers (Wagemaker et al., 2008) Also, in the LMB, river flooding is frequent. This poses the question whether flood damage assessment tools as developed in western countries could also be used in ex-post evaluation of actual floods. Additionally it must be evaluated whether such tools have universal applicability or that adjustments have to be made to match local conditions in the LMB.

This paper presents preliminary results of a pilot-project, carried out in the so called 2T Kok river basin in the Chiang Rai region in northern Thailand. Final results are expected to be available in February 2009. For this study the dutch HIS-SSM tool has been selected as a prototype. HIS-SSM stands for the Damage and Casualties tool of the High Water Information System in The Netherlands. In the remaining, however, the tool will simply be termed DACA-2T (Damage and Casualties Assessment tool for the 2T Kok river basin).

The remainder of this paper is structured as follows. The purpose and approach on floodrisk assessment in the Netherlands is presented in Chapter 2 and 3. This is followed by an introduction of the DACA-2T project in Chapter 4. Since it proved that major adaptations had to be made to HIS-SSM to make DACA-2T effective to the study area, this is described in Chapter 5 and Chapter 6. Chapter 7 concludes on the study and also some preliminary results are presented. Finally some recommendations are given with focus on the way forward.

2 FLOOD RISK ASSESSMENT IN THE NETHERLANDS

In The Netherlands some 50% of the area is protected by dikes and dunes to prevent sea and river flooding (see Figure 1)..

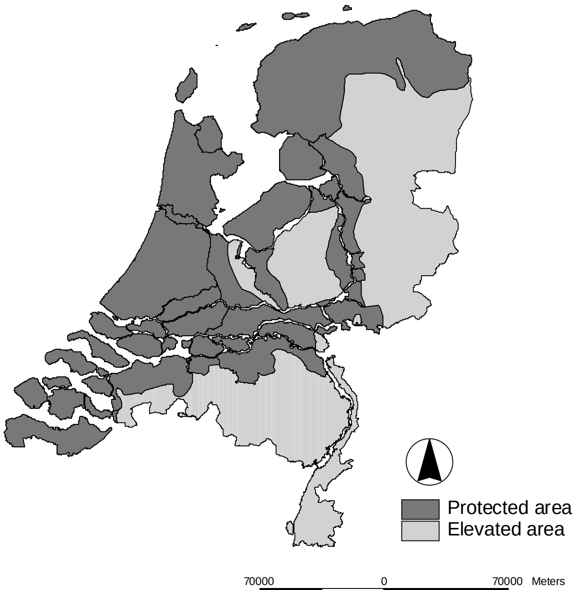

Figure 1. The Netherlands and protected area against flooding.

The safety standards of these structures are registered by law, however to what extent the current dikes comply to these standards today and in the future is subject to continuous debate. To assess flood hazard and potential flood damage, a risk-approach is adapted in which both issues are linked.

In the approach is risk defined as the product of probability of flooding and impact of flooding. (Eq.1)

$$Risk = probability \times impact \quad (1)$$

Probability refers to the statistical probability that a flood of certain return period occurs while impact refers to the actual damages by the flood. Obviously, and as discussed above, different floods may be related to different damages and consequently different risks. Assessing these relations is at the core of risk assessments and allows for assessment of risk reduction and analyses of costs and benefits when decisions have to be made on new infrastructural works to mitigate or prevent flooding

Flood risk reduction may result from:

1 lowering of probability of flood occurrence in terms of water heights when extra discharge capacity in the river is created by widening or deepening of the river beds or when a flood is prevented by constructions of dykes and embankments (see Figure 2A).
2 lowering the impact of a flood for instance by constructing a compartmentalization dike or when people are encouraged to reduce the effect of a flood by preparing themselves properly. This may be the result of a solid early warning system. (see Figure 2B);
3 both a reduction on the probability of the occurrence and the impact of floods. (Figure 2C).

To determine the actual risk of flooding in The Netherlands, the Ministry of Transport, Public Works and Water management initiated a project to outline ‘the safety’ of The Netherlands. The first phase of the project (VNK1) started in 2001 and finished in 2005 (Ministerie van Verkeer en Waterstaat, 2005). For the second phase (VNK2) results are expected in 2010. In the project the probability and impacts of flooding, as well as risk of flooding of, so called, dike rings in The Netherlands are documented. Also research is carried out after the strength of structures, the weak locations in the dike rings and how to deal with uncertainty (Ministerie van Verkeer en Waterstaat, 2008). In this project, the potential impact on society is being mapped using the HIS-SSM model.

In the Netherlands assessments of flood risks and potential flood damage are jointly used in a cost-benefit analysis to evaluate cost effectiveness of proposed flood measures. In this respect and since January 1st 2007, by law all infrastructural measures of national importance require such assessment to consider positive and negative effects of a proposed measure. Criteria considered are safety, economy and quality of life. The effects of floods on the economy are expressed in monetary terms through the HIS-SSM tool. For flood management measures this comprises an assessment of a proposed measure on the change in risk (Ministerie van Verkeer en Waterstaat, 2007).

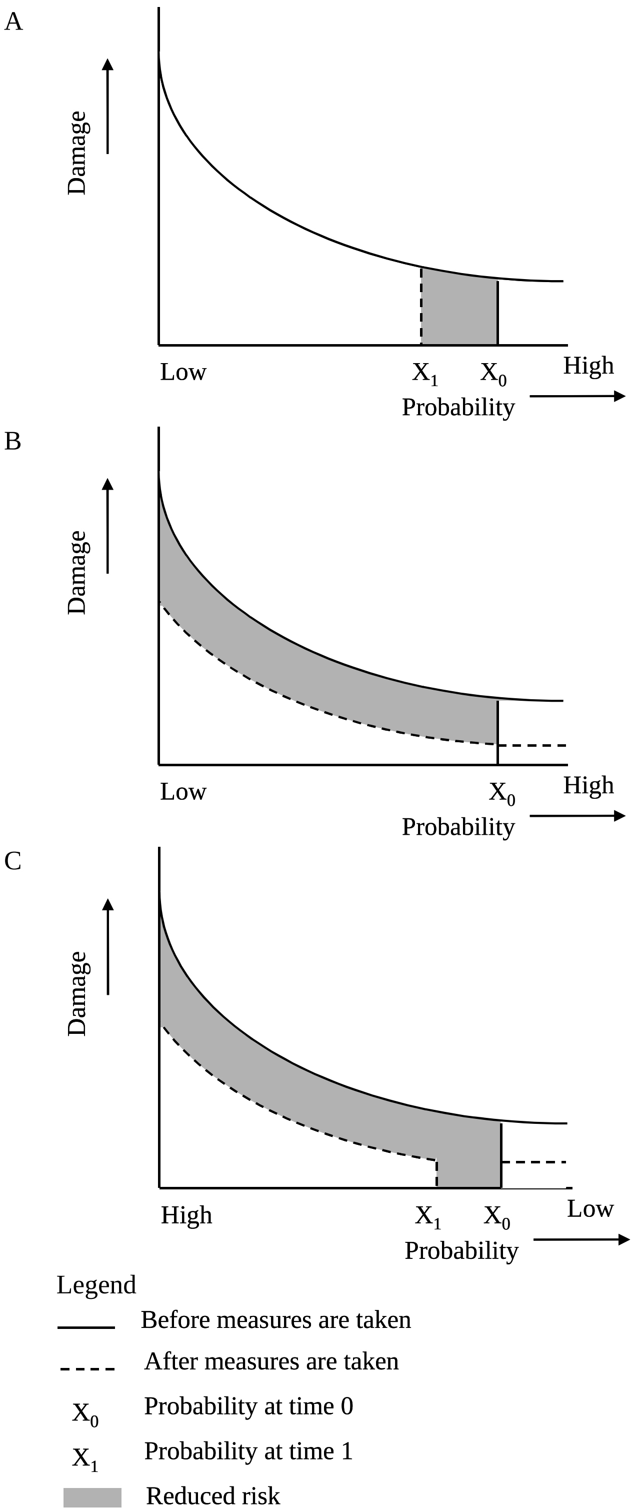

Figure 2. Reduction of risk due to a reduction of the probability of flooding (A), a reduction of the impact of flooding (B) or both (C).

3 HIS-SSM MODEL

3.1 *Concept*

In The Netherlands flood damage assessment is done by HIS-SSM using the so-called ‘Standard method’ that requires input by the ‘Standard dataset’. The ‘Standard method’ was developed in 2000 and serves to define categories for damages, as well as to define potential damages by specified flood characteristics such as flow depth and velocity. Since its first development the procedure has been updated regularly (see e.g. Huizinga et al, 2005 and Groot Zwaaftink & Dijkman, 2007). The process of damage assessment using HIS-SSM is illustrated in Figure 3.

HIS-SSM uses spatially distributed data on land utilisation and requires input of a flood scenario. A 2-dimensional hydraulic flow model that is based on mass and momentum conservation principles commonly defines such scenario. Forcing of the model is done by selected and predefined time series of inflow discharges and water levels and as such allow for assessments of newly introduced structures and measures to reduce potential damages. Obviously any difference in the expected total damage value gives an insight in the economic effectiveness of the measure.

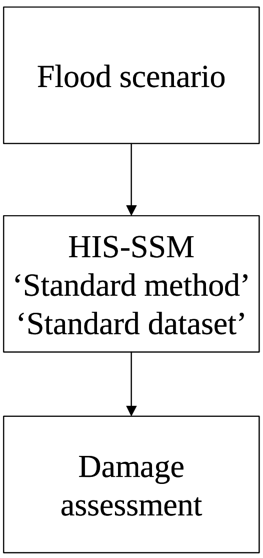

Figure 3. Process of damage assessment using HIS-SSM with its ‘Standard method’ and ‘Standard dataset’.

3.2 *Standard method*

In the ‘Standard method’ three types of damages are considered:

- Direct damage within the flooded area by physical damage to buildings, inventories, terrain and infrastructure. The economic value of such flood damage is estimated based on rebuilding and/or replacement costs.
- Direct damage within the flooded area as caused by business interruption and economic damage by production loss. The economic value of this flood damage is estimated based on productivity costs.
- Indirect damage: economic damages outside the flooded area due to loss of production. For example transportation routes through the flooded area cannot be used or production stops due to lack of supplies from industry within the flooded area. The economic value of this flood damage is estimated based on productivity costs.

In the ‘Standard method’ these damages are estimated for 31 damage categories that relate to landcover and utilization. Actual damage categories are differentiated according to damage type. For each damage category and type of damage, the economical damage S (expressed in Euro’s) is calculated by Equation.2:

$$S = \sum_{i=1}^{n} \alpha_1 n_i S_i \qquad (2)$$

where α_i is the ‘damage factor’ for category i , n_i is the number of units (e.g. houses) in category i and S_i is the maximum damage per unity in category i. Each category (i) represents a landcover type. The damage-factor α_i represents the effect of hydraulic conditions and is affected by the maximum water depth, rise in water level, flow velocity, and for built-up areas the type of buildings. The damage factor α_i is calculated using a damage function. (Kok et al., 2005). Not included in the method are type of floodwater (salt/fresh), duration of the flooding and seasonal landcover variations in agricultural regions.

The ‘Standard method’ has been developed for application in the whole of the Netherlands. This makes the ‘Standard method’ easy to apply, transparent and fast. Results are comparable and reproducible due to the fact that related software contains a ‘Standard dataset’ covering the whole country (Kok et al., 2005). Since its development there is a continuous debate on the methodology of the ‘Standard method’ Critics argue against the approach since the outcome only can be interpreted as an approximation of an actual damage by the many assumptions imposed. General notion however is that by using the method, decision makers have a better grasp towards identifying the benefits of a new measure or structure. Also it allows for justification of economic efficient public investments. In addition the program is developed as such that the method is transparent and easy to adapt.

3.3 *Standard dataset*

The ‘ Standard dataset’ that is used by the ‘Standard method’ consists of three components:

1 Spatial information on damage categories: damage categories that are considered are landuse/landcover, infrastructure, special objects and population. In the ‘Standard dataset’ a total of 31 damage categories are considered.
2 Damage functions for each combination of damage category and type of damage (direct damage to buildings and infrastructure, direct damage due to production loss and indirect damage). A damage function scales damages between 0 and 1, where 0 stands for no damage and 1 stands for maximum damage. This factor is related to a damage value by scaling it linearly to a pre-defined maximum damage value. In the ‘Standard dataset’ there are 50 combinations of damage categories and damage type. For some of these combinations the same damage function is used. In total there are 22 damage functions within the ‘Standard dataset’.
3 Maximum damage values for each combination of damage category and type of damage. The damage function is scaled to damage through a maximum damage value. The values of maximum damage in the Netherlands are based on Briene et al., (2002)

3.4 *Strong points of HIS-SSM*

In short, the benefits of HIS-SSM that is based on the ‘Standard method’ and ‘Standard dataset’ are:

- Damage is assessed in a spatially distributed fashion that takes into account the spatial distribution of damage categories, as well as specified characteristics of flood scenarios. It also is possible to group the damage per spatial unit, for example administrative unit or dike-ring area once the damage is calculated.
- Damage is assessed per damage category. This way the contribution of each damage category to the total damage is easy to derive.
- The method is transparent and easy to adapt. Within the interface it is possible to derive how damage is determined. If necessary the method can be adapted by adapting a damage function for a damage category.
- It can be used as a tool within flood risk assessment.
- It can be used to assess the costs and benefits of flood measures

4 DACA – 2T PROJECT

In this study a “Damage and Casualties Assessment” (DACA) tool as based on HIS-SSM is developed, for the 2T Kok River Basin in northern Thailand. For the project area necessary adjustments to the tool are made to serve the preferences of local, regional and/ or national organizations. Adjustment primarily relate to the flood characteristics considered and the definition and set-up of the data base on spatial information, damage functions and maximum damage values.

4.1 *Study area*

The study area covers Chiang Rai city and part of the Chiang Rai region in Northern Thailand. Chiang Rai city area covers some 50 km2 and is home to some 250.000 people. In the region river flooding is frequently observed by flooding since a number of river systems drain through the city. Figure 4 presents a diagram of the Chiang Rai study area with river systems and flood extent for the 2002 flood event indicated.

Rivers systems are the Nam Mae Kok, Nam Mae Lao and Nam Mae Korn that are of different size. Flooding is commenly caused by flash flood events from the Nam Mae Korn and Mae Lao.

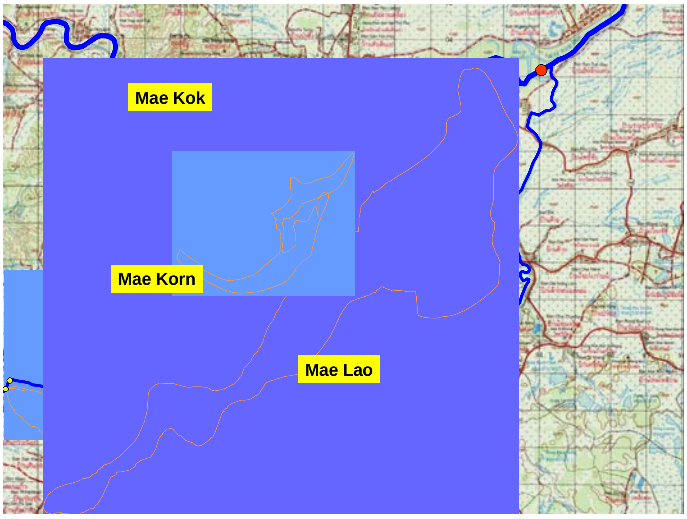

Figure 4. Chiang Rai study area with flood extent indicated for the September 2002 flood event (after Royal Irrigation Department, Ministry of agriculture, Thailand).

A field visit in June 2008 learned that many measures are being taken to prevent and mitigate river flooding:

- Between the Nam Mae Korn and the Nam Mae Kok at a distance of 12 km of Chiang Rai a diversion canal is made to diverse water from the Nam Mae Korn to the Nam Mae Kok. The capacity of this bypass is 50 m^3/s.
- The capacity of Chai Sombat weir at the Nam Mae Lao was too low, which resulted in high water levels. To prevent water flowing into agricultural area levees were constructed around

the weir and a shortcut was made. The height of the levees is based on historical high water levels.

- Several storage reservoirs in the Nam Mae Lao as well as in the Nam Mae Korn are constructed, under construction or planned in near future.

4.2 *Activities*

The DACA 2T project consists of three components:

1 Development of DACA 2T: On the basis of Dutch HIS-SSM, the interface of DACA-2T will be adjusted to serve the preferences of local, regional and/ or national decision-makers in the 2T Kok River Basin. The dataset on damage categories will be gathered and evaluated and damage functions and maximum damage values will be drawn up and imported in the damage model. Result is a full functioning DACA-2T.

2 Demonstration of DACA 2T for different flood scenarios: The model will be demonstrated for different flood scenarios. Aim is to determine three normative flood scenarios and determine the resulting flood damage using DACA-2T

3 Dissemination of results: A 5-day workshop is scheduled in which possible users of the instrument are invited to run and test the damage model. In addition to an actual training on how to use and adapt DACA-2T, normative flood scenarios will be developed jointly, DACA will be run and tested. The possibilities of improving DACA-2T and expanding it to other regions in the Lower Mekong Basin will be discussed. If the application of DACA 2T is considered a success a final seminar will be organised in which it will be demonstrated to a larger audience.

5 DEFINITION OF APPROPRIATE FLOOD SCENARIOS

5.1 *Introduction*

The flooding around Chiang Rai is mainly caused by overland flow from the Nam Mae Korn and the Nam Mae Lao. Flooding around Chiang Rai as a result of high water level at the Nam Mae Kok is not common. The cathment area of Nam Mae Lao is 3000 km^2 and that of Nam Mae Korn is 170 km^2. During the first part of the rainy season (Mai to July) the soil absorbs the rain, but in August and September the soil is saturated and heavy flash floods might occur. As the slope of the two rivers is rather steep, flooding due to backwater from the Nam Mae Kok is not noticed. (provincial office Royal Irrigation Department Chiang Rai, pers. comm.). In order to test DACA for representative floods in the area, flood scenarios are being developed for this purpose. The remainder of this chapter describes the methodology by which the flood scenarios will be derived, given the available data.

5.2 *Data*

Daily measured discharges and water levels are used of the Nam Mae Lao at the measurement point Ban Tha Sai, (derived from the HYMOS database at the RFMMP in Phnom Pehn). The measurements cover the period of 1 April 1972 to 31 December 2002. In the available time series discharges for the years 1995 and 1996 are missing. As the time series are measured daily, the extreme peak discharge based on hour is expected to be higher. The estimation is made that the peak discharge based on hour measurements is 5% higher than the peak discharge based on daily measurements. The discharge for the Nam Mae Korn is measured by the Royal Irrigation Department (RID) at measurement point G4. Within the timeframe of the project it was not possible to obtain the time series for the Nam Mae Korn. The flow in the Nam Mae Korn is therefore derived from the flow in the Nam Mae Lao proportional to their respective conveyance capacities (Ogink, 2008a). The maximum capacity of the Nam Mae Lao is 180 m^3/s and of the Nam Mae Korn 44 m^3/s.

5.3 *Method*

Within the DACA project three flood scenarios are determined with a return period of once in the five years (T5), once in the 25 year (T25) and once in the 100 year (T100). The followed procedure for flood mapping exist of four steps:

1 Derive synthetic discharge hydrograph;

For the return periods T2, T5, T10, T25, T50 and T100 the peak discharge is determined using General Extreme Value (GEV) (Coles, 2001) based on the annual maximum discharges within the measured period. Figure 5 shows the peak discharges for the Nam Mae Lao (Ogink, 2008b).

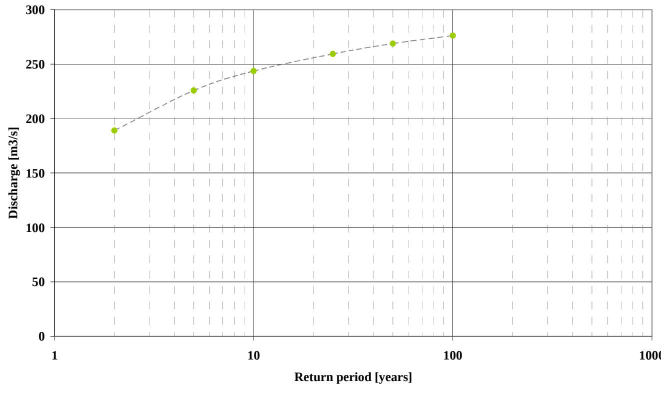

Figure 5. Return period of peak discharges for Nam Mae Lao at Ban Tha Sai based on annual discharges using GEV.

As duration of the flood determines the flood volume, the form of the synthetic discharge hydrographs is important. Therefore the synthetic discharge hydrographs is derived from the shape of the 20 largest independent flood peaks in the Nam Mae Lao (Ogink, 2008a). The result is given in Figure 6.

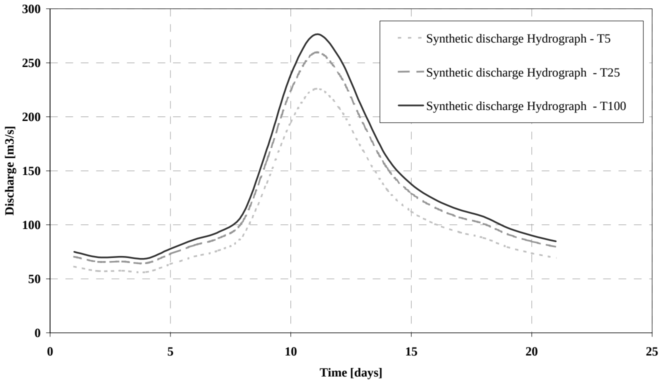

Figure 6. Synthetic discharge hydrographs for Nam Mae Lao at Ban Tha Sai.

2 Derive surface curve;

As i) no model was available of the study area, and ii) the flooded area around Chiang Rai is relative flat, the assumption is made that the flood volume is stored in the flood prone area. Therefore grid cells within the area are selected from the Digital Terrain Model (DTM) and turned into a surface curve, as shown in Figure 7.

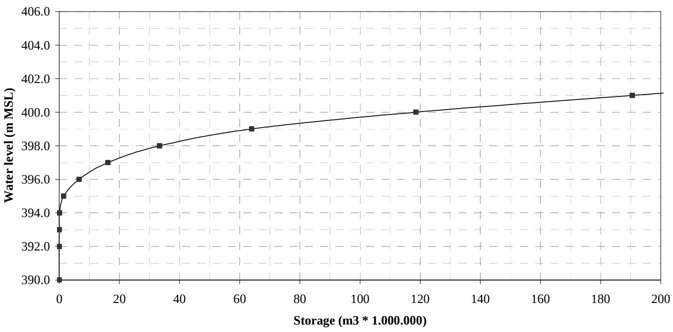

Figure 7. Surface curve of flood prone area.

This procedure has two negative aspects, which causes an overestimation of the water depth:

- While it is not a hydrodynamic approach the lowest points in field are filled first.
- As the area is not complete flat and bounded by high obstacles everywhere, in real the storage would be less.

3 Determine volume;

The volume in the synthetic discharge hydrograph above the maximum conveyance capacity is assumed to be flooded.

4 Return volume into water depth.

While now the flood volume is known the water depth can be determined using Figure 7. By subtracting the elevation of the DTM from the water level (m. MSL), the water depth is calculated per grid cell.

6 DEFINITION AND SET-UP OF DATASET

6.1 *Spatial information*

The landcover database of DACA-2T defines the damage categories for which damage can be assessed in the tool. The database is under development. The mapping effort of the landcover is limited to land features that respond differently to river flooding with respect to economical damage. It was decided to use as much as possible the pre-existent spatial information on landcover as available in Governmental Organizations (G.O.) and Public Offices. Reasons for this decision are:

– The use of information from G.O. is official, reliable and ensures continuity in time.
– G.O. have the resources and experience to produce the information with the required timing.
– The use of G.O. standard information to assess damage in quantitative form adds relevance to the G.O. producer.
– The need for an expedite and accurate damage evaluation after the recurrent flood events in the region promotes the effort that G.O. dedicate to the adaptation of their actual databases to fit better the needs of the assessment tool.
– The use of information from G.O is expected to support the collaboration and data sharing among organizations, keeping the ownership of the basic information, sharing the product and promoting common projects preventing data collection overlap.

In general the spatial information in the database is divided in two major standard landscapes: rural and urban. The rural database on land cover and utility will be derived after four sources in Thailand:

1 Land Development Department (LDD) in Bangkok;
2 Regional Land Development Department of Chiang Rai province;
3 Department of Disaster, Prevention and Mitigation (DDPM) in Bangkok; and
4 Regional DDPM Chiang Rai province

The most complete urban database belongs to the regional cadastral office. However, this information cannot be disclosed. As an optimal alternative data of the Department of Public Works, Town and Country (DPT) in Bangkok is selected for use. The information is contained in a clearinghouse in the Internet, but today is restricted only to the main city boundaries. Plans are made to extend it to the entire country in the next three years.

6.2 *Damage functions*

With the damage functions the effect of hydraulic conditions for each combination of damage category and damage type is defined. Most damage functions in HIS-SSM use only the maximum flood depth as a parameter. For The Netherlands, where high flow velocities are to be expected near the breach only, this approach is justifiable. In the region of Chiang Rai, where flooding occurs due to flash floods, flow velocity might be of more importance. In addition, it might be relevant to include the flood duration for Chiang Rai region, to account for its effects on agricultural damage and on economic activity.

From a field visit to the study area in June 2008, it appeared there is no data available on damages related to flood characteristics. When a flood occurs in Thailand, surveys are carried out to assess the number of people, objects and land utilities that are affected by the flood. Flood characteristics (such as flood extent, water depth, duration of flooding, and an indication on flow velocity) are not being recorded in this survey. As a consequence, it is also difficult to relate the affected landcover and utilities to a flood extent being derived from other sources (e.g. by a flood scenario). The aggregation level of these surveys is at village level, which complicates the determination of the exact location of the affected landcover and utilities. This implies that deriving a relation between flood characteristics and affected landcover utilities cannot be done based on data that is available in Thailand. As such the damage functions of HIS-SSM will be used, were appropriate and assumptions on adaptations for relevant damage categories will be made based on literature and field observations done in the study area during the field visit of June 2008.

6.3 *Maximum damage values*

As discussed before (paragraph 3.2), DACA-2T requires for each combination of damage category and damage type a maximum damage value. This value represents the reproduction/replacement costs for direct physical damages to buildings and land utilities. In case of damage to (small) businesses in and outside the flooded area the value of the productivity costs should be used. From a field visit to the study area in June 2008, it appeared that not all these data are recorded or known in Thailand.

The surveys on damage assessment that are carried out after flood take only the direct damage to structures and land utilities into account. Damage inside or outside the flooded area due to production loss of (small) businesses is not taken into account. This implies that maximum damage values for these damage relations cannot be defined based on available data on flood events in Thailand.

For the direct damage to buildings and land utilities the government of Thailand has compensation values. Table 2 gives the compensation values as of 2006 for different agricultural land utilities (data obtained from, Chiang Rai provincial office DPMD).

Table 2. Government compensation for flooded agricultural land (compensation values valid from 2006), 1 rai = 0,16 ha.

Land utility	Baht/rai [per person]	Remarks
Agriculture		
Rice, totally destroyed	414	
Crop, totally destroyed	579	
Other Plants, totally destroyed	786	
Rice, partially destroyed	142	
Crop, partially destroyed	161	
Other Plants, partially destroyed	161	
Fishery		
Farm. Ponds and peddy fields	3406	Not more than 5 rai
Shrimp and shell fish	9098	Not more than 5 rai
Freshwater fish	257	Not more than 80 m^2
Livestock		
Traditional cock and hen rearing	22.50	Not more than 300
Commercial cock and hen rearing	15	Not more than 1000
Ducks	15	Not more than 1000

The total of the amount that is compensated is presented as an estimation of the damage in damage reports (e.g. MRC, 2006). However, the actual damage differs from the damage based on compensation costs. Table 3 gives the rebuilding costs of 4 houses in Chiang Rai province due to a fire in 2008, versus the value of compensation that was granted. The maximum compensation for a house is 30.000 Baht (data obtained from, Chiang Rai provincial office DPMD). As data on actual damage per land utility is scarce, the relation between the actual damage and the compensation value is unknown. In addition, the relation will differ per land utility.

Table 3. Rebuilding costs and compensation value for four houses in Chiang Rai province (compensation values as from 2006).

Rebuilding costs of house [Baht]	Value of compensation [Baht]
20.000	20.000
38.000	30.000
50.000	30.000
15.000	13.310

Thus, in addition to the maximum damage values for production loss, the maximum damage values for physical damage to buildings, infrastructure and other land utilities cannot be derived from data available in Thailand. Using compensation values as maximum damage values would align with the methodology as is currently applied in Thailand. It is arguable whether this is really a correct damage evaluation method, given the considerations as discussed above.

7 CONCLUSIONS & RECOMMENDATIONS

This pilot study could serve as a practical link between economic valuation techniques for flood damage assessment and ex-ante evaluation of measures by different decision makers. The study proceeds with the results of damage assessment that is already being done in the region. The translation to ex-ante evaluation of flood control measures does not exist yet and is novel to the region. During the study it was found that the level of knowledge on flood damage assessment differs between The Netherlands and Thailand. This causes differences in damage evaluation. In a manner DACA-2T can serve as a tool for standardized assessments of damages and as such might serve to unify policies and protocols of damage assessments. The tool assesses damage in a spatially distributed fashion that takes into account the spatial distribution of damage categories, as well as specified characteristics of flood scenarios. This makes the tool transparent. Moreover the use of the DACA-2T tool can be of political and economic relevance since it gives decision-makers like governments, financiers and others a better grasp to evaluate decisions. By weighing the damages resulting from a potential flood, the tool could be used to assess the costs and benefits of flood measures.

REFERENCES

Betts, H. 2002. Flood damage analysis using GIS at Gold Coast City Council. Australian Journal of Emergency Management, 17 (1): 33 – 37.

Briene, M., Koppert, S., Koopman, A. & Verkennis A. 2002. Financiële onderbouwing kengetallen hoogwaterschade. Rotterdam, The Netherlands: NEI B.V.

Coles, S. 2001. An Introduction to Statistical Modeling of Extreme Values. London: Springer-Verlag.

FEMA. 2007. Multi- Multi-hazard Loss Estimation Methodology - Flood Model HAZUS®MH MR3 - Technical Manual. Washington, D.C. Department of Homeland Security, Federal Emergency Management Agency, Mitigation Division

Groot Zwaaftink, M. E. & Dijkman, M.E. 2007. HIS- Schade en Slachtoffers Module versie 2.4 – Gebruikershandleiding. Nijmegen: Royal Haskoning and Geodan

Huizinga H.J., Dijkman, M, Braak, W.E.W van den & Waterman, R. 2005. HIS- Schade en Slachtoffer Module - Versie 2.2, Lelystad: HKV consultants.

Kok, M., Huizinga, H.J., Vrouwenvelder, A.C.W.M., & Braak, W.E.W., van den. 2005 Standaard methode 2005, Schade en Slachtoffers als gevolg van overstromingen. Lelystad: HKV consultants.

Messner F., Penning-Rowsell E., Green C., Meyer V., Tunstall S. & Veen A. v/d. 2007. Evaluating flood damages: Guidance and recommendations on principles and methods FloodSite Project Report T09-06-01.

Meyer, V.& Messner, F. 2005. National flood damage evaluation methods, a review of applied methods in England, The Netherlands, the Czech Republic and Germany. Leipzig-Halle. Umweltforschungszentrum

Ministerie van Verkeer en Waterstaat, RIZA. 2005. Flood risks and safety in the Netherlands (Floris) – Floris study – Full report. DWW-2006-014. The Hague, Ministerie van Verkeer en Waterstaat.

Ministerie van Verkeer en Waterstaat, RIZA. 2007. Werkwijzer OEI bij SNIP.. RIZA Rapport 2007.010. Rijswijk: Quantes.

Ministerie van Verkeer en Waterstaat. 2008. Netherlands Safety Map. www.verkeerenwaterstaat.nl.

MRC. 2006 . Annual flood report 2005 – Flood Management and Mitigation Programme. Vientiane, Lao PDR. MRC.

MRC. 2007 . Annual Mekong flood report 2006 – Flood Management and Mitigation Programme. Vientiane, Lao PDR. MRC.

MRC. 2008. Characteristic data on the Mekong River Basin. 6th Annual Mekong Flood Forum, 27-28 May 2008, Phnom Penh, pg 13 – 17.

Ogink, H.J.M. 2008a. Flood hazard assesment focal area, data requirements. Preliminary. Deltares.

Ogink, H.J.M. 2008b. Flood hazard mapping for Nam Mae Kok, Flash and combined flood approach. Preliminary. WL Delft Hydraulics & Royal Haskoning, Deltares and IHE.

UNCHS (Habitat). 2001. Assessment of vulnerability to flood impacts and damages. Disaster Management Programme, 32 pg.

Wagemaker, J. Leenders, J.K. & Huizinga, J. 2008. Economic valuation of flood damage for decision makers in the Netherlands and the Lower Mekong Basin. 6th Annual Mekong Flood Forum, 27-28 May 2008, Phnom Penh, Cambodja.