Development of a *Flood Vulnerability GIS* Application

A Tool for Community Self-Reliance and Flood Risk Reduction

ADB-TA 4574-CAM

Draft

February 2007

Prepared for:

Asian Disaster Preparedness Centre
Bangkok, Thailand

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DEVELOPMENT OF A *FLOOD VULNERABILITY GIS* APPLICATION

A TOOL FOR COMMUNITY SELF-RELIANCE AND FLOOD RISK REDUCTION

ADB-TA 4574-CAM

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1.0 INTRODUCTION

This report and accompanying CD-ROM presents the geographical information system (GIS) and mapping component developed as part of the ADB-TA 4574-CAM, "Community Self-reliance and Flood Risk Reduction", conducted in association with the Asian Disaster Preparedness Centre (ADPC). A *Flood Vulnerability GIS Atlas Interpretation Guide* (Hatfield 2007), which describes the GIS Atlas and maps, is included in the CD-ROM.

The TA is designed to assist the Government of Cambodia, non-government organizations (NGOs) and local leaders become better prepared for extreme flood events, and to build capacity at the community-level for flood disaster prevention and mitigation. The key outcome will be the adoption of improved participatory flood risk management principles by village development councils and targeted vulnerable communities in the provinces of Takeo, Svay Rieng, Prey Veng and Kandal.

The objective of this TA is to ensure that "the improved participatory flood (and drought) risk management strategy for targeted vulnerable communities in the lower Mekong River basin provinces of Cambodia is adopted by the key stakeholders."

In order to support participatory flood management activities, information in the form of maps is required. Remote and GIS play a key role in helping decision-makers have the required information to assist with flood management. Under the TA, Hatfield Consultants (Vancouver, Canada) worked with ADPC to develop a simple GIS related to flood vulnerability, and provide environmental expertise to the project team,

1.1 STUDY AREA AND OBJECTIVES

The study area comprises four provinces of Cambodia, lying along the Mekong and Bassac Rivers, where floods caused by the annual monsoon rains are generally accepted as having the most serious impact on the local population. The activities conducted under the TA targeted four of the main flood-prone provinces of Cambodia, namely Kandal, Takeo, Prey Veng and Svey Rieng. The overall aim of the GIS and mapping component of the TA was conducted by Hatfield to assess flood vulnerability at commune level as follows:

1. Identify available and relevant data on flooding and the impact of flooding in four flood/drought prone provinces of Cambodia;

2. Compile topographic, flood data, socioeconomic and environmental data into a GIS;

3. Conduct spatial and statistical analyses on the compiled data to produce four indices of vulnerability: flood vulnerability, rice dependency, poverty and access vulnerability; and

4. Create a simple *Flood Vulnerability GIS* suitable for distribution, to facilitate access to information by decision-makers and stakeholders in the region.

The *Flood Vulnerability GIS* is designed to support decision-making for the identification of flood-prone communes, as well as to assist government agencies, local non-governmental organizations (NGOs), and targeted communities affected by flood and drought from four provinces of Cambodia: Kandal, Takeo, Prey Veng and Svey Rieng. The development of the GIS focused on mapping the historical flooding as well as the communities living in flood-prone areas, while attempting to provide visual and analytical information to assess the vulnerability of these communities; subsequently, this information could help reduce the risk of adverse effects from flooding. GIS and remote sensing can be used to provide valuable information to planners and decision-makers, whose mandate is to manage and mitigate the impacts from annual floods that affect a majority of the Cambodian population living in the Mekong and Tonle Sap floodplains.

GIS have a wide variety of applications in natural resource management, but one of the key strengths of GIS is spatial modelling. Modern GIS software allows the user to describe geographic features using both vector and raster data models. Vector data models allow the user to represent discrete and thematic features using points, lines and polygons. Raster data models use grid-based images to represent continuous and thematic data as layers or surfaces of numerical values. Remote sensing presents a unique perspective of the Earth's surface. Remote sensing allows detailed information to be captured over wide areas, irrespective of administrative borders.

1.2 OUTLINE OF THIS REPORT

Following the introduction, the report is structured into four main sections.

- *Section 2* introduces methods used to construct the GIS database and describes the analysis used to assess flood vulnerability;
- *Section 3* presents examples results through Illustrative examples of the analysis conducted to assess flood vulnerability;
- *Section 4* provides a brief discussion of the major findings, and the challenges encountered in the development of the GIS;

The report is supported by three Appendices:

- *Appendix 1* presents the metadata;
- *Appendix 2* provides details of the calculation of the flood exposure indicators; and
- *Appendix 3* is a list of the most vulnerable communes presented by province.

2.0 METHODS

The GIS was developed following standard GIS and statistical methods, commonly used to integrate a variety of different spatial data to produce new information pertinent to the issue under investigation.

2.1 CONCEPTUAL BASIS OF A *FLOOD VULNERABILITY GIS*

The conceptual basis for the development of the *Flood Vulnerability GIS* is illustrated in Figure 1. The **first step** is to identify and assess available data sources, and then integrate the data into standard GIS format (i.e., map projection, file type, etc.). It is important that an assessment of the quality of data is conducted this stage and any limitations identified. The **second step** is to conduct basic GIS and statistical analysis to distinguish certain aspects of the data, or to derive new information from the individual or combined datasets. The important issue is to that the new datasets are easy to interpret, and as such they are usually referred to as *Indicators*. The indicators produced in the *Flood Vulnerability GIS* aim to provide information on the conditions affecting or characterizing an area, place, or group of people; for example, the *number of households headed by a woman* can be used as an *indicator of poverty*, and the *frequency of flooding* can be used as an *indicator of flood exposure*. The derivation of indicators is an important step, and they are often very illustrative of the conditions affecting the location population; however, the interpretation of numerous indicators can be difficult, because of the number and variety of indicators. The **third and final step** in the development of the *Flood Vulnerability GIS* is the integration of numerous indicators to produce a measure of vulnerability that is easier to interpret.

In order to ensure that there is clarity in the interpretation of the data and analysis conducted, the following important definitions in the context of this GIS are provided:

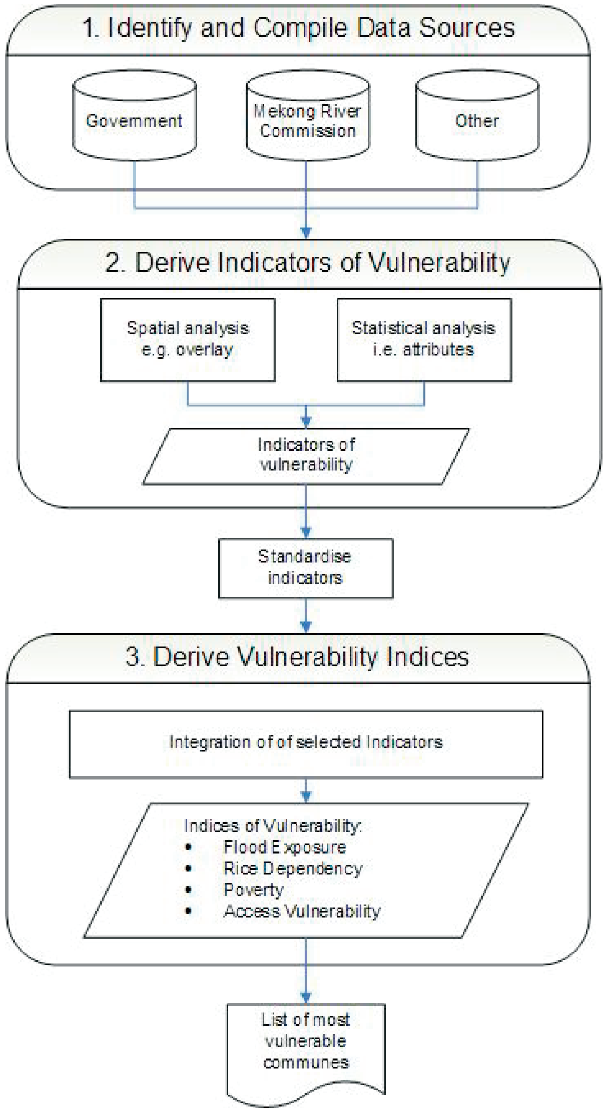
- **Indicator** — provides information on the conditions affecting or characterizing an area, place, or group of people (e.g., difficulty to access clean water can be used as an indicator of poverty);

- **Index** (plural indices) — a value for each commune calculated from the integration of several indicators;

- **Vulnerability** — describes the relationship that people have with their environment. Vulnerability is defined in relative terms, and vulnerability can be determined by assessing the values of the indices;

- **Dependency** — used as a synonym for vulnerability when applied specifically in the context of measuring the importance of rice cultivation for the community needs. Commune-level indices of rice dependency are one of the four key indices developed in this document.

Figure 1 Conceptual basis for the development of the *Flood Vulnerability GIS*.



In this study, several indicators are integrated to form an *index*, and depending on the set of indicators used, there are four *indices*:

- Flood Exposure Index — based on several indicators related to the frequency, duration, and magnitude of flooding derived from remote sensing and flood models, and elevation information;

- Poverty Index — based on socioeconomic indicators derived from SEILA’s commune and village-level socioeconomic database; selected indicators are related to households facilities, education and number of households headed by women with young children;

- Rice Dependency Index — based on SEILA's commune-level data related to wet-season rice cultivation using area of cultivation and production for 2004; and

- Accessibility Index — based on SEILA's village-level data related to access-time and distance to main road and market, number of families per boats as well as percent of roads flooded in 2000.

Details of the statistical and GIS methods used to create the numerous indicators and the four indices are provided in Section 2.4 and 2.5, below.

2.2 DATA SOURCES

The maps and GIS information developed as part of the TA were constructed using readily available data, primarily provided by the Mekong River Commission (MRC), Regional Flood Management and Mitigation Centre (RFMMC), and the Cambodian Ministry of Public Works and Transportation (MPWT). Additional data derived from satellite imagery were provided courtesy of the Canadian Space Agency (CSA), and commune and village level socioeconomic data were obtained from the SEILA/UNDP Programme[1], which is regularly updated.

The organizations that provided data for the *Flood Vulnerability GIS* are summarized in Table 1, and include:

1. MRC/RFMMC/CSA – includes RADARSAT-derived flood extent data collected from 1999 to 2002, and model-derived flood extent and elevation data provided by the MRC and RFMMC;

2. Cambodian MPWT – the most recent datasets identifying administrative boundaries and infrastructure were made available by MPWT;

3. SEILA – Village and Commune level socioeconomic indicators for the year 2004; and

4. World Food Programme, Vulnerability Assessment Mapping Unit (VAM) – data at the commune level:

    - Flood Prone Priority Areas: First priority (1), Second priority (2), Third priority (3); and

    - Drought Prone Priority Areas, First priority (1), Second priority (2), Third priority (3).

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[1] The Seila Programme for poverty alleviation and good governance is a Royal Government of Cambodia development Programme supported by UNDP and a number of donor agencies, and implemented in collaboration with several partners.

Table 1 Summary of datasets included in the *Flood Vulnerability GIS*.

Data Layer	Source	Scale	Description/Assessment
RADARSAT-1*	MRC	1:50,000	Extent of inundated area at specific dates (10 dates selected from 1999 to 2002); Based on analysis conducted by Hatfield, under contract to MRC and CSA (see Hatfield 2001 to 2003)
Mike11**	MRC	n/a	Model predicting the maximum inundated area for three levels: minor, medium and major flood events.
DEM§	MRC	1:50,000	Digital Elevation Model (DEM) 50 m resolution of flood prone areas
Hydrology	MRC	1:50,000	Rivers, streams and lakes
Administrative Main	MPWT†	1:50,000	Province, District, Commune boundaries.
Human	MPWT	1:50,000	Settlement boundaries, Village centre location, Main Buildings location (includes temple, school, health centres).
Road	MPWT	1:50,000	Road network (update 2003-2005)
Land use	MPWT	1:50,000	Land use (update 2003-2005)
Socioeconomic Indicators	SEILA	n/a	Commune and village-level socioeconomic data
Flood-prone Priority Level	WFP/VAM	n/a	Rice dependency, rice sufficiency, frequency of flood / rice crop damage events.
Drought-prone Priority Level	WFP/VAM	n/a	Based on drought affectedness, rice dependency, precipitation and Normalized Difference Vegetation Index (NDVI).

* Mekong River Commission (MRC) was the main source for RADARSAT-1 GIS data.

** MIKE11: Hydrodynamic model 2001 produced by DHI, validated using RADARSAT-1 Imagery 30-Aug, 23-Sep, 17-Oct.

§ DEM derived from a number of input contour datasets, point-spots (hydro-station, elevation, etc.), stream network, lakes, etc.

† MPWT provided the administrative layers, infrastructures and land use datasets.

2.2.1 MRC/RFMMC/CSA Data

Over the past 10 years, MRC and Hatfield have obtained a number of RADARSAT-1 satellite images to estimate the extent of the inundated area of the Cambodian floodplain. The same dataset was also used to verify the various flood models developed by MRC. RADARSAT-derived flood extent area is one of the main estimators of flood vulnerability developed in the GIS.

In addition, the extent of flood events based on three scenarios, minor, medium and maximum flood (1 in 2, 1 in 5 and 1 in 20 year event, respectively) is included in the calculations. The estimations are derived from the MIKE11 hydraulic model simulation of the 2001 flood in Cambodia (Fuji *et al*. 2003). Maximum water levels were obtained from the year 2000 record flood year. Areas of 'local flooding' not covered by the model but identified as 'having water' using three RADARSAT-1 images[2] collected in 2001, were incorporated into the *Flood Vulnerability GIS*.

Detailed mapping of the extent of inundated areas was based on using a number of RADARSAT-1 scenes acquired during the flood season from 1999 to 2002. RADARSAT-1 technology provides cost effective means to accurately delineate

[2] RADARSAT-1 scenes: 30-Aug, 23-Sep and 17-Oct-2001.

large areas of inundated land irrespective of the presence of cloud cover during of the monsoon season. The dates selected for developing the GIS are presented in Appendix 1. The estimated extent of flooded area is included for each date and for the MIKE11 flood events.

The MRC data included the following:

- RADARSAT-1 derived extent of inundated area (flood extent) at various stages of the flood, between August and December, from 1999 to 2002 (10 dates/scenes selected);

- Extent of inundated area estimated for minimal, medium and major flood events and number of flood days estimated for a medium flood events; were derived from the hydraulic model simulation of the 2001 flood in Cambodia (MIKE11 hydrodynamic model); and

- 50m resolution digital elevation model (DEM) – elevation in meters above sea level; elevation data are available for each 50 × 50 m grid cell.

Shaded relief from the DEM provides a general representation of the landscape, valleys, hills and mountainous area. However, most of the land in the study area lies at lower altitudes, between 0 and 30 m, and the elevation and relief do not vary considerably in this dataset. This dataset was used to generate the flood-prone areas DEM, which provides elevation in meters above sea level for more than 90% of the study area.

2.2.2 MPWT Data

The MPWT provided important baseline data based on the Japanese International Cooperation Agency (JICA) Cambodian Reconnaissance Survey, which was conducted in 1998. These data were updated in 2003-2005 for a number of selected features, and more recently for health centres[3]. MRC's village centre GIS layer file was also included to provide additional information, such as place names and demographic data.

The *Flood Vulnerability GIS* includes political and main administrative boundaries as common layers to all maps. This comprises the country boundaries for Cambodia, Viet Nam, Lao PDR and Thailand, and the four targeted provinces are included as well as district and commune boundaries.

Village locations are included along with related socioeconomic data from SEILA/UNDP's village-level database. Built-up area boundaries, also referred as settlement areas, are shown as polygons within a commune boundary. However there is no village identification for built-up areas. As a result, all statistics related to built-up areas are calculated at the commune level.

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[3] The updated health centre GIS was provided by the Cambodia National Institute of Statistics.

The MWPT datasets used for the *Flood Vulnerability GIS* includes:

- Administrative boundaries (Province, District, Commune);
- Village centres (combined MRC and MPWT datasets);
- Settlement areas;
- Building centres (Schools, Temples, Health Centres, etc. – 13 categories used); and
- Road network.

2.2.3 Other GIS Data

Additional GIS data include the following:

- Communes classified according to the flood-prone and drought-prone priority levels defined by the World Food Programme (WFP) VAM Unit;
- Seila Programme commune and village-level socioeconomic complete dataset (from the 2004 database), are included with the GIS; this information can be accessed directly from the map. SEILA relies on data provided primarily by the head of each village, who reports to the chief of the commune. This information is compiled into the 'commune database' (CDB) and updated regularly. The database is available on the programme website;
- List of safe sites identified during a recent survey in Peam Chor District is presented in the Atlas, and included in the list of printed maps; and
- The complete sets of topo maps sheets prepared by MPWT covering the four target provinces (13 sheets in total).

2.2.4 Metadata

An important component of any GIS is a description of the data used, which is also known as metadata. Most of the data in the *Flood Vulnerability GIS* was obtained from official sources (e.g., MPWT, MRC) and therefore metadata are available. A simplified metadata document for each dataset obtained from official sources is provided in Appendix 1.

The new information derived for the *Flood Vulnerability GIS* required the creation of metadata. Metadata documents for new data are provided in Appendix 1.

2.3 SOFTWARE AND GIS STRUCTURE

The GIS was developed using ESRI ArcGIS 9.x software (ESRI 2006), which is a leading GIS software application. ArcGIS offers all the tools to compile the data and enables further analysis to derive new information.

The GIS is organized into six main components:

1. **Base data,** which includes administrative boundaries (country, province, district, commune and village boundaries), buildings and infrastructure locations (hospital, school, temple, and road), land use/land cover and stream networks);

2. **Elevation** in the form of a digital elevation model (DEM) and derived hill-shades/shaded relief, which provide elevation and a three-dimensional impression of the landscape;

3. **Flood extent,** including flood extent derived from **RADARSAT-1 satellite imagery** for the flood season months between 1999 and 2002;

4. **NGO intervention**, which includes a comprehensive set of locations of NGOs involvement in the four selected provinces; and

5. **Vulnerability Indices including:** flood exposure, wet-season rice dependency, poverty, and access vulnerability.

An advantage of ArcGIS is that it offers strong mapping and analysis capabilities, and also provides the option to publish maps along with a free reader application (which is analogous to Adobe Acrobat Reader). The GIS is packaged and distributed as a CD-ROM, with the following features:

1. GIS data and metadata;

2. ArcReader software package, which is a GIS application developed by ESRI (www.esri.com) to provide basic map browsing capabilities in a simple desktop application. Users can view different maps 'layers', zoom and pan around the maps, and explore the attributes;

3. A series of 82 maps, showing each indicator by province and for the study area (four provinces);

4. Users' Guide for use of the GIS (this Section and Appendix 1) – which includes a summary of approach and guide for users along with metadata lists for users' reference; and

5. Outputs of all attributes at the commune level and village level (selected subset) in a series of spreadsheets (MS Excel) organized by province.

2.4 FLOOD VULNERABILITY INDICATORS

An important step in the process to define indicators of vulnerability is to overcome the difficulties of data availability. The indicators defined are based the available data. Spatial analysis was conducted using ArcGIS to generate a number of indicators relevant to the impact of the annual flood. The indicators are defined at **commune-level** to produce maps identifying vulnerability. The flood vulnerability indicators are described in Table 2.

Table 2 Summary of commune-level flood vulnerability indicators.

Group	Indicator
Flood Exposure	Average percent area inundated – RADARSAT Low Flood
	Average percent area inundated – RADARSAT High Flood
	Average commune elevation
	Percent area inundated – Mike11 min. flood
	Percent area inundated – Mike11 med. flood
	Percent area inundated – Mike11 major flood
	Percent area inundated – Mike11 medium flood (duration)
	Average no. of commune flood-days – Mike11 med. flood
	Average percent of infrastructure inundated (for settlement area, village and building) – RADARSAT-1 Flood
	Average elevation (for settlement area, village and building) – DEM
	Average no. of flood-days (settlement area, village and building) – RADARSAT-1
	Percent of road flooded (2000 flood year) – RADARSAT-1
Poverty	Percent Households with thatched roof*
	Percent Households with access to clean water*
	Adult literacy rate*
	Percent of children in school*
	Percent of households headed by a woman with children ≤ five-years old*
Rice	'Wet-Season' rice (rainfed, irrigated and combined) as a percent of commune area;
	'Wet-season' rainfed and 'Wet-season' rainfed irrigated rice as a percent of total rice production area
	'Wet-season' production as a percent of annual rice production
	'Wet-season' rice production per hectare per annum (metric-ton/ha)
	'Dry-season' rice production per hectare per annum (metric-ton/ha)
Access	Length of road network – GIS-based estimate
	Average access time from village to main roads and markets*
	Average distance from village to main roads*
	Average distance from village centre to nearest 3 health centres – GIS-based linear estimate
	Number of families per boat*

* From a larger range of indicators from the SEILA village-level database

2.4.1 GIS Operations

GIS operations such as *overlay* or *intersect* were performed to derive the indicators, for example to intersect human-defined features such as commune and settlement boundaries (polygons), roads (lines) and village centres and main building locations (points) with RADARSAT-1 and MIKE11 flood extents, the DEM, and flood duration. The particular GIS operation conducted and vulnerability indicators calculated is dependent upon the type of input data.

For example, a village centre is a point location, which means that flood indicators such as *average number of 'flood-days'* and a*verage elevation for village centre* are appropriate; of course, it is not possible to calculate flooded area for a point location. In contrast, the commune is a polygon (or area), which means that a GIS operation to intersect the commune boundary with the flood extent can be used to derive *percent of commune flooded*. Examples of the types of GIS operations used to calculate flood exposure are:

- **Polygon intersects with polygon**: e.g., commune boundary intersects with RADARSAT-1 flood extent to derive percent of commune flooded.

- **Points intersect with polygon**: village point features intersect with RADARSAT-derived flood extents to determine average frequency of inundation events; and

- **Line intersects with polygon**: Road vectors (lines) intersect with RADARSAT-1 flood extent (2000) to determine *percent of road flooded (2000 year flood)*.

Full details of the analyses conducted to derive the flood vulnerability indicators are provided in Appendix 2.

2.4.2 Standardization of Indicators

Before indicators can be combined to form an index, they must be standardized to place indicators in the same scale and ensure that the index is statistically robust. Standardization requires that the distribution of indicator values conforms to a normal distribution – if this is not the case, a transformation must be made; for example, the indicator *number of families per boat* has a highly skewed and non-normal distribution, and a logarithmic transformation was applied before completing the standardization.

The indicators are standardized using the z-score transformation as follows:

$$z = (x - \mu)/sd$$

Where x is the indicator value for a given commune and μ is the average indicator value of all the communes and *sd* is the standard deviation. The standardization results in an indicator with a mean value equal to 0 and a standard deviation of 1.

In order to integrate indicators, the positive or negative values must reflect a consistent effect in terms of vulnerability. For example, communes with a high percent of illiterate adults or percent of female headed households will have a positive indicator value, which is ultimately linked to higher levels of poverty. In contrast, for some indicators, such as percent of families with access to water, a high indicator value is ultimately linked to lower levels of poverty. Therefore, the standardization of the indicator is modified by reversing the means part of the equation above; i.e., $(\mu - x)$.

2.5 FLOOD VULNERABILITY INDICES

Based on the set of indicators derived and available in the GIS (see Table 2), a set of four indices were defined based on the integration of indicators:

- **Flood Exposure Index** – combines 12 indicators derived from RADARSAT-1, flood model, and the DEM (see Flood group of indicators in Table 2);

- **Poverty Index** – combines 5 indicators based on those from the SEILA programme (see Poverty group of indicators in Table 2);

- **Rice Dependency Index** – focuses mainly on 'wet season' rice cultivation and combines 8 indicators in total (see Rice group of indicators in Table 2); and

- **Accessibility Index** – combines 6 indicators from the Access group of indicators in Table 2 and 1 indicator from the Flood group of indicators (Percent of road flooded).

To generate the four vulnerability indices, the appropriate set of standardized indicators was combined. For all the indices, negative values reflect communes in a relatively **better-off** situation, whereas positive values reflect communes in a relatively **worse-off** situation. For improved interpretability, the value 100 was added to the final index and the resulting indices are distributed above and below 100.

2.5.1 Levels of Vulnerability

The vulnerability indices developed and calculated using the GIS were classified into easily interpretable low, medium and high classes, or levels of vulnerability. Index scores above 100 was used as threshold to identify communes as 'vulnerable'; the fact that the data were standardized means that the group selected represents approximately 50% of all the communes in the four provinces. From this set, the communes were then grouped into three classes of approximately equal size (quantiles); the first class corresponds to low (1), the second Medium (2) and the third High (3) level of vulnerability. Grouping of the communes provides a convenient method to compare each commune in relation to the whole study area, and to establish relative vulnerability.

3.0 RESULTS

3.1 FLOOD EXPOSURE

To illustrate the steps taken to calculate the flood exposure index, three communes appearing vulnerable to flooding in Takeo Province were selected. The three communes show high consistency among the indicators of exposure derived from different data sources. The flood exposure indicators included in Table 3.

RADARSAT-1 derived indicators (Figure 2) have similar values as those derived from the elevation data. However, the MIKE11 model tends to generalize the flood extent area in areas highly prone to flood (Figure 3); it returns 100% flood coverage without distinction of small areas located on higher ground, and therefore appears of limited use for analysis carried out at the commune or village scale. All indicators are likely to show (Figure 4) similar values, which is understandable considering the fact that the MIKE11 model was calibrated using the RADARSAT-1 flood extent data. Average elevation for the village centres and buildings was expected to be higher than for the commune area; however, this was only shown for Romenh Commune.

Table 3 Summary of flood exposure indicator values and Flood Exposure Index for three communes.

Indicators	Units	Thlea Prachum	Prey Khla	Romenh
Area Total	ha	3,347	7,195	7,003
Area Inundated – Low	%	14.4	36.3	52.1
Area Inundated – High	%	92.5	74.8	83.8
Average elevation – DEM	m	4.3	3.9	2.5
RADARSAT/DEM derived indicators		**102**	**102**	**104**
Min. flood event	%	91.4	100	83.5
Med. Flood event	%	100	100	100
Major flood event	%	100	100	100
Med. Flood event (Duration)	%	2.1	31.6	82.7
Average No. of 'Flood-day'	days	0	54	44
Mike11 derived indicators		**101**	**103**	**104**
Average infrastructure inundated	%	35.3	40	45.4
Average elevation – DEM	m	4.3	4.9	3.1
Average No. of 'Flood-day'	days	0	0	54
Road flooded	%	100	100	100
'human features 'derived indicators		**103**	**103**	**105**
Overall Flood Index Value		**106**	**108**	**113**

Figure 2 RADARSAT-derived extent of area flooded over three communes in Kandal Province; image captured between September and December from 1999 to 2002 – low flood (left panel) and high flood (right panel).

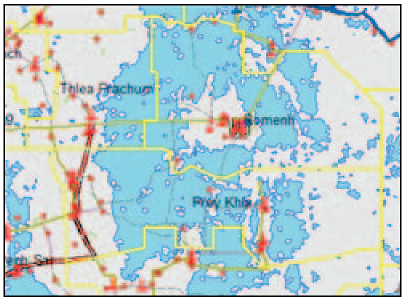
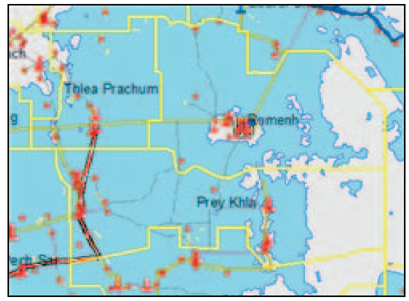
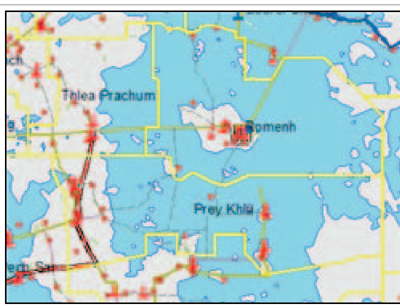
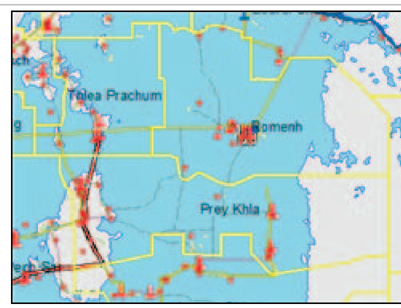
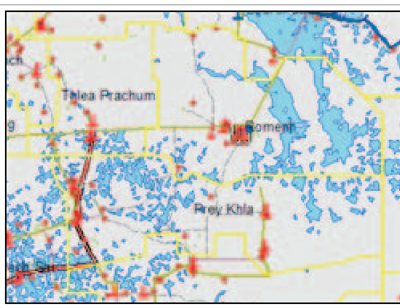
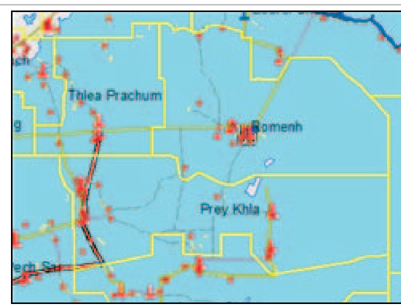
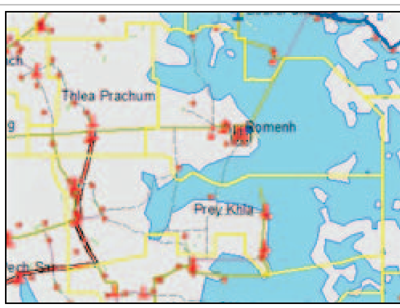
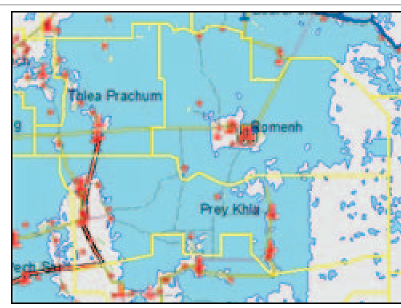
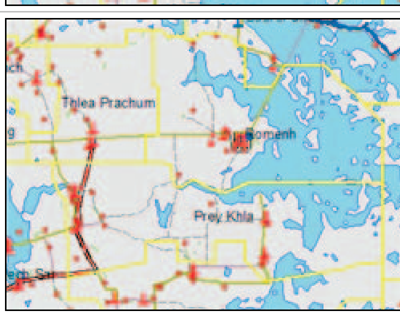
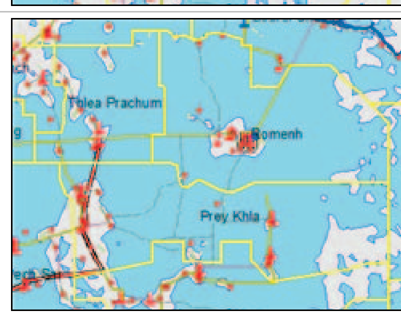
Low Flood		High Flood	
	Sep 24 1999		Aug 24 - Sep 4 2000
	Oct 25 1999		Sep 23 - Oct 5 2000
	July 10 2002		Oct 19-29 2000
	Aug 15 2002		Oct 17 2001
	Dec 25 2002		Sep 20 2002

Figure 3 **Mike11 derived extent of area flooded: minimum flood event (left panel), medium and major flood events (central panel), and flood extent and duration of flooding as indicated by the shades of blue, from 5 days (light blue) to 131 days (darker), in the right panel.**

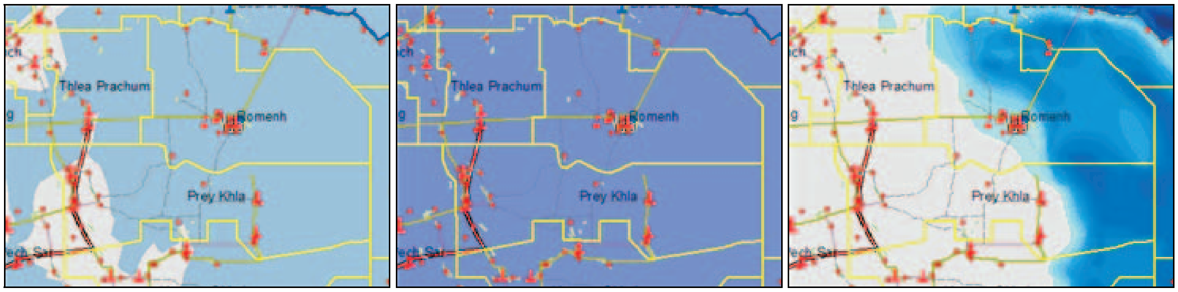
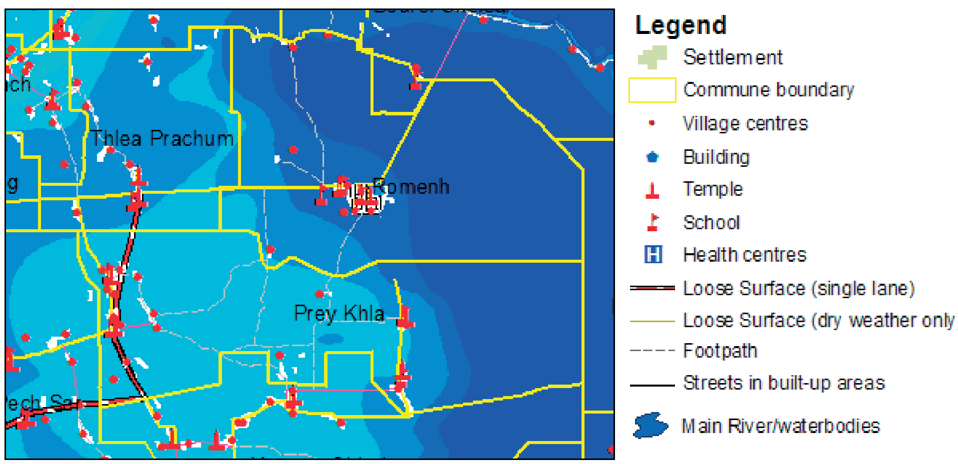


Figure 4 **Simplified view of DEM showing elevation classes at the commune scale. Elevation ranges from about 1.5 m (dark blue) to 5 m (light blue).**



Note: the communes selected are from Kaoh Andaet District (Prey Veng Province).

The communes selected for the illustration appear 'vulnerable', or 'exposed', to floods, particularly Romenh Commune, which is low lying and found close to the main rivers. According to the **Flood Exposure Index**, all the communes score over 100: Thlea Prachum (top left) was classified as 'Low' with a value of 106, Romenh with a value of 113 was 'High' (top right) and Prey Khla (bottom) was 'Medium' with a value of 108.

Average indicator values related to flood exposure are summarized for the four provinces in Table 4.

Table 4 Indicators used for calculating flood exposure index, and average values by province.

Indicators:	Units	Average Indicator Value				
		KDL	TAK	PVG	SVR	Total
Average area Inundated – Low	%	24	17	21	5	18
Average area Inundated – High	%	53	36	56	20	44
Average elevation in commune – DEM	m	7.7	9.7	6.9	4.9	7.4
Mike11 min. flood – area	%	57	37	60	63	54
Mike11 med. flood – area	%	70	60	73	28	61
Mike11 major flood – area	%	73	45	62	33	56
Mikke11 med. flood (Duration) - area	%	52	26	40	18	37
Average No. of ‘Flood-day’ in commune	days	92	42	51	21	57
Average infrastructure inundated	%	22	12	22	9	17
Average elevation: settlement, village and building	m	8.4	9.8	7.5	5.1	7.8
Average No. of ‘Flood-day’ (settlement, village and building)	days	53	13	24	6	28
Road flooded	%	34	29	38	15	31
Flood Exposure Index:		Average Index Value				
	z-score	103.0	97.0	101.6	96.0	100

Province abbreviation in header row: KDL = Kandal, TAK = Takeo, PVG = Prey Veng, SVR = Svay Rieng.

3.2 POVERTY

The five indicators of poverty selected for this project were the basis for the Poverty Index, and are based on those established by SEILA/UNDP. Maps of the *Poverty Index* (Map Series 1) and *Population Density* (Map Series 2) are described in the *Flood Vulnerability Atlas Map Interpretation Guide*. (Hatfield 2007).

Average indicator values related to poverty, summarized for the four provinces, are presented in Table 5. Based on average index values, the results suggest that levels of poverty are similar among the four provinces. However, this is a rather simplified view of the socioeconomic situation, and does not take into consideration the range of poverty found within each province. Among the five indicators of poverty, the “percent of thatched roofs” and “access to clean water“ show the most differences among the four provinces.

Table 5 Indicators used for calculating poverty index, and average values by province.

Indicators:	Units	Average Indicator Value				
		KDL	TAK	PVG	SVR	Total
Percent Households with thatched roof	%	23	27	45	44	33
Percent Households with access to clean water;	%	42	35	77	84	57
Percent of adults illiterate (Adult literacy rate)	%	11	15	16	14	14
Percent of children in school (school attendance rate);	%	10	12	14	15	13
Percent of households headed by a woman (with children ≤ 5-year-old)	%	2.4	3.6	3.5	3.1	3.1
Poverty Index		Average Index Value				
	z-score	99.1	100.6	100.6	99.9	100

Province abbreviation in header row: KDL = Kandal, TAK = Takeo, PVG = Prey Veng, SVR = Svay Rieng

3.3 RICE DEPENDENCY

The indicators used for assessing rice dependency are presented in Table 6 as average values for the four provinces. The *wet-season rice dependency maps* (maps 12, 13 and 15) are found in the *Flood Vulnerability Atlas Map Interpretation Guide* (Hatfield 2007). Overall scores for wet-season rice dependency identify Svay Rieng as the most dependent province. This is revealed particularly by the importance in wet-season rice cultivation area as well as production. By contrast, Kandal Province, which is largely inundated during the monsoon season, has the lowest level of wet-season rice production.

Table 6 Indicators used for calculating rice-dependency index, and average values by province.

Indicators:	Units	Average Indicator Value				
		KDL	TAK	PVG	SVR	Total
Commune area used for rice (wet and dry-season)	%	35	63	60	61	53
Commune area used for wet-season rainfed rice cultivation	%	9	38	38	51	34
Commune area used for wet-season irrigated rice cultivation	%	4	6	3	>1	4
Rice cultivation area used for wet-season rainfed rice crop	%	34	71	63	88	60
Rice cultivation area used for 'wet-season irrigated' rice crop	%	13	9	6	1	8
Total rice production from wet-season rice	%	29	52	55	83	53
Production from wet-season rice	Ton ha^{-1}	1.5	1.3	1.3	0.9	1.2
Production from dry-season rice	Ton ha^{-1}	2.2	2.2	2.1	1.7	2.1
Rice Dependency Index:		Average Index Value				
	z-score	97.3	101.2	100.7	102.2	100

Province abbreviation in header row: KDL = Kandal, TAK = Takeo, PVG = Prey Veng, SVR = Svay Rieng

3.4 ACCESSIBILITY

Seven indicators of vulnerability related with access and transportation were compiled to form the Accessibility Index; as average values for the four provinces are shown in Table 7. The *Access Vulnerability Maps* (Map Series 16) is found in Appendix 3. Accessibility vulnerability scores were consistently found below 100 for all provinces except for Prey Veng. This can be explained by the level of difficulties related to access to road and markets experienced by the population living in Prey Veng. The proportion of road flooded is also an important factor affecting this province.

Table 7 Indicators used for calculating the access-vulnerability index, and average values by province.

Indicators:	Units	Average Indicator Value				
		KDL	TAK	PVG	SVR	Total
Total length of road network	1000 km	1.9	2.4	3.2	2.1	9.7
Percent of road network flooded	%	33	15	39	26	29
Average distance to nearest 'year-round' road	Km	2.2	1.9	7.8	1.8	3.5
Average access time to nearest 'year-round' road	Min.	17	12	31	9	18
Average access time to nearest 'main' market	Min,	32	27	50	36	37
Average distance to nearest (3) health centres (linear)	Km	7.3	7.3	10.1	9.8	8.5
Number of families per boat	n	48	173	117	300	121
Access Vulnerability Index Value		Average Index Value				
	z-score	99.5	98.9	102	99.5	100

Province abbreviation in header row: KDL = Kandal, TAK = Takeo, PVG = Prey Veng, SVR = Svay Rieng

3.5 OVERALL FLOOD VULNERABILITY RANKING

An overall ranking of communes is possible, to generate a list showing the most vulnerable communes. The simplest approach to identify the 'most vulnerable' communes is to rank the communes by score for each vulnerability index. This has been completed in Appendix 2, where all 443 communes are listed and the score and rank provided for each index.

3.6 COMBINATION OF INDICES

Each index provides information on different aspects of vulnerability. The *Flood Exposure GIS* provides flexibility in how information can be combined. For example, the Flood Exposure Index and Rice Dependency Index can be combined to identify communes in terms of food security; these communes could be targeted for 'food security' intervention. A number of combinations of indices were made in order to identify groups of the most vulnerable communes. The procedure to identify the vulnerable groups of communes was completed as follows:

- **Group 1**: score greater than 100 for **all four indices (**which corresponds to a vulnerability level of 1 or higher). A total of 17 communes are found within this group.

- **Group 2**: score greater than 100 for the Flood, Rice and Poverty Indices, but **not Access Index.** A total of 28 communes are found within this group.

- **Group 3:** score greater than 100 for the Flood and Rice indices, but **not Access and Poverty Indices**. A total of 17 communes are found within this group; and

- **Group 4**: scores greater than 100 for the Flood, Access, and Poverty Indices, but not Rice Index. A total of 67 communes are found within this group.

There are only 17 communes in Group 1, which are arguably the most vulnerable communes, representing only 4% of all communes. Prey Veng Province has the largest share of most vulnerable communes, followed by Svay Rieng. When the combination of indices is altered, as in the different groups of indices in Table 8, the number of communes selected as most vulnerable changes; however, regardless of the number or combination of indices used to select communes, Prey Veng is clearly identified as having the most vulnerable communes.

Table 8 Number of communes selected by Province based on vulnerability level for different combinations of indices.

Group	No. of Communes					% of communes in study area
	Kandal (147)	Takeo (100)	Prey Veng (116)	Svay Rieng (80)	Total (443)	
1	1	1	11	4	17	4
2	3	4	12	9	28	6
3	8	15	23	11	57	13
4	20	12	29	6	67	15
Communes found in any of the above groups	27	27	41	13	108	24
% of communes in province	18	27	35	16	24	n/a

Note: Total number of communes for each province shown inside brackets.

4.0 DISCUSSION

The concept of vulnerability has both a geophysical and a socioeconomic dimension. Living close to the water can be both a benefit and a threat, while the ability to cope with the flood is linked with complex socioeconomic factors. In the context of this project, poverty is narrowly defined around a very small number of indicators which act as proxy for the broader concepts of poverty elaborated by international aid organizations. Human poverty is defined in terms of denial of choices and opportunities for living a tolerable life (UNDP 1997) including education and health as well as vulnerability and exposure to risk (World Bank 2001).

Defining flood vulnerability or poverty levels presents considerable challenges. For example, communes that appear extensively flooded in RADARSAT-1 satellite observations do not necessarily experience severe problems with living conditions. Over the years, local populations have adapted to the recurring seasonal floods by adopting flood prevention strategies, and flood proofing through erecting houses on stilts and establishing their land holding on higher grounds where possible. Rice cultivation strategies have also been adapted to avoid, and often take advantage of, the floods. Considering that a significant proportion of the Cambodian population (36%) still lives below the poverty line (US $0.46-0.63 per day in 2002)[4], accurate economic indicators can be difficult to obtain, or hard to assess.

Despite the challenges, this report demonstrates that available data can be integrated and analysed to provide various indices of flood vulnerability. The indices were developed using standard GIS analytical tools, and made use of readily available data. Many of the datasets are collected on a regular basis by the Seila Programme. The Seila Commune Database (CDB) includes a number of standard variables easily updated and kept current[5]. Given the standard nature of the software platform, the GIS product could be easily updated, either with updated information or by extending the current coverage to new areas.

In the absence of field verification measures, it is difficult to validate criteria that could be applied to detect vulnerable communities. Flood vulnerability assessment could greatly benefit from village-level data on crop and infrastructure damage due to floods. Such data were available for a smaller number of commune (116 out of 443), and mainly concentrated in two provinces, Takeo and Svey Rieng.

The Flood Vulnerability GIS, and associated map products are provided in the accompanying CD-ROM with this report.

[4] Council for Social Development (CSD) 2002, *National Poverty Reduction Strategy, 2003 – 2205.*

[5] See Fujii (2003) for a review of the Seila CDB information and poverty index calculations.

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6.0 CLOSURE

We trust the above information meets your requirements. If you have any questions or comments, please contact the undersigned.

HATFIELD CONSULTANTS:

Approved by: February 17, 2007

Andy Dean, Ph.D.
Remote Sensing and GIS Specialist

Date

Approved by: February 17, 2007

Thomas G. Boivin, M.Sc., R.P.Bio.
President

Date

APPENDICES

Appendix 1

Metadata — Vulnerability GIS

A1.0 METADATA — VULNERABILITY GIS

A1.1 BASE DATA

All data compiled on the CD-ROM have the following standard information:

- Projection: UTM 48N
- Datum: Indian 1960.
- Vector Format: ESRI shapefile
- Raster Format: Erdas Imagine

A1.1.1 MRC/FMMC Data

Refer to MRC for the details regarding MRC datasets:

Information and Knowledge Management Programme
P.O. Box 6101,
Unit 18 Ban Sithane Neua, Sikhottabong District,
Vientiane 01000, Lao PDR.
Tel: (856) 21 263 263
Fax: (856) 21 263 264
For general queries: mrcs@mrcmekong.org

A concise summary of the metadata for the MRC base data is provided in Table A1.1.

A1.1.2 MPWT Data

Refer to MPWT for the details regarding MWPT datasets:

Ministry of Public Works and Transportation
P.O. Box 2599,
No. 106 Norodom Blvd,
12202 Phnom Penh, Cambodia
Tel: +(855) 23 427 845
Fax: +(855) 23 214 907
E-Mail: mpwt@online.com.kh
Website: www.mpwt.gov.kh

A concise summary of the metadata for the MPWT base data is provided in Table A1.2.

Table A1.1 Metadata for MRC base data.

Data Layer	Format	Scale	Update	Important fields – alias	Filename	File Location
Country	Shapefile	1:50,000		COUNTRY: Country ID	b-counbnd.shp	\GIS\adpc\Admin\
Main Cities	Shapefile			NAME: Name of cities;	Cities_Cambodia.shp (source: b-citypt)	\GIS\adpc\admin\
RADARSAT-1*	Shapefile	1:50,000	1999 to 2002	in092499: 24-Sep-1999: in102599: 25-Oct-1999; in080900: Aug/Sep-2000; in091000: Sep/Oct-2000; in101000: 19/29-Oct-2000; in101701: 17-Oct-2001; in071002: 10-Jul-2002; in081502: 15-Aug-2002; in092002: 20-Sep-2002; in122502: 25-Dec-2002;	in092499_Intersect.shp; in102599_Intersect.shp; in080900_Intersect.shp; in091000_Intersect.shp; in101000_Intersect.shp; in101701_Intersect.shp; in071002_Intersect.shp; in081502_Intersect.shp; in092002_Intersect.shp in122502_Intersect.shp	\GIS\adpc\Inundation\ Radarsat
Mike11 minor	Shapefile	n/a		MINOR: (2) Year; Area_mn1 – Area flooded (ha): Area (ha)	Khum-mn1.shp	\GIS\adpc\Inundation\ MinFloods
Mike11 medium	Shapefile	n/a		MEDIUM: (5) Year; Area_md1 – Area flooded (ha): Area (ha)	Khum-md1.shp	\GIS\adpc\Inundation\ MedFloods
Mike11 major	Shapefile	n/a		MAJOR: (20) Year; Area_mj1 – Area flooded (ha): Area (ha)	Khum-mj1.shp	\GIS\adpc\Inundation\ MajFloods
Flood prone area DEM	Imagine ESRI GRID	1:50,000		Value: elevation above sea level	clip_fld-dem1	\GIS\adpc\Inundation\ FloodDEM\
Hillshade	ESRI GRID			Value: elevation (m)	camb-hil50	\GIS\adpc\Topog\
Rivers	Shapefile	1:50,000		WTR_TYPE: Water type RIV_CODE: River ID (MRC metadata); RIV_NAME: River name	b-rivmain50.shp	\GIS\adpc\Water\
Streams	Shapefile	1:50,000		CODE_50: Rivers classification based on 50th maps (2) perennial; (3) ephemeral; (4) left shore; (5) right shore; (6) channels. (see MRC for more info. b-riv50)	b-riv50_clipped.shp	\GIS\adpc\Water\
Irrigation-length	Shapefile			SHP_LENGTH: canal (arc) length (m)	irrigLgthCanal.shp	\GIS\adpc\c_irrig
Irrigation-area	Shapefile			SHP_AREAHA: canal area (ha)	irrigAreaComm_clip.shp	\GIS\adpc\c_irrig

* File nomenclature for RADARSAT shapefiles: “in101000_Intersect”, where the first part identified the date (s) of acquisition 19/29-Oct-2000 and the last part indicates the type of spatial analysis performed as part of this project.

Table A1.2 Metadata for MPWT base data.

Data Layer	Format	Scale	Update	Important fields	Filename	File Location
Province	Shapefile	1:50,000		Prov_Name: Province name; CODEKHET: Province ID; Prov_area: Province area (ha)	Prov_mpwt99.shp	\GIS\ADPC\Admin\
District	Shapefile	1:50,000		Distr_Name: District name; CODESROK: District ID; Distr_area: District area (ha)	Districts_mpwt99.shp Districts_4prov.shp	\GIS\ADPC\Admin\
Commune	Shapefile	1:50,000		KHUM: Commune name; CODEKHUM: Commune ID; Comm_area: Commune area (ha)	CommunesAllCambodia.shp Communes_4prov.shp	\GIS\ADPC\Admin\
Settlement	Shapefile	1:50,000		Area_cc: Settlement area (ha)	Comm_Settlm.shp	\GIS\adpc\Admin\
Village centre	Shapefile (points)	1:50,000		VNAMEENG: Village name; CommCode: Commune ID; VillCode: Village ID	Village_center4prov.shp	\GIS\adpc\Admin\
Main Buildings	Shapefile	1:50,000		CODE: Building road code No. (Table A1.3); BldgCatg: temple, school, health centres, etc.	Buildg_inCommNew.shp	\GIS\adpc\Admin\
Roads	Shapefile	1:50,000	2003-2005	CODE: Road code No. (Table A1.4); LENGTH: length of road segment/arc (m)	Road_CommIntersect.shp	\GIS\adpc\Admin\
Land use	Shapefile	1:50,000	2003-2005	LU_CODE: Land use code No. (Table A1.5); TOPO_CODE: Topographic Map Landuse Code Number (Table A1.6); Area_LU: Landuse area (ha); LU_Name: Landuse type (name); LU_Catg: Landuse category	Landuse_within.shp	\GIS\adpc\ LanduseMWPT\
Land use / Flood	Shapefile	1:50,000		Same as above, and; LUfld_ha: Landuse area flooded (ha); LUfld_Perc: Landuse area flooded (%)	Landuse_within_Dissolve.shp	\GIS\adpc\ LanduseMWPT\
Topo sheets	ESRI GRID	1:100,000		n/a	5930; 5931; 5932; 6030; 6031; 6032; 6130; 6131; 6132; 62306231	\GIS\adpc\MPWT\ map100_1\
Toposheet index	Feature Class: polygon	1:50,000		SHEET_NUMBER; TILE-NAME; SHEET_NAME	n/a	\GIS\adpc\MPWT\index
Irrigation-area	Shapefile			SHP_AREAHA: canal area (ha)	irrigAreaComm_clip.shp	\GIS\adpc\c_irrig

Table A1.3 Infrastructure point features code.

Code	Description
21	Buildings
26	Khet Office and Krong Office
27	Srok Office and Khan Office
29	Temple
30	School
31	Church
32	Mosque
33	Stupa
34	Post Office
35	Hospital
37	Historical Site
40	Mine
41	Port

Source: MPWT 5. Update Layer: pop_pts (updated 2005).

Table A1.4 Code for roads and road related line data.

Code	Description
1	All weather, hard surface road, two or more lanes wide
2	All weather, hard surface road, one lane wide
3	All weather, loose surface, two or more lanes wide
4	All weather, loose surface, one lane wide
5	Dry weather, loose surface
6	Cart track
7	Footpath
8	Streets in built-up areas
60	Ferry
61	Ford

Source: MPWT 3. Update Layer: rd_lin (updated 2005).

Table A1.5 Land Use Code, Category and Name.

LU_ CODE	Classification	Category	Name
1	U	Urban, Built-up Areas	Settlement
2	I	Urban, Built-up Areas	Infrastructure (Airfield, factory, etc.)
3	Ar	Agricultural lands	Paddy field
4	Al	Agricultural lands	Receding and Floating rice fields
5	Au	Agricultural lands	Field crop
6	As	Agricultural lands	Swidden agriculture (Slash and burn)
7	Ao	Agricultural lands	Orchard
8	Ap	Agricultural lands	Plantation (Rubber plantation)
9	Av	Agricultural lands	Village garden crop
10	Ag	Agricultural lands	Garden crop
11	Arv	Agricultural lands	Paddy field with villages
12	G	Grasslands	Grassland (undifferentiated)
13	Ga	Grasslands	Abandoned field covered by grass
14	Gf	Grasslands	Flooded grassland
15	Gs	Grasslands	Grass Savannah
16	Gm	Grasslands	Grass with termite mounds
17	Ms	Grasslands	Marsh and swamp
18	S	Shrublands	Shrubland (undifferentiated)
19	Sa	Shrublands	Abandoned field covered by shrub
20	Sf	Shrublands	Flooded shrub
21	St	Shrublands	Woodland and scattered trees (C < 10%)
22	Fe	Forest covers	Evergreen broad leafed forest
23	Fc	Forest covers	Coniferous forest
24	Fd	Forest covers	Deciduous forest
25	Fdo	Forest covers	Dry Deciduous (Open) forest
26	Fx	Forest covers	Mixed forest from evergreen and deciduous species
27	Fr	Forest covers	Riparian forest
28	Fs	Forest covers	Bamboo and Secondary forests
29	Ff	Forest covers	Flooded forest
30	Fm	Forest covers	Mangrove forest
31	Fmd	Forest covers	Degraded mangrove forest
32	Fp	Forest covers	Forest plantation
33	Wl	Water Features	Lakes (>8 ha)
34	Wp	Water Features	Lakes (<8 ha)
35	Wr	Water Features	Reservoir
36	Ws	Water Features	Shrimp/Fish farming and Salt pan
37	Wo	Water Features	Others (Sea, Bay, etc.)
38	B	Soils and Rocks	Barren land
39	Bs	Soils and Rocks	Sand bank
40	Br	Soils and Rocks	Rock outcrop

Source: MPWT (1999).

Table A1.6 Topo-code data for land use grouped and dissolved data.

Code	Description
53	Lake or Pond
55	Salt Evaporator
51	Open Water (oceans, large lakes and rivers)
91	Rock Outcrops
96	Sand Terrain
98	Barren Land
151	Dense Forest or Jungle
152	Clear Forest
153	Shrubland
155	Plantation
156	Flooded Grassland
157	Flooded Shrub
158	Flooded Forest
159	Marsh or Swamp
160	Rice Field
161	Mangrove
162	Field Crops
163	Swidden Agriculture
164	Grassland
165	Orchards
166	Village Garden Crops
167	Receding Rice Fields and Floating Rice Fields
169	Urban, and Built-up Areas

Source: MPWT Library layer: topo_landuse (1999).

A1.1.3 SEILA/UNDP Data

Detailed information regarding the Seila Programme is available online:

http://www.seila.gov.kh/indexs.asp?language=kh&pgid=1

The Commune Database (CDB) contains basic socioeconomic data collected at village level. The database provides baseline information. The database is managed by the Provincial Departments of Planning Statistics (PDPS) under the technical supervision of the Ministry of Planning (MoP).

The internet web address to access the database is:

http://203.189.130.76:8080/database/index_en.asp?language=en&pgid=13&title=0

A1.1.4 WFP/VAM Data

The flood and drought-prone priority areas identified by WFP are presented in the "Mapping Vulnerability to Natural Disasters in Cambodia" (WFP 2003).

Also available on the WFP website are flood and poverty related information including a large number of thematic maps:

http://www.methodfinder.com/wfpatlas/index.php?page=07&lang=e&PHPSESSID=a3aa2ef2362e4195a2e323b2a964595d

Table A1.7 Metadata for World Food Program VAM-based drought and flood prone priority areas.

Source shapefile name: WFPindex_flooddrought.shp.

Data Layer	Format	Scale	Update	Important fields / Attributes	File Location
Drought and Flood-prone Priority areas	Shapefile	n/a		drought_in: Drought index level* flood_inde: Flood index level* URBRUR: Urban/Rural†	\GISADPC\vIndicators\

* Index: (0) no priority; (1) high (2) medium, (3) low

† (1) Urban, (2) Rural

A1.1.5 Additional Data

A number of additional datasets are included in the GIS to provide context and other information that may be important with regard to interventions.

A1.1.5.1 Village/NGO intervention

Location:	NGOs Village Interventions\NGO group A, B & C
Shapefile Name:	VillageNGO_Intervention.shp
Projection:	UTM, Meters, Zone 48, Datum: Indian 1960
Feature Type:	Point
Description:	Location (village) of NGO's intervention. Additional information includes demographic data (number of families and population), elevation (DEM) value and occurrence of inundation.

Table A1.8 Metadata for Village / NGO Intervention data.

Data Layer	Format	Scale	Update	Important fields / Attributes	File Location
NGO Intervention	Shapefile	n/a		VNAMEENG: Village name CommCode: Commune ID VillCode: Village ID FAMILY: Family Population: Population flDEM: DEM Elevation (m) CRC1: Cambodian Red Cross (EWS) CRC2: Cambodian Red Cross (CBDP) CARE1: CARE (DPAP) CARE2: CARE (DPM-LAF) PADEK VISION: World Vision International CWS: Church World Service CCK: Chamroen Chiet Khmer OccPerc: Percent occurrence of inundation (see Table A1.9)	\GIS\adpc\NGOs

Field calculation	Equation
OccPerc:	([in0924]+[in1025]+[in0809]+[in0910]+[in1010]+[in1017]+[in0710]+[in0815]+[in0920]+[in1225]+[mk11mn]+[mk11md]+[mk11mj])/13

* Fields displayed in Atlas are denoted with a check mark (✓).

A1.1.5.2 Village Center and Building Flood Data – RADARSAT-1 (10 dates), MIKE11 (3 events) and RADARSAT imagery (3 dates)

Location:	Flood Mapping\RADARSAT-1\ Flood Mapping\MIKE11 Model\ Elevation\Flood-prone Area DEM\Flood-prone Area DEM\
Shapefile Name:	VillageCenter_floodrawdata.shp and Building_floodrawdata.shp
Projection:	UTM, Meters, Zone 48, Datum: Indian 1960
Feature Type:	Point
Description:	Village and building location and associated flood statistics: occurrence of inundation and elevation (DEM) value. Additional information: RADARSAT-1 image at three different stages of the flood (early: Sep, peak: Oct and post peak Oct. 2000) darker tones indicate flooded areas.

Table A1.9 Village Centre and Main Building fields.

Field Name	*Alias Name – Descriptors*	Atlas*
VNAMEENG	Village Name English	✓
VillCode	Village Code	✓
CommCode	Commune Code	✓
CODE	Building Code (MPWT)	✓
Area_check	Commune area (ha)	✓
flDEM	DEM elevation (m)	✓
OccPerc:	Occurrence (%)	✓
in0924	Flooded in Sep 24/99	✓
in1025	Flooded in Oct 25/99	✓
in0809	Flooded in late Aug-Sep/00	✓
in0910	Flooded in late Sep-Oct/00	✓
in1010	Flooded in Oct 19-29/00	✓
in1017	Flooded in Oct 17/01	✓
in0710	Flooded in July 10/02	✓
in0815	Flooded in Aug 15/02	✓
in0920	Flooded in Sep 20/02	✓
in1225	Flooded in Dec 25/02	✓
mk11mn	Flooded in mk11 minor event	✓
mk11md	Flooded in mk11 med event	✓
mk11mj	Flooded in mk11 major event	✓
mk11durmd	Flooded in mk11 ex-dur med	✓
rsat_ea	RADARSAT-1 early flood 25-Aug and 4-Sep, 2000 – 8bt image	✓
rsat_pe	RADARSAT-1 peak flood 23-Sep and 5-Oct, 2000 – 8bt image	✓
rsat_po	RADARSAT-1 post flood 19/22-Oct, 2000 – 8bt image	✓
Field Calculation	**Equation**	
OccPerc:	([in0924]+[in1025]+[in0809]+[in0910]+[in1010]+[in1017]+[in0710]+[in0815]+[in0920] +[in1225]+[mk11mn]+[mk11md]+[mk11mj])/13	

* Fields displayed in Atlas are denoted with a check mark (✓).

A1.1.5.3 Commune-base Inundation – flood extent area (10 dates) road flooded (3 dates) and other data

Location: Flood Mapping\Communes_FloodDATA\
Shapefile Name: «Communes_shp »
Projection: UTM, Meters, Zone 48, Datum: Indian 1960
Feature Type: Polygon
Description: Commune-level data, area flooded for 10 dates. Also included, area irrigated, length of irrigation canal, length of road network. Length of flood flooded for 3 dates in 2000 and total length of road flooded in 2000.

Table A1.10 Commune attribute fields related to inundation.

Field Name	*Alias Name – Descriptors*	Atlas*
CODEKHUM	CODEKHUM (Commune Code)	✓
AreaTot_ha	Commune area (ha)	✓
101000_AR	Area flooded - Oct 19-29/00	✓
092499_AR	Area flooded - Sep 24/99	✓
102599_AR	Area flooded - Oct 25/99	✓
080900_AR	Area flooded - late Aug-Sep/00	✓
091000_AR	Area flooded - late Sep-Oct/00	✓
101701_AR	Area flooded - Oct 17/01	✓
071002_AR	Area flooded - July 10/02	✓
081502_AR	Area flooded - Aug 15/02	✓
092002_AR	Area flooded - Sep 20/02	✓
122502_AR	Area flooded - Dec 25/02	✓
areaIr_AR	Area irrigated (m^2)	✓
cnlgth	Canal length (m)	✓
rdlnTot	Road network length (m)	✓
HCntavgDis	Health Centres avg dist (m)	✓
rdfld0809	Road flooded - late Aug-Sep/00	✓
rdfld0910	Road flooded - late Sep-Oct/00	✓
rdfld1010	Road flooded - Oct 19-29/00	✓
rdfld2000	Road flooded - Aug-Oct/00	✓

* Fields displayed in Atlas are denoted with a check mark (✓).

A1.1.5.4 RADARSAT, MIKE11 Flood Extent and other GIS data included in the *Flood Vulnerability GIS*.

File location	File name
ADMIN	
admin\	Comm_Settlm.shp
admin\	Road_CommIntersect.shp
Inundation\	Hydrost.shp
RADARSAT	
inundation\radarsat\	in081000_Union.shp
inundation\radarsat\	rsat_peak_statsbyCommune.shp
FLOOD DEM	
inundation\floodDEM\	BuildgbyCommDEM_stats.shp
inundation\floodDEM\	VillCenterbyCommDEM_stats.shp
inundation\floodDEM\	SettlembyCommDEM_stats.shp
inundation\floodDEM\	CommunDEM_stats.shp
MIKE11	
inundation\medfloods\	Commun_ExtDur_stat.shp
Inundation\MedFloods\	clip_b-du-md1
inundation\majfloods\	b-ex-mj.shp
inundation\	Communes_mk11.shp

A1.2 VULNERABILITY INDICATORS AND INDICES

All data containing the values for the indicators was generated with reference to communes (see metadata above). Each section below refers to a new file name, and provides a list of the new fields and their description.

A1.2.1 Poverty

Location:	Vulnerability Indices\Poverty\Poverty Index (level)\ Vulnerability Indices\Poverty\Poverty Index (score)\ Vulnerability Indicators\Poverty Index\
Shapefile Name:	socio_econoPovDensity.shp
Projection:	UTM, Meters, Zone 48, Datum: Indian 1960
Feature Type:	Polygon
Description:	Commune-level poverty index and population density, and related poverty indicators and other variables used in calculations of index.

Table A1.11 Poverty fields and calculations.

Field Name	Description	Atlas*
CODEKHUM	CODEKHUM – Commune Code	✓
Province	Province	✓
District_	District	✓
Commune_	Commune	✓
Area_ha	Area total (ha) – (other name: *Area_check*)	✓
SettlArea	Settlement area (ha)	✓
Density	Population density	✓
Fam	Family total	✓
Person	Population	✓
Female	Female total	✓
Male	Male total	✓
JuvenTot	Youth total	✓
Over65	Elderly (>65) total	✓
PovIndex	**Value for Poverty Index**	✓
Houses	Houses total	✓
P1_water	Houses with water (%)	✓
P2_roof	Houses with thatch roof (%)	✓
P3_school	Children (6-14) not in school (%)	✓
P4_literacy	Adults illiterate (%)	✓
FemHHh_UD5	Female headed households total	✓
P5_fmhhh	Female headed households (%)	✓
z1	Normalized poverty indicator (PI) 1: % Households with water – Normalized [P1_water]	
z2	Normalized PI 2: % Thatch roof houses standardized – Normalized [P2_roof]	
z3	Normalized PI 3: % Children not in school standardized – Normalized [P3_school]	
z4	Normalized PI 4: % Adults illiterate standardized – Normalized [P4_literacy]	
z5	Normalized PI 5: % Female headed households standardized – Normalized [P5_fmhhh]	
Indicators (calculation)	**Equation**	
z1	([P1avg]-[p1_water])/[p1std]	
z2	([P2_roof]-[p2avg])/[p2std]	
z3	([P3_school]-[p3avg])/[p3std]	
z4	([P4_literacy]-[p4avg])/[p4std]	
z5	([P5_fmhhh]-[p5avg])/[p5std]	
Index	**Equation**	
PovIndex	100+([z1]+[z2]+[z3]+[z4]+[z5])	

* Fields displayed in Atlas are denoted with a check mark (✓).

A1.2.2 Flood Exposure

Location:	Vulnerability Indices\Flood\Flood Index (level)\ Vulnerability Indices\Flood\Flood Index (score)\ Vulnerability Indicators\Flood Exposure\
Shapefile Name:	VulnIndicators_Floods.shp
Projection:	UTM, Meters, Zone 48, Datum: Indian 1960
Feature Type:	Polygon
Description:	Commune-level vulnerability indices and related indicator variables.

Table A1.12 Flood Exposure fields and calculations.

Field Name	*Alias Name – Descriptors*	Atlas*
CODEKHUM	CODEKHUM – Commune Code	✓
Area total (ha)	Area total (ha) – (other name: *Area_check*)	✓
Province	Province	✓
District	District	✓
Commune	Commune	✓
Vind_Allz	Flood-Vulnerability Index (Combined Vind_RsDEM & Vind_mk11)	✓
Vind_RsDEM	Vuln Index (R'Sat & DEM) – (other name: *VindexA1*)	✓
avgInundL1	Area inundated low-flood (%)	✓
avgInundH1	Area inundated high-flood (%)	✓
DEMavg	DEM mean elevation (m)	✓
Vind_mk11	Vuln Index (Mike11)	✓
Mean_dyA3	Day inundated avg. per commune	✓
perc_fldA3	Area inundated dur-med (%) – (other name: *percInundA3*)	✓
perc_exmn	Area inundated ex-min (%)	✓
perc_exmd	Area inundated ex-med (%)	✓
perc_exmj	Area inundated ex-maj (%)	✓
Vind_Spot	Vuln Index (village, building, road) – (other name: *VindexA4*)	✓
ocfld_perc	Inundation occurrence (%) - total sampled days all locations (other name: *occVilBldavg*)	✓
DEMavg_loc	DEM mean elevation - all locations (m) – (other name: *DemVilBldavg*)	✓
Dayavg_loc	Day inundated avg. all locations – (other name: *DurVilBldavg*)	✓
rdfld_perc	Road inundated avg. (km)	✓
zA1a	[avgInundL1] Normalized – Area inundated low-flood (%)	
zA1b	[avgInundH1] Normalized – Area inundated high-flood (%)	
zDEM	[DEMavg] Normalized – DEM mean elevation (m)	
zA3a	[Mean_dyA3] Normalized – Day inundated avg. per commune	
zA3b	[perc_fldA3] Normalized – Area inundated dur-med (%)	
zA3Mn	[perc_exmn] Normalized – Area inundated ex-min (%)	
zA3Md	[perc_exmd] Normalized – Area inundated ex-med (%)	
zA3Mj	[perc_exmj] Normalized – Area inundated ex-major (%)	
zA4occ	[ocfld_perc] Normalized – Occurrence of inundation (%)	
zA4Dem	[DEMavg_loc] Normalized – DEM mean elevation, all locations (m)	
zA4Dur	[Dayavg_loc] Normalized – Day inundated avg. all locations	
zA4rdfld	[rdfld_perc] Normalized – Road inundated avg. (km)	
Vind_All	**Value for Flood-Vulnerability Index**	
Indicators (calculation)	**Equation**	
Vind_All	[Vind_z*** All]	
Vind_Allz	100+([zA1a]+[zA1b]+[zDem]+[zA3a]+[zA3b]+[zA3Mn]+[zA3Md]+[zA3Mj])	
Vind_RsDEM	100+([zA1a]+[zA1b]+[zDEM])	
Vind_mk11	100+([zA3a]+[zA3b]+[zA3Mn]+[zA3Md]+[zA3Mj])	
Vind_Spot	If ([zA4Dem] is null: 100+([zA4occ]+[zA4Dur]+[zA4rdfld]), If not null: 100+([zA4occ]+[zA4Dem]+[zA4Dur]+[zA4rdfld]))	
ocfld_perc	([in0924]+[in1025]+[in0809]+[in0910]+[in1010]+[in1017]+[in0710]+[in0815]+[in0920]+[in1225]+[mk11mn]+[mk11md]+[mk11mj])/13	

* Fields displayed in Atlas are denoted with a check mark (✓).

A1.2.3 Rice Dependency

File Location:	Vulnerability Indices\Rice\Rice Index (level)\ Vulnerability Indices\Rice\Rice Index (score)\ Vulnerability Indicators\Wet Season Rice \ Vulnerability Indicators\Wet Paddy Area
Shapefile Name:	VulnIndicators_Rice.shp
Projection:	UTM, Meters, Zone 48, Datum: Indian 1960
Feature Type:	Polygon
Description:	Commune-level rice 'dependency' index, related wet-season rice indicators and other variables used in calculations of indices.

Table A1.13 Wet-Season Rice Dependency fields and calculations.

Field Name	*Alias Name – Descriptors*	Atlas*
CODEKHUM	CODEKHUM – Commune Code	✓
Province	Province	✓
District_	District	✓
Commune_	Commune	✓
Area_ha	Area total (ha) – (other name: *Area_check*)	✓
Vind_Rice:	**Rice Vulnerability Index**	✓
Perc_Area:	Prop total area used for rice – (other name: *RicePercTotArea*)	✓
PercPrdWet:	Prop rice prod from wet rice – (*PercWetProd*)	✓
PercWRiceA:	Prop cult rice area as wet-Rainfed – (*WetRainPerc*)	✓
PercIRiceA:	Prop cult rice area as wet-Irrigated – (*WetIrriPerc*)	✓
PropWRiceA:	Prop total area as wet-Rainfed – (*PropAreaWetRain*)	✓
PropIRiceA:	Prop total area as wet-Irrigated – (*PropAreaWetIrri*)	✓
ProdWperHa:	Wet season rice prod (MT/ha) – (*WetProdperHa*)	✓
ProdDperHa:	Dry season rice prod (MT/ha) – (*DryProdperHa*)	✓
WetRain_ha:	Wet rainfed rice area (ha) – (*WET_RAINFED*)	✓
WetIrrg_ha:	Wet irrigated rice area (ha) – (*WET_IRRI*)	✓
DryIrrg_ha:	Dry full irrigated rice area (ha) – (*DRY_IRRI_FULL*)	✓
DryRece_ha:	Dry recession rice area (ha) – (*DRY_RECESS*)	✓
WetRice_MT:	Wet season rice harvest (MT) – (*WET_PADDY*)	✓
DryRice_MT:	Dry season rice harvest (MT) – (*DRY_PADDY*)	✓
zRice1	Prop total area used for rice – Normalized [zRice1]	
zRice2	Prop rice prod from wet rice – Normalized [zRice2]	
zRice3	Prop cult rice area as wet-Rainfed – Normalized [zRice3]	
zRice4	Prop cult rice area as wet-Irrig – Normalized [zRice4]	
zRice5	Prop total area as wet-Rainfed – Normalized [zRice5]	
zRice6	Prop total area as wet-Irrig – Normalized [zRice6]	
zRice7	Wet season rice prod [MT/ha] – Normalized [zRice7]	
zRice8	Dry season rice prod [MT/ha] – Normalized [zRice8]	
zRiceA:	zRiceA	
zRiceB	zRiceB	
PaddyTotHa:	Paddy Field total area (ha)	✓
PadFldPerc:	Paddy field area flooded (%)	✓
PadVilTHa:	Paddy field & village area (ha)	✓
PadVFldPer:	Paddy field/Village area flooded (%)	✓
RecesTotHa:	Recession ricefield area (ha)	✓
RecFldPerc:	Recession ricefield area flooded (%)	✓

* Fields displayed in Atlas are denoted with a check mark (✓).

Table A1.13 (Cont'd.)

Field Name	*Alias Name – Descriptors*	Atlas*
Indicators (calculation)	**Equation**	
Vind_Rice:	IIf([zRiceB] Is Null, 100+[zRiceA], 100+([zRiceA]+[zRiceB]))	
zRiceA:	([zRice1]+[zRice2]+[zRice3]+[zRice4]+[zRice5]+[zRice6])	
zRiceB	IIf([zRice7] Is Not Null,IIf([zRice8] Is Not Null,[zRice7]+[zRice8],[zRice7]),IIf([zRice8] Is Not Null,[zRice8]))	
PaddyTotHa:	Paddy Field total area (ha) – Lu_ha (code =3)	
PadFldPerc:	Paddy field area flooded (%) – LuFld_ha/Lu_ha (code =3)	
PadVilTHa:	Paddy field & village area (ha) – Lu_ha (code =4)	
PadVFldPer:	Paddy field/Village area flooded (%) – LuFld_ha/Lu_ha (code =4)	
RecesTotHa:	Recession ricefield area (ha) – Lu_ha (code =11)	
RecFldPerc:	Recession ricefield area flooded (%) – LuFld_ha/Lu_ha (code =11)	

* Fields displayed in Atlas are denoted with a check mark (✓).

A1.2.4 Access Vulnerability Index

File Location:	Vulnerability Indices\Access\ Accessibility Index (level)\ Vulnerability Indices\Access\ Accessibility Index (score)\ Filename: VulnIndicators_Access.shp
Projection:	UTM, Meters, Zone 48, Datum: Indian 1960
Feature Type:	Polygon
Description:	Commune-level rice 'Access/Transportation' vulnerability index and related indicators and other variables used in calculations of indices.

Table A1.14 Access Vulnerability fields and calculations.

Field Name	*Alias Name – Descriptors*	Atlas*
CODEKHUM	CODEKHUM – Commune Code	✓
Area_check	Commune area (ha)	✓
SettleArea	Settlement area (ha)	✓
Fam	Family total	✓
Person	Population total	✓
r_BOAT	Row boat total	✓
m_BOAT	Motorboat total	✓
Boat_All	Boat all total	✓
Fam_Boat	No of Families per boat	✓
MarketHrs	Hours to market avg. – (*Market_avghrs*)	✓
RoadHours	Hours to road avg. – (*Road_avghrs*)	✓
Road_avgkm	km to road avg.	✓
Roadtotkm	Road total km	✓
Rdfldkmtot	Road flooded total km	✓
RdFldPerc	Road flooded (%)	✓
VindTransp	**Access Vulnerability. Index**	✓
zFamBoat	zFamBoat	
zMarketHrs	zMarketHrs	
zRoadHrs	zRoadHrs	
zRoadkm	zRoadkm	
zRoadFld	zRoadFld	
zRoadTotKm	zRoadTotKm	
zBoatsTot	zBoatsTot	
zHCenter	zHCenter – Avg. distance to nearest 3 health centers	
HCavgDist	Average dist. to Health Center (m)	
zFBoatLog	zFBoatLog	
RdFldPerc	Road flooded (%) – [Rdfldkmtot]/[Roadtotkm]	
zFBoatLog	Log10([zFamBoat])	
Indicators (calculation)	**Equation**	
VindTransp	100+([zFBoatLog]+[zMarketHrs]+[zRoadHrs]+[zRoadkm]+[zRoadFld]+[zRoadTotKm]+[zHCenter])	
zFamBoat	([Fam_Boat]-[FamBoat_avg])/[FamBoat_std]	
zMarketHrs	([Market_avghrs]-[MarketHrs_avg])/[MarketHrs_std]	
zRoadHrs	([Road_avghrs]-[RoadHrs_avg])/[RoadHrs_std]	
zRoadkm	([Road_avgkm]-[Roadkm_avg])/[Roadkm_std]	
zRoadFld	([RdFldPerc]-[RdFldPerc_avg])/[RdFldPerc_std]	
zRoadTotKm	([RoadTotKm_avg]-[Roadtotkm])/[RoadTotKm_std]	
zBoatsTot	([BoatsTot_avg]-[Boat_All])/[BoatsTot_Std]	
zHCenter	([HCavgDist]-[HCavgDist_avg)/[HCavgDist_std]	
zFBoatLog	Log10([zFamBoat])	

* Fields displayed in Atlas are denoted with a check mark (✓).

A1.2.5 Flood Disaster Damage (2000)

File Location:	Flood Disaster Data (2000)\District level\Disaster data\ Flood Disaster Data (2000)\District level\ Rice and flood\ Flood Disaster Data (2000)\District level\House and flood\
Shapefile Name:	Disast2000_Districts
Projection:	UTM, Meters, Zone 48, Datum: Indian 1960
Feature Type:	Polygon
Description:	District-level flood damage related data for the 2000 flood year.

Table A1.15 District-level Flood Damage data for 2000.

Field Name	*Alias Name – Descriptors*	Atlas*
CODESROK	CODESROK – District Code	✓
District_name:	District Name – (other name: *District_n; NameE*)	✓
CommAffectTot:	Commune affected total – (*CommAffect; NosKhum*)	✓
VillageTot:	Village total – (*NoVillage*)	✓
VillAffectTot:	Village affected total – (*VillAffect; Village*)	✓
VillAffectPerc:	Village affected (%) – (VillAffec_1)	✓
FamilyTot:	Family total	✓
FamAffectTot:	Family affected total (*Family*)	✓
FamAffectPerc:	Family affected (%)	✓
Injured_SickTot:	Injured & Sick total – (*Injured_Si; Injured_Sick*)	✓
DeathTot:	Death total – (*DeathTot; Death*)	✓
Fam_evacTot:	Family evacuated total – (*Fam_evacTo; Fam_evac*)	✓
FamEvacPerc:	Family evacuated (%) – (FamEvacPer)	✓
Pop_evacTot:	Population evacuated total – (*Pop_evacTo; Pop_evac*)	✓
WetRiceTot:	Wet rice area total (ha) – (*WetRiceTot; WetRiceHa*)	✓
Rice_floodedTot:	Rice area flooded (ha) – (*Rice_flood; Rice_flooded*)	✓
RiceFloodedPerc:	Rice area flooded (%) – (RiceFloode)	✓
Rice_destrucTot:	Rice area destroyed (ha) – (*Rice_destr; Rice_destruc*)	✓
RiceDestructPerc:	Rice area destroyed (%) – (RiceDestru)	✓
OtherCrop_floodedTot:	Other crop area flooded (ha) – (*OtherCrop_; othCrop_fld*)	✓
OtherCrop_detroyTot:	Other crop area destroyed (ha) – (*OtherCrop1; othCrop_dst*)	✓
HouseTot:	House total – (*HouseTot; House*)	✓
House_floodedTot:	House flooded total – (*House_floo; House_fld*)	✓
HouseFloodedPerc:	House flooded (%) – (HouseFlood)	✓
HousePartDestr_Tot:	House partially destroyed total – (*HousePartD; House_PD*)	✓
HouseTotDestr_Tot:	House totally destroyed total – (*HouseTotDe; House_TD*)	✓
CowBufflo_Tot:	Cow & Buffalo lost total – (*CowBufflo_; Cow_Buffl*)	✓
Pig_Tot:	Pig lost total – (*Pig*)	✓
WellsContam_Tot:	Wells contaminated total – (*WellsConta; Well_contam*)	✓
Indicators (calculation)	**Equation**	
VillAffectPerc:	[VillAffectTot]/[VillageTot]	
FamAffectPerc:	[FamAffectTot]/[FamilyTot]	
FamEvacPerc:	[Fam_evacTot]/[FamilyTot]	
RiceFloodedPerc:	[Rice_floodedTot]/[WetRiceTot]	
RiceDestructPerc:	[Rice_destrucTot]/[WetRiceTot]	
HouseFloodedPerc:	[House_floodedTot]/[HouseTot]	

* Fields displayed in Atlas are denoted with a check mark (✓).

Location:	Flood Disaster Data (2000)\Commune level\Disaster data\ Flood Disaster Data (2000)\Commune level\ Rice and flood\ Flood Disaster Data (2000)\Commune level\Family and flood\
Shapefile Name:	Disast2000_Comm_TAK_SVR.shp
Projection:	UTM, Meters, Zone 48, Datum: Indian 1960
Feature Type:	Polygon
Description:	Takeo and Svay Rieng Province Commune-level flood damage related data for the 2000 flood year.

Table A1.16 Commune-level Flood Damage data for 2000.

Field Name	*Alias Name – Descriptors*	Atlas*
CODEKHUM	CODEKHUM	✓
Area_ha / Area_check	Area total (ha)	✓
SettlArea	Settlement area (ha)	✓
DistrictName	District Name	✓
CommGis	Commune Code	✓
CommName	Commune Name	✓
VindStrDam	***Vuln Index – Flood damage / People***	✓
VillageTot	Village total	✓
VilAffcTot	Village affected total – (other name: *VillAffectTot*)	✓
VilAffPerc	Village affected (%) – (*VillAffectPerc*)	✓
FamilyTot	FamilyTot	✓
FamAffcPer	Family affected (%) – (*FamilyAffected_Perc*)	✓
FamEvacPer	Family evacuated (%) – (*FamilyEvacuated_Perc*)	✓
HousFldPer	House flooded (%) – (*HouseFlooded_Perc*)	✓
HousDstPer	House destroyed (%) – (*HouseDestroyedAll_Perc*)	✓
VindRicDam	***Vuln Index – Flood damage / Rice***	✓
AreaHa	AreaHa	✓
WetRiceTHa	Wet rice area total (ha) – (*WetRiceTot*)	✓
DryRiceTHa	Dry rice area total (ha) – (*DryRiceTot*)	✓
RiceFldHa	Rice area flooded (ha) – (*Rice_floodedTot*)	✓
RiceFldPer	Rice area flooded (%) – (*RiceFlooded_Perc*)	✓
RiceDestHa	Rice area destroyed (ha) – (*Rice_destrucTot*)	✓
RiceDstPer	Rice area destroyed (%) – (*RiceDestroyed_Perc*)	✓
OCropFldHa	Other crop flooded area (ha) – (*OtherCrop_floodedTot*)	✓
OCropDstHa	Other crop destroyed (ha) – (*OtherCrop_detroyTot*)	✓
CowBuffTot	Cow & Buffalo lost total – (*CowBufflo_Tot*)	✓
Pig_Tot	Pig lost total	✓
WelContTot	Wells contaminated total – (*WellsContam_Tot*)	✓
zC1Vill	zC1Vill	
zC1FamA	zC1FamA	
zC1HouseF	zC1HouseF	
zC1FamE	zC1FamE	
zC1RiceF	zC1RiceF	
zC1RiceD	zC1RiceD	
Indicators (calculation)	**Equation**	
zC1Vill	([VillAffectPerc]-[VillAffectPerc_avg])/[VillAffectPerc_std]	
zC1FamA	([FamilyAffected_Perc]-[FamAffectPerc_avg])/[FamAffectPerc_std]	
zC1HouseF	([houseFlooded_Perc]-[HouseFldPerc_avg])/[HouseFldPerc_std]	
zC1FamE	([FamilyEvacuated_Perc]-[FamEvacPerc_avg])/[FamEvacPerc_std]	
zC1RiceF	([RiceFlooded_Perc]-[RiceFldPerc_avg])/[RiceFldPerc_std]	
zC1RiceD	([RiceDestroyed_Perc]-[RiceDestrPerc_avg])/[RiceDestrPerc_std]	
VindStrDam	100+([zC1Vill]+[zC1FamA]+[zC1FamE]+[zC1HouseF])	
VindRicDam	100+([zC1RiceF]+[zC1RiceD])	

* Fields displayed in Atlas are denoted with a check mark (✓).

Appendix 2

Analysis Conducted to Derive Flood Vulnerability Indicators

A2.0 DERIVATION OF FLOOD VULNERABILITY INDICATORS

A2.1 FLOOD EXPOSURE INDICATORS

Using ArcGIS spatial analysis tools, the degree of exposure to flood was estimated for each commune. There are 12 flood exposure indicators, which are presented in five sections below. The process used to derive flood exposure indicators are summarized in Figure A2.1. The process of derivation of indicators, indices and levels of vulnerability is illustrated in further detail in Figure A2.2.

A2.1.1 Percent of Commune Flooded

RADARSAT-derived flood extent and Mike11 flood extent for minor, medium and major flood events were used to derive these indicators. The total flooded area for the four targeted provinces is shown in Table A2.1, whereas the average values for the indicators are shown in Table A2.2.

Variation between low and high flood conditions are considerable, as shown by total area flooded for each RADARSAT-1 acquisition date selected. Therefore, RADARSAT-based average percent of commune flooded was calculated separately for low and high flood events, in order to reduce the variance in the values. In contrast, the difference observed between the three MIKE11 flood events is relatively small, although the extent of flooded area is larger for a medium flood event compared to a major event for the four provinces under study. Neither RADARSAT-1 nor Mike11[1] data take water depth into account. The flood duration data (medium flood) is based on inundated area at depth greater than 30 cm.

Table A2.1 Total flooded area of the four targeted provinces based on RADARSAT-1 and MIKE11 data.

RADARSAT-1 Image Date	Flood Severity	Area Flooded (ha)
Sep 24, 1999	Low	246,000
Oct 25, 1999	Low	432,000
Late Aug-Sep, 2000	High	680,000
Late Sep-Oct, 2000	High	696,000
Oct 19-29, 2000	High	716,000
Oct 17, 2001	High	743,000
July 10, 2002	Low	149,000
Aug 15, 2002	Low	374,000
Sep 20, 2002	High	617,000
Dec 25, 2002	Low	190,000
MIKE11		
Minimum flood event	Area	815,000
Medium flood event	Area	919,000
Major flood event	Area	845,000

[1] MIKE11 depth data were not included in this GIS.

Table A2.2 Average percent of commune flooded for the four targeted provinces.

Flood Severity	Average Percent of Commune Flooded
RADARSAT Low flood event (5 dates)	18%
RADARSAT High flood event (5 dates)	44%
Mike11 Minor event	54%
Mike11 Medium event	61%
Mike11 Major event	56%
Mike11 Medium event-(duration)	37%

A2.1.2 Number of Flood days

This indicator is estimated using the MIKE11 medium flood event model. GIS analysis was conducted to intersect **village centres**, **main buildings**, **settlement areas**, and **communes** with the flood duration data to generate values for the duration of the flood for each feature. For the commune calculation, flood days were counted only where water deeper than 30 cm occurred and covered more than 20 percent of commune area. According to these criteria, the number of flood days varies widely among communes. The average number of flood days for all the village centres, main buildings and settlement areas was 28. The average for communes (according to the criteria described) was 57 days. The number of flood-days calculated for this indicator is included in the GIS/Atlas for all the villages and main buildings of the study area[2].

A2.1.3 Infrastructure Inundation

This indicator is based on 10 dates of RADARSAT-1 derived flood extent data, and MIKE11 extent of area flooded for a minor, medium and major flood event. Thirteen flood vectors are used in total.

GIS analysis was conducted to intersect village centres, main buildings and settlement area (infrastructure) with the flood extent, to calculate the percentage of infrastructure inundated. Within the study area, the average percent of infrastructure inundated was 17%.

Flood vectors are shown on Map Series 17 for RADARSAT-1 data and Map Series 18 for MIKE11.

A2.1.4 Elevation

The estimated elevation above sea level derived from the DEM provides an indicator for the exposure to inundation events; however, this is dependent on the accuracy of the DEM, and does not take into account the complex behavior of the flood and flooding patterns.

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[2] Consult Vulnerability Atlas included with this report. The Atlas is presented in details in Appendix A1 for the Metadata and A4 for the GIS functionalities.

Figure A2.1 Schematic illustrating the process to derive flood exposure indicators.

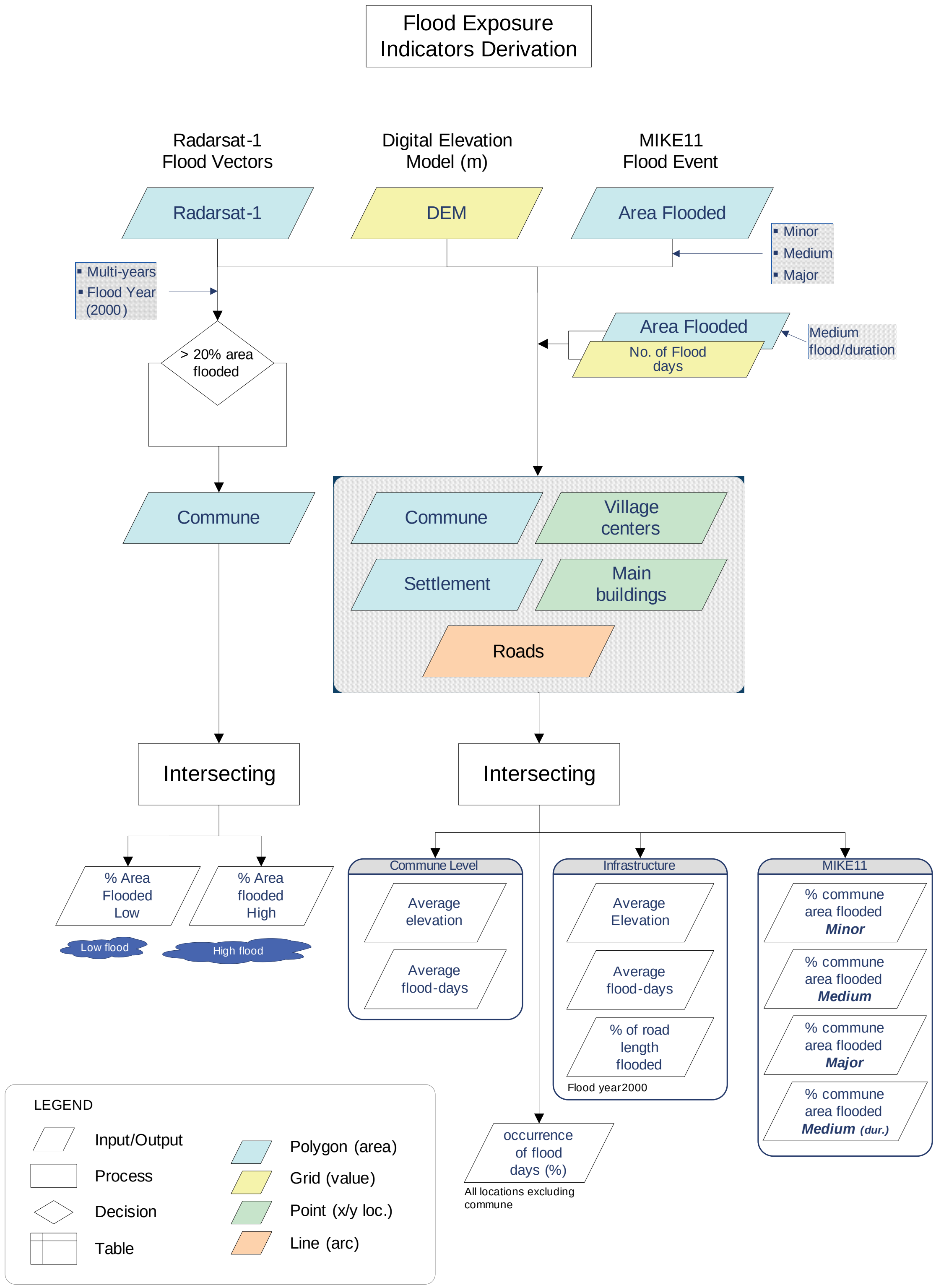
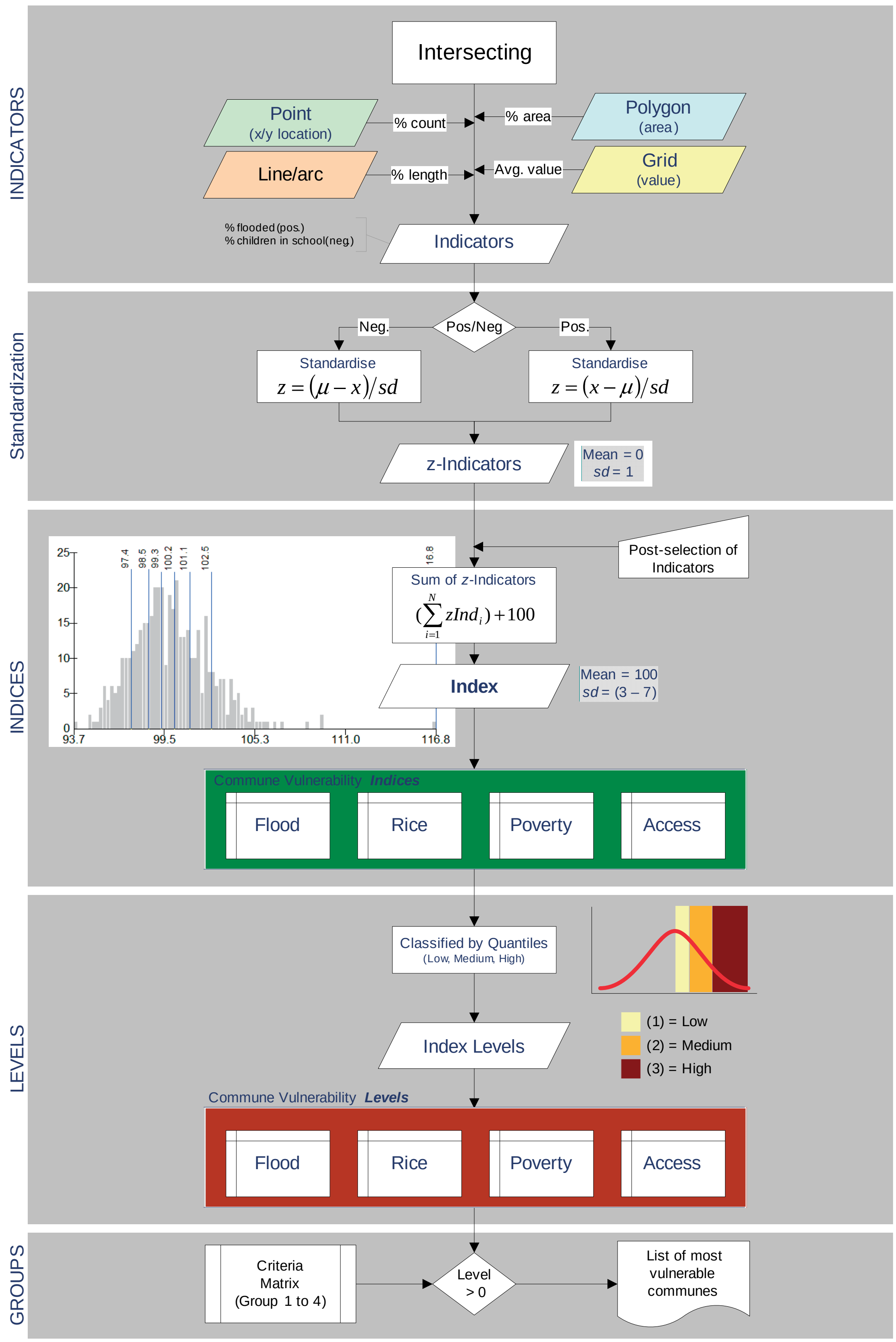


Figure A2.2 Schematic illustration showing the process for derivation of indicators, indices and levels of vulnerability.



Elevation above sea level was used to identify those areas more exposed to flooding. The exposure to flood was assessed for each commune using average elevation for the entire commune area and average elevation for all the combined human features selected (settlement areas, village centres and main buildings).

The data sets used to calculate this indicator are:

- Flood-prone area DEM (50 m resolution grid);
- Commune (polygon);
- Settlement (polygon);
- Village Centres (points); and
- Main buildings (points).

A2.1.5 Road Inundation

This indicator is based on the roads (lines) and RADARSAT-derived inundated area during the 2000 flood event. GIS analysis was conducted to intersect roads with RADARSAT-1 flood extent for three dates from September to October 2000, which were combined into one flood extent. The data sets used to calculate this indicator are:

- Road network including all road categories (lines); and
- RADARSAT-1 Scenes:
    - 24-Aug and 4-Sep-00 Flood vector;
    - 23-Sep and 5-Oct-00 Flood vector; and
    - 19 and 29-Oct-00 Flood vector.

A total of 10,000 km of road network was analysed spatially in relation to this maximum extent of the flooded area and the percent of roads flooded determined on a commune basis. This is simple analysis does not take into account the depth and duration of the flood event, because the road data and flood depth are not sufficiently accurate to complete this analysis. Road length classified as inundated accounted for 31% of the entire network.

A2.2 POVERTY INDICATORS

The Seila Programme commune and village-level socioeconomic database provided the main source of data used for the selection of flood-related poverty indicators integrated into the GIS. The SEILA programme selected five indicators to assess levels of poverty, which are linked to assets and infrastructure, education, and female headed households found at the commune level. The selected indicators gathered from Seila's village-level data sets are:

- Percent of families that have access to 'running' water (piped water, private pump well or private ring well, usable year round, at their house, or within 150m);
- Percent of houses with thatch roof;
- Percent of illiterate adults;
- Percent of children (6-14) not in school; and
- Percent of female-headed households.

See SEILA/UNDP website[3] for details.

A2.3 RICE DEPENDENCY INDICATORS

According to Seila (2004), rainfed rice accounts for more than 50 per cent of the total production in the study area. Rice production is measured in hectares (ha) and annual harvest in Metric Tons (MT). Rice production data are collected at the commune level. The SEILA database defines four categories of rice crops:

- Wet season rainfed;
- Wet season supplemental irrigated;
- Dry season recession; and
- Dry season full-irrigated.

Based on Seila's commune-level database, the rice dependency indicators were selected as follow:

- Total rice production area (ha);
- Wet-season rainfed and irrigated rice land area (ha);
- Wet-season rice production in Metric Tons (MT); and
- Dry-season rice production in Metric Tons (MT).

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[3] http://www.seila.gov.kh/indexs.asp?language=kh&pgid=1

Map 12 illustrates two wet-season rice dependency indicators: “percent of total rice crop area used for Rainfed rice” and “percent of commune area used for Wet-season rice”. See Map 13 and 15 to view the selection of rice-dependent communes and grouping according to levels of dependency.

A2.4 ACCESS VULNERABILITY

Several indicators were used characterize access vulnerability, based on Seila Programme database, road network GIS data, and the percent of road network inundated, which was described above:

- Length of road network (GIS-based);
- Access time from village to main roads and markets (Seila Programme estimate);
- Distance to main roads and health centres (GIS-based); and
- Number of families per boat (Seila Programme).
- Percent of road network inundated (2000 flood year), described above in section A2.1.5.

Note: the source of data for road network and flood vectors are presented in the previous section. Consult Map Series 16 to view the distribution of vulnerable communes in terms of access.

Appendix 3

List of Communes Identified as ‘Most Vulnerable’

A3.0 LIST OF COMMUNES IDENTIFIED AS ‘MOST VULNERABLE’

Table A3.1 List of communes selected based on ranking of vulnerability indices – Kandal Province.

District	Commune	ID	Density	Vulnerability Level*				Vulnerability Index				Overall Rank†	Group‡
				Flood	Poverty	Rice	Access	Flood	Poverty	Rice	Access		
Khsach Kandal	Roka Chonlueng	80312	2.6	1	3	3	2	105.3	104.3	107.7	101.2	9	1
Kaoh Thum	Preaek Thmei	80411	5.8	2	2	1	0	108.2	101.0	100.9	96.4	5	2
Saang	Kaoh Khsach Tonlea	81004	6.3	2	1	1	0	106.2	100.2	100.0	99.9	4	2
Khsach Kandal	Sanlung	80313	2.8	1	0	2	0	103.4	99.0	104.0	99.9	3	3
Kandal Stueng	Boeng Khyang	80104	2.9	1	0	1	1	103.9	95.8	101.3	100.8	3	3
Kandal Stueng	Preaek Kampis	80114	6.2	1	0	1	1	102.4	95.9	100.3	100.6	3	3
Khsach Kandal	Chey Thum	80302	2.0	1	0	1	1	105.0	99.1	101.5	100.8	3	3
Kaoh Thum	Kaoh Thum Ka	80404	8.3	1	0	1	0	104.3	98.2	101.1	97.3	2	3
Kaoh Thum	Preaek Chrey	80409	2.2	3	3	0	3	114.9	116.8	93.4	104.0	9	4
Lvea Aem	Barong	80602	1.2	3	3	0	3	122.7	104.1	91.6	108.3	9	4
Lvea Aem	Preaek Kmeng	80609	1.3	3	3	0	3	116.4	103.8	93.2	107.8	9	4
Lvea Aem	Kaoh Reah	80605	4.1	3	3	0	2	112.0	102.7	96.7	102.7	8	4
Lvea Aem	Sambuor	80612	3.5	3	3	0	2	111.0	102.6	95.2	101.5	8	4
Saang	Prasat	81006	0.7	3	2	0	3	112.5	102.1	94.3	105.9	8	4
Leuk Daek	Khpob ateav	80503	1.3	2	3	0	3	109.2	104.2	93.2	106.1	8	4
Lvea Aem	Preaek Ruessei	80611	3.4	3	1	0	3	116.5	100.8	94.9	106.5	7	4
Ponhea Lueu	Kaoh Chen	80905	2.6	3	2	0	2	122.6	101.1	92.9	101.9	7	4
Leuk Daek	Peam Reang	80504	1.4	2	2	0	3	106.1	101.3	92.0	103.9	7	4
Lvea Aem	Kaoh Kaev	80604	2.4	2	3	0	2	109.2	109.7	92.5	102.0	7	4
Lvea Aem	Tuek Khleang	80615	3.3	3	1	0	2	112.0	101.0	94.6	101.0	6	4
Mukh Kampul	Svay Ampear	80711	4.0	3	1	0	2	114.1	100.7	94.1	101.3	6	4
Leuk Daek	K'am Samnar	80502	1.7	2	1	0	3	108.2	100.0	92.7	110.7	6	4
Lvea Aem	Preaek Rey	80610	2.4	2	1	0	3	108.0	100.4	93.5	103.7	6	4
Saang	Krang Yov	81005	2.9	3	1	0	1	112.6	100.1	99.3	100.1	5	4
Saang	S'ang Phnum	81010	3.0	3	1	0	1	110.8	100.2	99.6	100.6	5	4
Khsach Kandal	Vihear Suork	80318	2.7	2	2	0	1	106.2	101.7	98.0	100.6	5	4
Leuk Daek	Preaek Dach	80505	1.1	1	1	0	3	105.3	100.3	98.2	103.2	5	4

* Level of vulnerability (syn.: exposure, dependency): 1 = Low, 2= Medium, 3 = high, 0 = above ‘vulnerability’ threshold (index score ≤ 100).

† Overall Rank = sum of levels (Flood + Poverty + Rice + Access).

‡ Ranking criteria and score; select communes where vulnerability level > 0.

Group 1	Communes found among the vulnerable classes (level > 0), in all four vulnerability indices
Group 2	Communes vulnerable in terms of Flood + Rice + Poverty
Group 3	Communes vulnerable in terms of Flood + Rice
Group 4	Communes vulnerable in terms of Flood + Access + Poverty

Table A3.2 List of communes selected based on ranking of vulnerability indices – Takeo Province.

District	Commune	ID	Density	Vulnerability Level*				Vulnerability Index				Overall Rank†	Group‡
				Flood	Poverty	Rice	Access	Flood	Poverty	Rice	Access		
Kaoh Andaet	Thlea Prachum	210506	1.7	2	2	2	2	106.1	102.2	103.1	101.6	8	1
Bourei Cholsar	Kouk Pou	210305	2.1	3	3	1	0	114.6	102.9	100.0	100.0	7	2
Bati	Pot Sar	210210	2.8	1	2	3	0	100.8	102.3	111.0	98.3	6	2
Treang	Thlok	211013	2.4	1	2	2	0	100.0	102.2	102.2	96.5	5	2
Kaoh Andaet	Pech Sar	210502	1.6	2	0	2	1	107.0	99.9	103.2	100.3	5	3
Treang	Chi Khmar	211003	2.9	1	0	3	0	102.4	98.7	105.1	99.1	4	3
Treang	Sambuor	211009	2.3	2	0	2	0	107.0	99.4	102.2	96.5	4	3
Treang	Smaong	211011	2.7	1	0	3	0	101.4	98.8	105.3	98.3	4	3
Kiri Vong	Angk Prasat	210401	1.3	2	0	1	0	108.4	99.2	100.9	98.9	3	3
Prey Kabbas	Char	210604	2.9	2	0	1	0	107.2	96.2	101.2	99.2	3	3
Prey Kabbas	Prey Lvea	210610	3.3	1	0	2	0	101.9	96.5	102.5	97.6	3	3
Treang	Sanlung	211010	1.7	1	0	2	0	101.3	99.3	103.8	98.9	3	3
Prey Kabbas	Kampeaeng	210605	3.5	1	0	1	0	101.3	97.4	100.0	98.7	2	3
Prey Kabbas	Pou Rumchak	210608	3.1	1	0	1	0	100.4	99.1	100.4	97.5	2	3
Prey Kabbas	Prey Kabbas	210609	2.9	1	0	1	0	102.0	96.3	100.3	97.7	2	3
Bourei Cholsar	Bourei Cholsar	210301	0.6	3	3	0	3	116.9	105.7	95.1	107.2	9	4
Bourei Cholsar	Chey Chouk	210302	0.7	3	3	0	3	110.6	105.3	92.4	116.3	9	4
Angkor Borei	Kouk Thlok	210103	0.5	2	3	0	3	109.6	105.1	93.7	103.6	8	4
Bourei Cholsar	Kampong Krasang	210304	0.5	2	3	0	3	109.1	106.6	95.9	115.3	8	4
Kiri Vong	Kamnab	210403	1.1	3	3	0	2	119.4	103.4	96.5	102.0	8	4
Kaoh Andaet	Prey Yuthka	210504	0.8	3	2	0	3	114.5	102.4	96.2	103.1	8	4
Prey Kabbas	Kampong Reab	210606	3.0	3	3	0	2	121.0	104.4	94.0	101.1	8	4
Kaoh Andaet	Krapum Chhuk	210501	1.3	2	3	0	2	108.6	102.7	98.3	101.9	7	4
Angkor Borei	Prey Phkoam	210106	2.0	2	3	0	1	109.1	103.2	97.1	100.6	6	4
Kaoh Andaet	Prey Khla	210503	1.4	2	3	0	1	108.5	102.7	99.7	101.0	6	4
Angkor Borei	Angkor Borei	210101	2.8	3	1	0	1	111.8	100.8	95.7	100.1	5	4

* Level of vulnerability (syn.: exposure, dependency): 1 = Low, 2= Medium, 3 = high, 0 = above 'vulnerability' threshold (index score ≤ 100).

† Overall Rank = sum of levels (Flood + Poverty + Rice + Access).

‡ Ranking criteria and score; select communes where vulnerability level > 0.

Group 1	Communes found among the vulnerable classes (level > 0), in all four vulnerability indices
Group 2	Communes vulnerable in terms of Flood + Rice + Poverty
Group 3	Communes vulnerable in terms of Flood + Rice
Group 4	Communes vulnerable in terms of Flood + Access + Poverty

Table A3.3 List of communes selected based on ranking of vulnerability indices – Prey Veng Province.

District	Commune	ID	Density	Vulnerability Level*				Vulnerability Index				Overall Rank†	Group‡
				Flood	Poverty	Rice	Access	Flood	Poverty	Rice	Access		
Preah Sdach	Boeng Daol	140903	2.2	3	3	3	3	113.2	103.8	105.3	107.2	12	1
Preah Sdach	Seena Reach Otdam	140911	2.4	3	3	3	3	110.9	104.6	104.2	104.1	12	1
Kampong Trabaek	Cheang Daek	140303	1.4	3	2	2	3	109.9	101.0	102.8	104.0	10	1
Peam Chor	Ruessei Srok	140609	2.0	3	2	2	3	110.7	101.5	103.8	109.3	10	1
Preah Sdach	Angkor Reach	140901	2.8	2	2	2	3	109.4	102.0	103.5	105.2	9	1
Preah Sdach	Chey Kampok	140904	2.9	2	2	2	3	108.6	101.1	102.2	103.4	9	1
Preah Sdach	Rumchek	140910	3.8	2	3	2	2	107.0	103.3	103.0	102.0	9	1
Peam Ro	Prey Kandieng	140708	2.2	2	3	1	2	107.6	103.0	100.8	102.5	8	1
Preah Sdach	Krang Svay	140906	3.4	2	1	3	2	108.4	100.8	104.8	101.2	8	1
Kampong Trabaek	Cham	140302	2.5	2	1	1	3	106.0	100.4	100.1	103.5	7	1
Kampong Leav	Baray	141101	1.7	2	3	1	1	106.9	103.6	100.7	101.0	7	1
Kampong Trabaek	Kampong Trabaek	140307	2.9	3	2	2	0	110.6	102.1	104.0	98.3	7	2
Sithor Kandal	Pnov Ti Pir	141205	1.5	2	0	3	3	107.3	99.1	104.2	108.7	8	3
Sithor Kandal	Chrey Khmum	141202	1.8	1	0	3	3	104.4	99.9	108.9	106.0	7	3
Kampong Trabaek	Prey Poun	140312	3.7	1	0	3	2	100.3	100.0	105.7	102.4	6	3
Pea Reang	Prey Sniet	140808	1.7	2	0	1	3	108.1	96.8	100.8	108.9	6	3
Sithor Kandal	Pnov Ti Muoy	141204	2.0	2	0	2	2	107.7	98.7	102.1	102.5	6	3
Sithor Kandal	Prey Daeum Thnoeng	141208	1.9	1	0	2	3	100.9	99.1	103.3	105.0	6	3
Kampong Trabaek	Chrey	140304	2.9	1	0	2	2	101.3	98.9	102.7	101.5	5	3
Preah Sdach	Lvea	140907	2.5	2	0	2	1	106.6	99.9	102.6	100.8	5	3
Pea Reang	Roka	140811	2.3	1	0	1	2	103.8	96.9	101.5	101.8	4	3
Sithor Kandal	Rumlech	141210	2.6	1	0	2	1	103.2	98.2	102.3	100.5	4	3
Pea Reang	Prey Pnov	140807	1.8	1	0	1	1	101.0	99.1	100.7	100.0	3	3
Peam Chor	Angkor Angk	140601	1.5	3	3	0	3	115.9	103.3	94.9	104.1	9	4
Peam Chor	Kampong Prasat	140602	1.2	3	3	0	3	115.9	103.1	93.7	109.8	9	4
Peam Chor	Kaoh Sampov	140605	0.6	3	3	0	3	117.5	104.7	94.7	108.8	9	4
Peam Chor	Krang Ta Yang	140606	2.6	3	3	0	3	114.3	105.2	99.3	111.0	9	4
Kampong Leav	Preaek Anteah	141105	2.9	3	3	0	3	113.1	102.8	94.1	107.8	9	4
Kampong Trabaek	Peam Montear	140308	1.5	3	2	0	3	115.1	101.8	96.8	104.1	8	4
Peam Chor	Kaoh Chek	140603	1.7	3	2	0	3	110.9	102.1	95.5	109.9	8	4
Peam Chor	Kaoh Roka	140604	1.3	3	2	0	3	111.4	101.8	92.5	114.3	8	4
Peam Chor	Preaek Sambuor	140608	1.5	2	3	0	3	108.3	103.0	92.9	112.3	8	4
Peam Chor	Svay Phluoh	140610	1.8	3	2	0	3	110.2	102.4	94.2	104.1	8	4

Table A3.3 (Cont'd.)

District	Commune	ID	Density	Vulnerability Level*				Vulnerability Index				Overall Rank†	Group‡
				Flood	Poverty	Rice	Access	Flood	Poverty	Rice	Access		
Pea Reang	Preaek Ta Sar	140806	1.7	2	3	0	3	108.2	105.0	93.5	108.5	8	4
Preah Sdach	Preah Sdach	140908	2.2	3	2	0	3	113.6	102.1	99.5	106.2	8	4
Kampong Leav	Preaek Chrey	141106	2.1	3	2	0	3	116.3	102.0	91.6	105.2	8	4
Pea Reang	Mesa Prachan	140805	3.5	3	1	0	3	111.5	100.5	97.3	104.8	7	4
Preah Sdach	Banteay Chakrei	140902	1.6	3	2	0	2	114.7	101.4	95.6	102.1	7	4
Preah Sdach	Reathor	140909	2.0	3	1	0	3	110.8	100.8	96.7	105.6	7	4
Pea Reang	Kampong Prang	140803	1.8	1	3	0	1	105.4	103.4	98.4	100.4	5	4
Peam Chor	Preaek Krabau	140607	3.0	2	1	0	1	106.0	100.9	96.1	100.6	4	4

* Level of vulnerability (syn.: exposure, dependency): 1 = Low, 2= Medium, 3 = high, 0 = above 'vulnerability' threshold (index score ≤ 100).

† Overall Rank = sum of levels (Flood + Poverty + Rice + Access).

‡ Ranking criteria and score; select communes where vulnerability level > 0.

Group 1	Communes found among the vulnerable classes (level > 0), in all four vulnerability indices
Group 2	Communes vulnerable in terms of Flood + Rice + Poverty
Group 3	Communes vulnerable in terms of Flood + Rice
Group 4	Communes vulnerable in terms of Flood + Access + Poverty

Table A3.4 List of communes selected based on ranking of vulnerability indices – Svay Rieng Province.

District	Commune	ID	Density	Vulnerability Level*				Vulnerability Index				Overall Rank†	Group‡
				Flood	Poverty	Rice	Access	Flood	Poverty	Rice	Access		
Kampong Rou	Banteay Krang	200201	0.8	2	2	3	1	106.7	101.9	104.4	100.2	8	1
Svay Chrum	Svay Thum	200515	2.6	1	2	1	2	100.7	101.7	100.6	102.6	6	1
Kampong Rou	Tnaot	200212	1.7	1	2	1	1	104.3	102.3	101.0	101.0	5	1
Svay Chrum	Kruos	200511	2.2	1	2	1	1	101.1	101.1	100.6	100.6	5	1
Kampong Rou	Thmei	200211	1.3	3	2	1	0	110.0	102.3	100.5	98.3	6	2
Kampong Rou	Svay Toea	200210	2.3	1	1	2	0	104.0	100.0	102.2	97.2	4	2
Svay Chrum	Basak	200502	1.5	1	2	1	0	101.5	101.0	100.9	98.4	4	2
Svay Chrum	Chek	200506	3.1	1	1	2	0	100.4	100.0	102.0	97.4	4	2
Kampong Rou	Reach Montir	200206	1.2	1	1	1	0	101.4	100.5	100.5	98.4	3	2
Chantrea	Chres	200104	1.2	1	0	1	3	100.4	99.0	101.4	103.1	5	3
Kampong Rou	Samyaong	200208	0.9	1	0	2	1	102.3	99.0	102.9	100.1	4	3
Chantrea	Chantrea	200103	0.6	2	3	0	3	108.5	104.1	96.0	103.9	8	4
Chantrea	Tuol Sdei	200110	0.3	2	3	0	3	108.9	109.5	99.1	103.9	8	4

* Level of vulnerability (syn.: exposure, dependency): 1 = Low, 2= Medium, 3 = high, 0 = above 'vulnerability' threshold (index score ≤ 100).

† Overall Rank = sum of levels (Flood + Poverty + Rice + Access).

‡ Ranking criteria and score; select communes where vulnerability level > 0.

Group 1	Communes found among the vulnerable classes (level > 0), in all four vulnerability indices
Group 2	Communes vulnerable in terms of Flood + Rice + Poverty
Group 3	Communes vulnerable in terms of Flood + Rice
Group 4	Communes vulnerable in terms of Flood + Access + Poverty