MAPPING VULNERABILITY TO NATURAL DISASTERS IN CAMBODIA

National Committee for Disaster Management, Royal Government of Cambodia
United Nations World Food Programme

March 2003

With support from the Italian Cooperation and
International Fund for Agricultural Development (IFAD)

FOREWORD

It is our great pleasure to present you with this report "Mapping Vulnerability to Natural Disasters in Cambodia." The report is the result of close collaboration between the Minister of Water Resources and Meteorology (MOWRAM) and the United Nations World Food Programme (WFP).

The report presents the main findings of the first ever attempt to identify priority areas prone to floods and droughts at the commune level in Cambodia. It clearly identifies various factors contributing to vulnerability of rural populations as a result of these natural disasters. In particular, the analysis focuses on three elements: food security, rice dependency, and the nature of the disaster. The combination of existing relevant information and data from surveys, assessments, geographic information systems (GIS), and satellite images, has enabled us to better identify and understand which communes are especially prone to natural disasters.

As a result, we hope that the outputs of this analysis will be used by policy makers and other stakeholders to appropriately address flood and drought issues in terms of improved preparedness, mitigation and response. It is important to note that while the analysis is based on much of the available data and information, it does not cover all aspects of droughts and floods in this country. Users may therefore like to incorporate other indicators for their specific purposes.

We are grateful to all those involved in making this report possible. In particular, we greatly appreciate assistance from the Mekong River Commission Secretariat in providing flood images of 2000 and 2001 as well as significant inputs for the analysis. Our grateful acknowledgement is extended to Livia Montana for assistance in obtaining GIS climatic data from the University of East Anglia. Lastly, we would like to thank the Italian Cooperation and International Fund for Agricultural Development (IFAD) for support provided in disseminating the results.

Rebecca Hansen
WFP Representative/Country Director

H.E. Lim Kean Hor
Minister of Water Resources and Meteorology

TABLE OF CONTENTS

1. Introduction

Cambodia is considered one of the most disaster prone countries in South-East Asia. This has been especially true over the last decade as the country has been repeatedly hit by natural disasters, especially floods and droughts. Cambodia has been severely affected by droughts and floods almost every 2 years for the last 10 years. The country was hit by bad droughts in 1995, severe floods in 1996, severe droughts again in 1998, the worst floods in 70 years in 2000, and both drought and floods in 2001. Finally, while the country has been in the process of recovering from two consecutive years of disasters, the late arrival of rains in the early wet season and flash flooding of the Mekong River later in 2002 have taken the situation from bad to worse.

In response to these catastrophes, the Royal Government of Cambodia (RGC) met with donors, UN agencies, and NGOs to formulate a response to the situation. Under the coordination of the National Committee for Disaster Management (NCDM), concerned agencies at national and provincial levels, got together to develop joint responses to the needs of the affected population once disasters strike. Minor measures have been put in place to mitigate the worst effects of disasters, but the responses have thus far been on an ad hoc basis.

Since natural disasters have been affecting the country increasingly often and are expected to continue to do so in the near future, it is necessary to prepare better disaster response and mitigation measures. An important aspect of such measures is the identification of disaster prone areas in need of priority interventions. Therefore, the main objective of the study is to identify areas prone to natural disasters, mainly floods and droughts, that are also particularly vulnerable to human suffering, particularly hunger, as a result of these disasters. For maximum precision in the planning of effective and efficient interventions, the results of the study are disaggregated to the commune level. The outputs of the analysis will contribute to the improved targeting of assistance to the most severely affected areas and most needy members of the population. The outputs will also provide valuable information for decision makers and planners at all levels.

2. Data

2. 1. GIS Data

A set of natural disaster related geographical indicators was used in this analysis. Given the rich collection of geographic data available for Cambodia, several flood and drought related indicators have been generated. Flood related indicators have been mainly derived from the RadaSat inundation vectors of 2000 and 2001 obtained from the Mekong River Commission. The images show the overall flooded areas, especially around the Tonle Sap Lake and along the Mekong River, where there have been large water cover areas during the flooding period, normally between August and October. It is clear that the Tonle Sap normally expands greatly during wet season, flooding large surrounding areas. It is important to note that due to the coarse resolution of the satellite images small flooded areas cannot be seen.

A set of drought related indicators has also been generated from geographical data. One of the most important drought related indicators is the long-term monthly average precipitation at commune-level.[1] Another important indicator is the Normalized Differential Vegetation Index (NDVI) taken from an AVHRR Satellite. The AVHRR is taken in color bands that are ideal for quantifying vegetation. The NDVI is highest in areas that are very green and lowest in non-green areas. As the NDVI is largely dependent on the time of the year, increasing during the wet season and decreasing during the dry season, an image representing the 20-year average between 1981 and 2000 is used. This indicator is used as a proxy of agricultural productivity.

2. 2. Crop Assessment Data

Under an agreement between The United Nations Food and Agricultural Organization (FAO) and The United Nations World Food Programme (WFP), a joint crop and food supply assessment is normally conducted if it is considered necessary or is requested by the Government, especially after a bad year of agricultural production. In response to

[1] 30 year average precipitation with 0.5 degree resolution ≅ 50k has been obtained from the University of East Anglia.

demand in the aftermath of disasters, several crop and food supply assessments have been conducted in Cambodia within the last 10 years to help ensure the food security of the affected population. The main objectives of the assessments are to gauge agricultural production (mainly rice, the staple food for Cambodians) and to evaluate the food outlook and food security situation for the following year.

The assessments have been conducted by WFP and FAO in co-operation with the Ministry of Agriculture, Forestry and Fisheries. The assessments include data collection at the lowest possible administrative level, in this case the commune level, and crop cutting surveys to gather reliable information about rice planted areas, harvested areas, and yield and production data. The assessments cover approximately 80-90 percent of communes/provinces in the country depending on the magnitude of the destruction resulting from droughts and floods. The results of the assessments normally represent about 90 percent of overall production in the country, and hence indicate national food security in terms of production.

Using the standard assessment form (Appendix A), the main data collected in the surveys have been: areas and production of wet-season rice; dry-season rice crops; population; number of rice growers; crop damage; and areas of other crops. The data are used to estimate and assess food production, particularly rice production, and demand for rice consumption at commune level. The data are also used to estimate the rice surplus or deficit for the next year. Finally, the data are used to identify the level of crop destruction in the most affected areas and to identify needs in those areas. This information is then used to target WFP food aid to the most needy areas and populations.

WFP has conducted four crop assessments in the last 10 years. The first crop assessment was conducted in late 1995 in response to that year's floods. The second was conducted in 1996 in response to the floods. The third was conducted in 1998 after severe droughts and the forth crop assessment was conducted in 2000 in response to one of the worst floods in 70 years.

3. Analysis and Results

3.1. Flood Prone Areas

Based on the existing information and data, three broad categories of analysis were carried out:

1. Flood affected areas;
2. Rice dependency; and
3. Food security, based on rice production/availability.

- *Flood Affected Areas*: Cambodia is endowed with the rich water resources of the Mekong and Tonle Sap rivers. The Mekong River extends across the country from the north-eastern border with Lao PDR, to the southern border with Vietnam. There are four main rivers i.e. the Upper Mekong, the Lower Mekong, the Bassac and the Tonle Sap River, which flows from the Tonle Sap Lake in the central part of the country. All four meet at the Chatomouk Junction in Phnom Penh.

  During the dry season the Mekong flows from the north to the south and finally empties into the South China Sea in Viet Nam. During the wet season, however, the Mekong waters partly reverse their flow, and flow upstream through the Tonle Sap River into the Tonle Sap Lake, which serves as a giant reservoir absorbing the excess wet season water. This rich water system sustains the livelihoods of the majority of the Cambodian population. Millions of people live along the banks of the rivers and in the surrounding areas growing agricultural crops. However, the waters that feed these crops are also a threat to lives and food security. When floods hit Cambodia, it is the people living in these areas who are affected the most.

  Given these geographical characteristics, flooding often occurs along the Mekong and around the Tonle Sap. Several recent floods show that there are two distinct flood patterns in Cambodia - flash floods and central area floods. The former refers to floods that hit areas along the Mekong and southern parts of the country. These floods normally occur when there are very heavy rains in upstream areas of the Mekong in Myanmar, Thailand or Lao PDR. Runoff overflows embankments and floods areas along the river. Many parts of provinces along the Mekong i.e. Stung Treng, Kratie, Kampong Cham, Kandal, Phnom Penh, Prey Veng, Svay

Rieng and Takeo, are very vulnerable to these floods. The most recent flash floods occurred in 2001.

Central area floods result from both runoff from the Mekong and heavy rains in Cambodia, especially around the Tonle Sap Lake. When there are heavy rains in the central part of the country, runoff floods areas along smaller rivers and parts of Siem Reap, Banteay Meanchey, Kampong Thom, Kampong Chhnang, Pursat and Battambang provinces around the Tonle Sap Lake. The flooding also reduces the absorption capacity of the lake, and hence channels water from the Mekong to down-stream areas in the southern parts of the country. This can cause floods in Kampong Cham, Kandal, Prey Veng, Svay Rieng and Takeo provinces, as was the case in 1996 and 2000.

To identify flood affected areas at commune level, satellite images of inundation vectors have been used in combination with crop assessment data. Figure 1 shows flooded areas in October 2000 and September 2001 during peak water levels. The images clearly indicate that the areas around the Tonle Sap Lake and along the Mekong were the most affected by floods.

Unfortunately, the satellite images do not allow us to identify two critical indicators of flood severity: depth, (or water level) and duration. Therefore, to better identify areas severely affected by floods, crop assessment data collected after the floods of 1996, 2000 and 2001 have been used in combination with the satellite images. Areas severely affected by floods are defined as those in which more than 20 percent of the wet-season rice planted area was destroyed by floods in any of those three years. Figure 2 shows the severely affected areas by the year in which the flood destruction occurred. It is clear that southern parts of the country including Kampong Cham, Kandal, Prey Veng, Svay Rieng, and Takeo provinces, are mostly affected by all three floods. These areas are shown in red. Areas in pink represent the areas affected by floods in 1996 and 2000, while green areas are those affected by flash floods in 2001. Areas in blue are those affected by the major floods of 2000 only.

Figure 1. Flood Affected Areas, Inundation Vectors Oct. 2000 and Sept. 2001

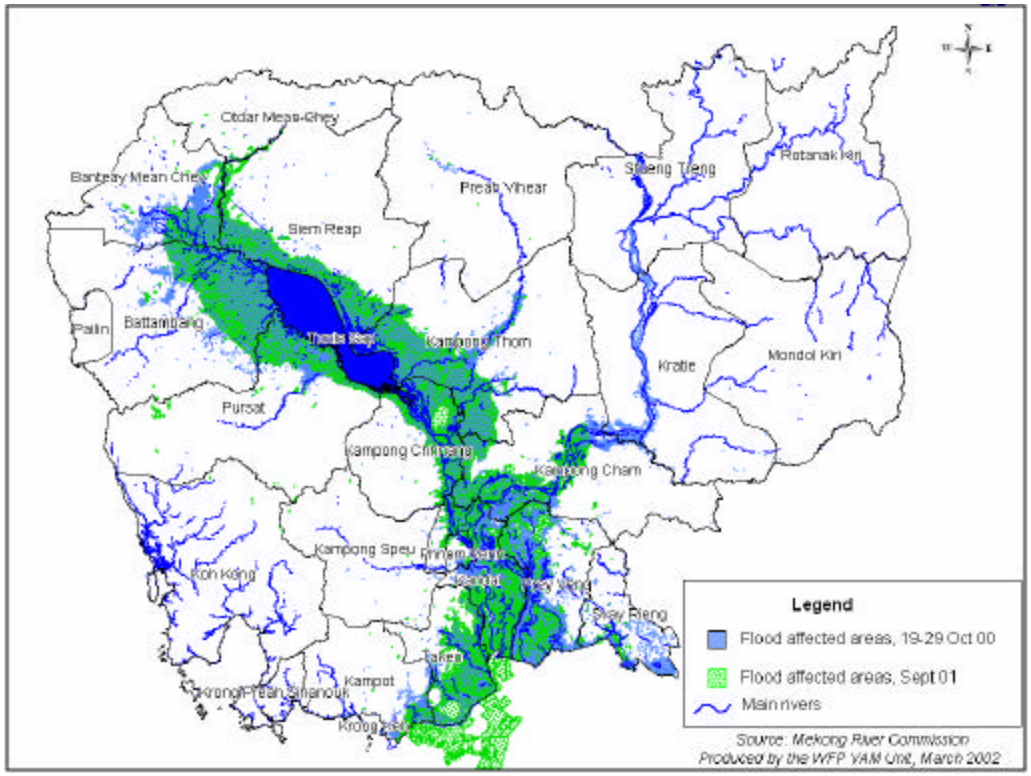
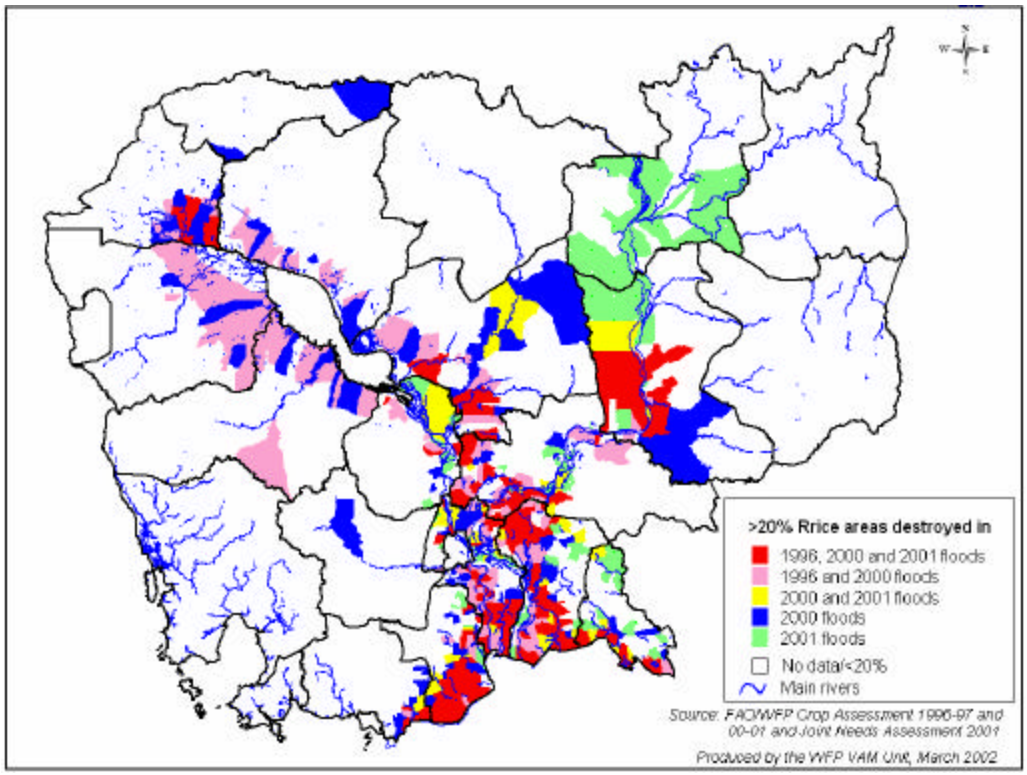


Figure 2. Wet-Season Rice Areas Destroyed by Floods



- *Rice dependency of the rural population:* Lessons learned from previous floods show clearly that the destruction resulting from floods depends largely upon the ability of the affected population to cope with the unfavorable situation. For the majority of the Cambodian population livelihoods mainly depend on agricultural production, primarily subsistence-based rice production in lowland areas around the Tonle Sap Lake and along the Mekong. As a result these people are particularly vulnerable to loosing their livelihoods during floods, which exacerbates the destruction caused by the floodwaters in these areas.

  To identify concentrations of rice farmers who live in flood prone areas and whose livelihoods depend largely upon rice production, crop assessment data have been used. Communes with greater than 80 percent of households fully engaged in rice production are considered to be high rice dependency communes.

- *Food Security Situation Based on Rice Production:* As mentioned above, Cambodian farmers depend largely on self-production of rice to ensure family food security. Because of limited off-farm income earning opportunities, the dependency on self-production of rice is highest in the rural areas. Farmers often describe themselves as being food secure if they have enough rice, mainly derived from their own production, to eat over the 12 months of the year.

  Due to insufficient information for assessing family food security at disaggregated levels, rice production at the commune level has been used as a proxy to estimate food security. Crop assessment data are used to calculate the food deficit or surplus for each commune based on a per capita need of 152 kg of milled rice per year. A commune is classified as being food insecure or having a rice deficit if there are more than two months of deficit per capita per year. Data for the flood years of 1996 and 2000 is used.

The above three indicators can be combined to give a composite measure of flood vulnerability, disaggregated to the commune level. Vulnerable communes can be classified into three categories, first priority, second priority and third priority, as shown in Table 1 and Figure 3. All three categories require that over 80 percent of households

are fully engaged in rice farming, and there is thus a very high degree of dependence upon rice production. First priority areas are defined as those that were severely affected (more than 20 percent of the wet-season rice area destroyed) by floods in 1996, 2000 and 2001, and were food insecure in 1996 and 2000 (i.e. faced food/rice deficit for more than two months per capita per year.) This combination implies that people in these areas are most vulnerable to being flooded and are most likely to face food shortages once floods hit. Regardless of whether they are experiencing flash flooding on the Mekong or central area flooding, people in these areas are facing substantial crop losses as well as serious food insecurity.

Second priority areas refer to areas that were severely affected by central area floods in 1996 and 2000 and were food insecure in 1996 and 2000.

Third priority areas are those that were severely affected by the flash floods on the Mekong in 2001, and that also faced food insecurity in 1996 and 2000. In these areas along the Mekong, the majority of the population are rice farmers who are not always able to produce enough rice for their own consumption. These people are thus particularly vulnerable to the flash floods.

Table 1. Criteria for Identifying Priority Areas for Assisting Vulnerable Populations in Flood Prone Areas

Criteria	First [1] Priority Areas	Second [2] Priority Areas	Third [3] Priority Areas
High rice dependency	Yes	Yes	Yes
Rice deficit in 1996 and 2000	Yes	Yes	Yes
Flooded in 2000 & 2001	Yes	Yes	Yes
>20% rice areas destroyed in 1996	Yes	Yes	No
>20% rice areas destroyed in 2000	Yes	Yes	No
>20% rice areas destroyed in 2001	Yes	No	Yes

[1] Areas have been flooded in 1996, 2000 and 2001 with greater than 20% rice planted areas damaged

[2] Areas have been flooded in 1996 and 2000 with greater than 20% rice planted areas damaged

[3] Areas have been flooded in 2001 by flash floods with greater than 20% rice planted areas damaged

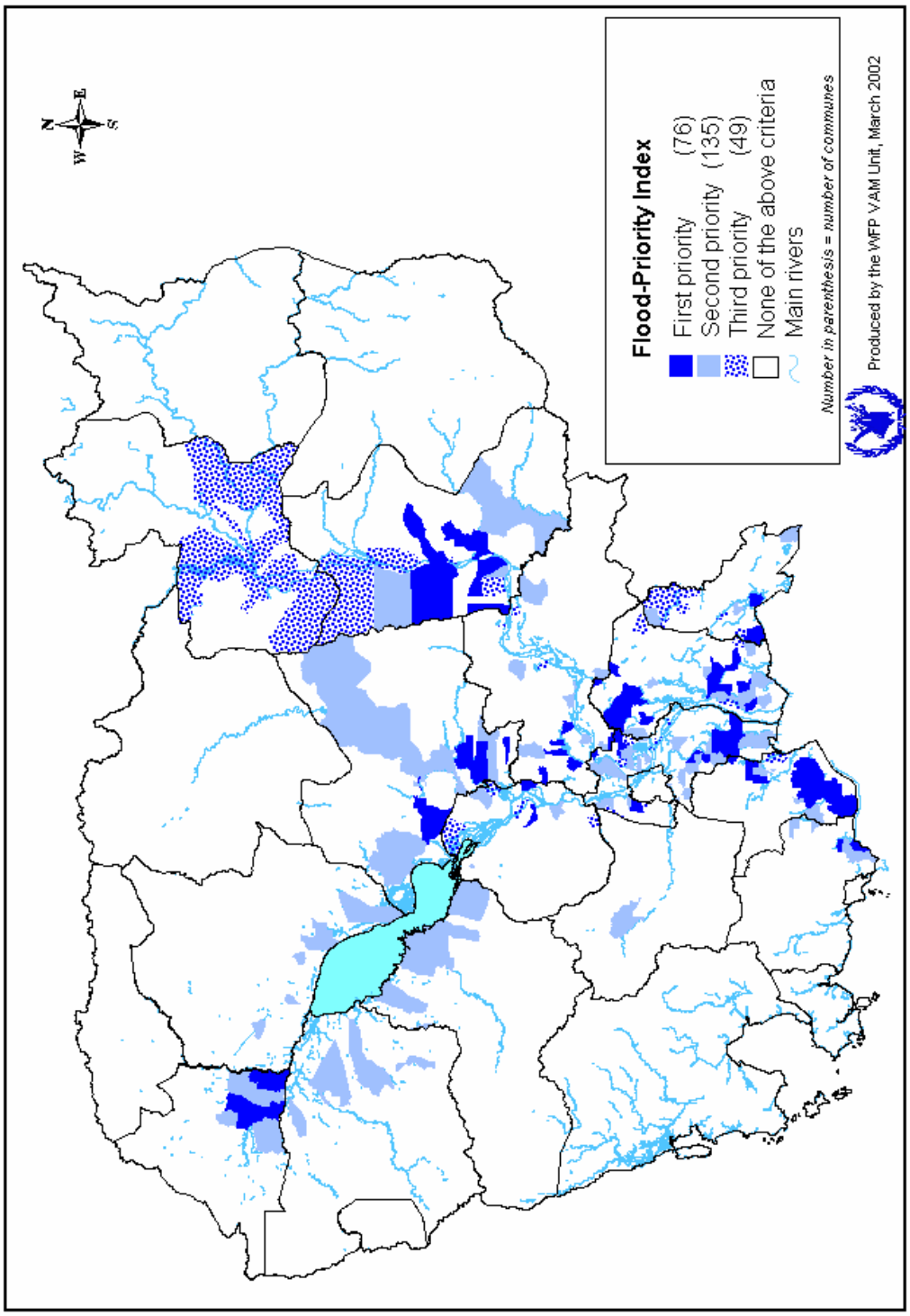


Figure 3. Priority Areas for Flood Interventions

3.2. Drought Prone Areas

As with the analysis of flood prone areas, three broad categories were considered in drought prone area analysis :

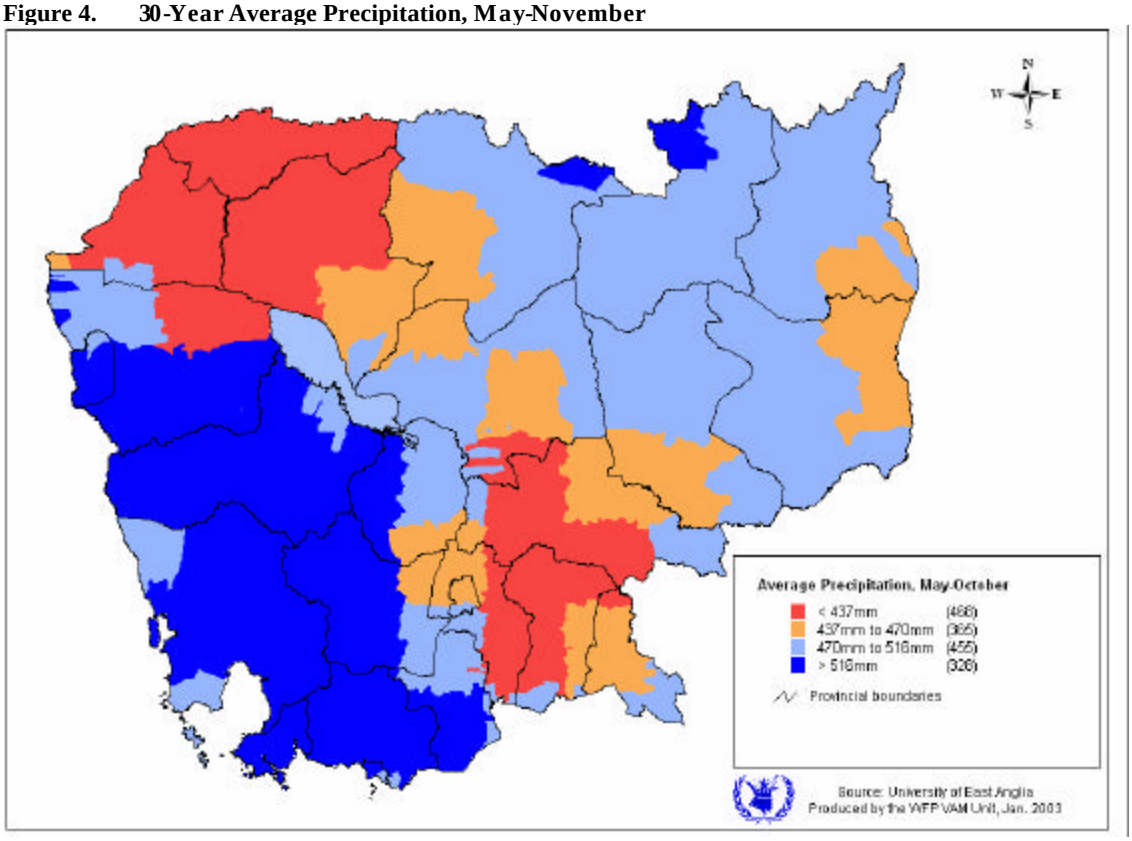
1. Drought affected areas;
2. Rice dependency; and
3. Food security based on rice production.

- *Drought affected areas*: Due to a lack of historical records on drought affected areas at geographical dis-aggregated level, geographical data sets were used to identify drought prone areas. Data sets of long-term average precipitation and NDVI were used in this analysis. Maps of long term average precipitation and NDVI have been generated for all communes in Cambodia at a very coarse resolution.

  Average precipitation data show that many parts of the country have received very high precipitation and other parts have received very little. The coastal areas, in the southwest of the country, receive the highest rainfall during the rainy season, May-October, as shown in Figure 4. This is due to the fact that during the wet season, monsoon rains sweep across the country from the southwest to the northeast. The Kravanh mountains, which run along the costal zone from the southwest to the northwest, often block the rains, and therefore receive more rainfall than other parts of the country. Figure 4 shows that these areas have received over 516 mm average wet season rainfall over the last 30 years.

  Other parts of the country received less rainfall during the same period. Highland areas in the east have received relatively high levels of rainfall while central areas have received lower wet season rainfall. The driest parts of the country are in the southeast and northwest, shown in Figure 4 in red and yellow. On average these areas received less than 470 mm per annum during the rainy season.

Figure 4. 30-Year Average Precipitation, May-November



As crop production and productivity are predominantly determined by rain distribution, NDVI, which captures the greenness of the ground and is often used as a proxy to measure agricultural productivity, varies accordingly. Its scale ranges from negative 1 for the least green areas, to positive 1 for the greenest areas. Within high average rainfall areas, NDVI is high, indicating higher crop productivity, with the opposite true in dry areas. Figure 5 shows 6-month average NDVI between June and November. It is clear that wet areas have higher NDVI, shown on the map in greens, and dry areas have lower NDVI, shown in red and orange.

Cropping intensity changes from month to month during the wet season, and monthly NDVI reflects these changes. Because the wet season normally starts in May, NDVI is generally lower in June than in later months and highest in November. Figure 6 shows monthly NDVI over the wet season.

Figure 5. 20-Year Average NDVI during Wet Season, June-November

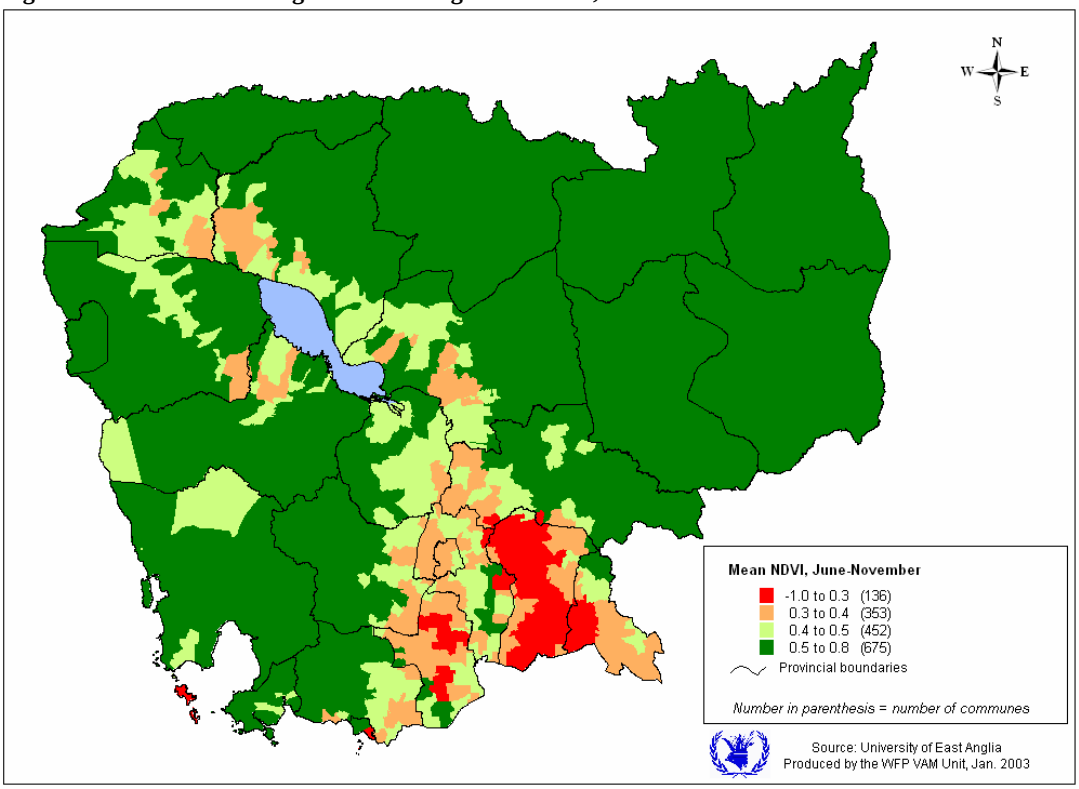
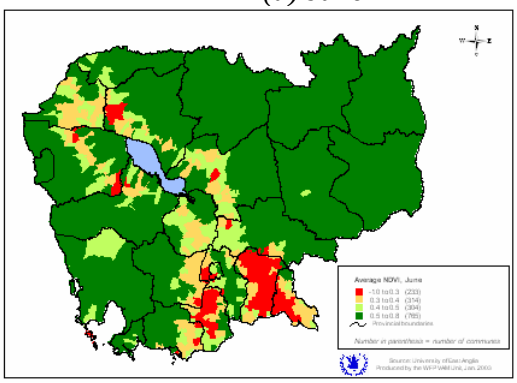
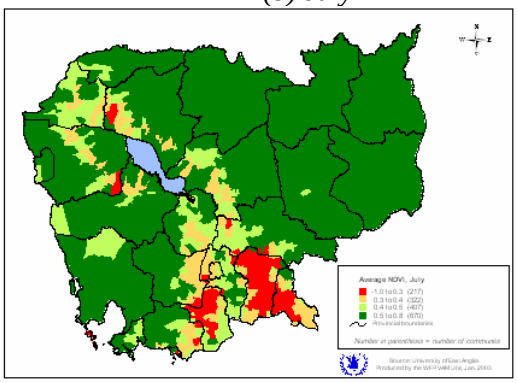


Figure 6. 20-Year Monthly Average NDVI

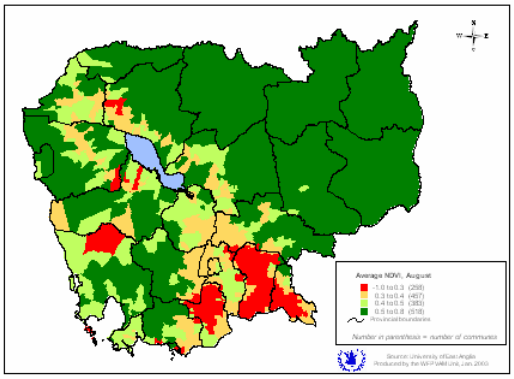
(a) June



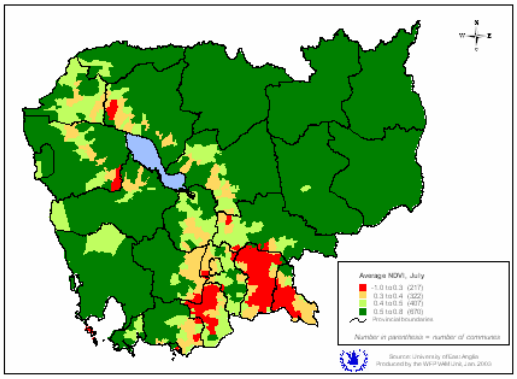
(b) July



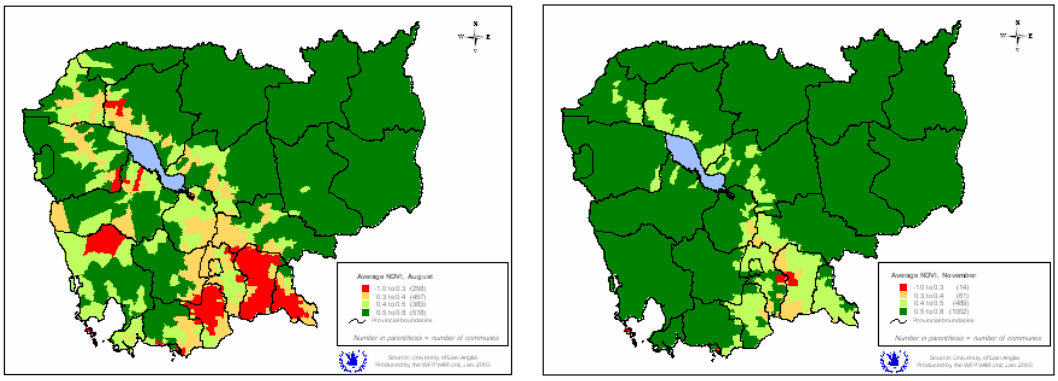
(c) August



(d) September



(e) October *(f) November*



- *Rice dependency:* As with floods, droughts have great impacts on Cambodian rice farmers, who depend extensively on rainfall. Annual precipitation is a determinant of rice productivity and rural food security. To identify concentration of rice farmers who live in drought prone areas, data of crop assessments in 1998, a drought year, have been used. Communes with greater than 80 percent of households fully engaged in rice production are considered to be high rice dependency communes.

- *Food security situation:* To assess family food security at a disaggregated level, rice production at commune level has again been used as a proxy. Crop assessment data from 1998 are used to calculate the food deficit/surplus at commune level based on a need of 152 kg milled rice per capita per year. A commune is classified as being food insecure or rice deficient if there are more than two months of deficit per capita per year.

By combining the above three indicators, priority areas for assisting vulnerable populations in drought prone areas can be identified and classified into three groups, as shown in Table 2 and Figure 7:

1st Priority: Areas where average precipitation and NDVI are less than 470 mm and 0.40 respectively. Over 80 percent of the population in these areas is also actively engaged in rice farming activities but they fail to produce enough rice for their consumption when

they are hit by droughts. It was estimated that the affected population in these areas had faced food shortages for more than two months per capita per year after they were severely hit by droughts in 1998. These areas should be given top priority for any drought related intervention programs.

2nd Priority: The criteria for second priority areas is the same as for first priority areas, except that these areas did not face food shortages as severe as those in the first priority areas.

3rd Priority: Areas where precipitation and NDVI are low, but the population is not highly rice dependent or food insecure. These areas are likely to face drought, but should be given a lower priority as the effects of droughts will not be are severe as in the first and second priority areas.

Table 2. Matrix of Priority Areas for Assisting Vulnerable Populations in Drought Prone Areas

Criteria	First Priority Areas	Second Priority Areas	Third Priority Areas
30 year average precipitation in 1st and 2nd lowest quintiles, less than 470 mm	Yes	Yes	Yes
20 year average NDVI in 1st and 2nd lowest quintiles, less than 0.40	Yes	Yes	Yes
High rice dependency, over 80 percent of population fully engaged in rice farming activities	Yes	Yes	No
Rice deficit in 1998, over two months of rice shortages per capita per year	Yes	No	No

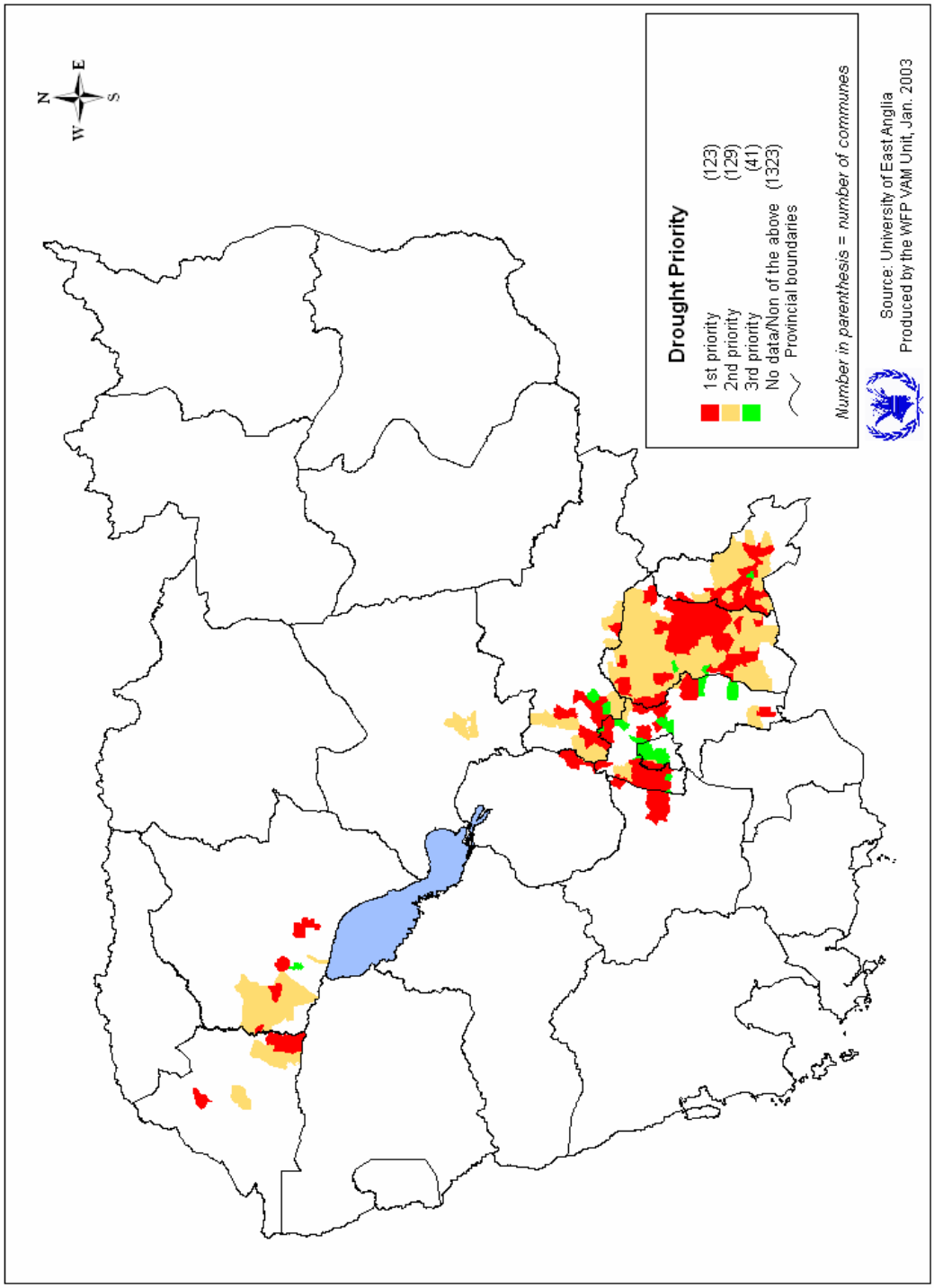


Figure 7. Priority Areas for Drought Interventions

4. Limitations

This study focuses mainly on food security and floods and droughts, but other factors should be taken into consideration when one makes a decision to provide interventions. For example, if the assistance is designed to provide better sanitation to populations in flood or drought prone areas, access to clean drinking water and latrines should be brought into the analysis.

Moreover, using rice production at the commune level as a proxy of food security in the communes might not accurately reflect the real food security situation. Detailed information on market access and the purchasing power of the affected population might be incorporated, once the data becomes available, and combined with the above analysis to better assess food security.

Appendix A. Crop and Food Supply Assessment Form

Ministry of Agriculture, Forestry and Fishery in cooperation with FAO and WFP
2000 Rice Crop Assessment (Commune Level Form)

Name of district officer: _____ District _____

Name of Commune officer: _____ Commune _____

Date of completion _____ Commune code [ ]

1. Number of Villages [ ]
2. Population of the Commune [ ]
3. Number of Households [ ]
4. Number of Households growing rice in 2000 [ ]
5. Area of land planted to paddy this wet season [ ]
6. Area of early wet season paddy

	Planted	Harvested
	[ ]	[ ]

7. Area planted to the following types of Rice in the main 2000 wet season

	Planted	Harvested
Early Maturing	[ ]	[ ]
Medium Maturing	[ ]	[ ]
Late Maturing	[ ]	[ ]
Floating Rice	[ ]	[ ]

8. Estimate of average yield for 2000 of all varieties

MT/ha [ ]

9a. Planned area to be planted for dry season rice ha [ ]

9b. Estimate of average dry season yield MT/ha [ ]

10.

	Flood	Drought	Pest
Area of rice affected	[ ]	[ ]	[ ]
Area of rice destroyed	[ ]	[ ]	[ ]

11. Area of rice affected by variety

	Flood	Drought	Pest
Early Maturing	[ ]	[ ]	[ ]
Medium Maturing	[ ]	[ ]	[ ]
Late Maturing	[ ]	[ ]	[ ]
Floating Rice	[ ]	[ ]	[ ]

12. Area of rice destroyed by variety

	Flood	Drought	Pest
Early Maturing	[ ]	[ ]	[ ]
Medium Maturing	[ ]	[ ]	[ ]
Late Maturing	[ ]	[ ]	[ ]
Floating Rice	[ ]	[ ]	[ ]

13. Area of other crops grown during this agricultural year

	ha		ha
Maize	[ ]	Sweet Pot	[ ]
Cassava	[ ]	Groundnut	[ ]
Vegetable	[ ]	Sugarcane	[ ]
Mungbeans	[ ]	Tobacco	[ ]
Soyabeans	[ ]	Sesame	[ ]

Others 1. _____ [ ]
2. _____ [ ]
3. _____ [ ]