

**SADC REGIONAL EARLY WARNING SYSTEM
FOR FOOD SECURITY**



Thematic Mapping:

A Practical Guide for Early Warning Monitoring and Reporting

Concepts and Essential Map Presentations

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PREFACE

The SADC Regional Early Warning System (SADC/REWS) operates as an integrated activity, comprising a **Regional Early Warning Unit** (REWU), based in Harare, and autonomous **National Early Warning Units** (NEWUs) in each of the 14 SADC member States. Activities of the National Early Warning Units are coordinated by the REWU, which acts as the Secretariat of the REWS.

The main **objective** of the SADC Regional Early Warning System is to provide user groups of early warning/food security information, particularly SADC member States and the international community, with **advance information on food security prospects in the region** through assessments of expected food production, food supplies and requirements.

The REWU thus is aimed at providing SADC, the member States and other user groups with early warning and food security information on:

- ❖ food crop performance;
- ❖ crop failures and subsequent shortfalls expected in food availability; and
- ❖ food stocks and projections of food needs.

The REWU compiles food security data for the SADC region, based on submissions from the NEWUs via fax and e-mail, and aggregates these for subsequent publication in a **Quarterly Food Security Bulletin**, supplemented by **Monthly Food Security Updates**. Similarly, the NEWUs themselves prepare national food security bulletins. Ad-hoc reports are submitted directly to decision-makers, as required.

The Famine Early Warning System Project (FEWS) is an USAID-funded project managed by the Associates in Rural Development (ARD, Inc.). FEWS is associated with SADC's Food Security Technical and Administrative Unit (FSTAU) primarily through its collaboration with the Regional Early Warning Unit (REWU) and the Regional Remote Sensing Project (RRSP), and to a lesser degree other FSATU projects. FEWS works with both the REWU and the national early warning units in most SADC-member countries.

This manual was an agreed upon product that was requested by the Regional Early Warning Unit to assist them in their support of the National Early Warning Units in SADC member States. This manual is divided into two volumes. **Volume 1** contains some important thematic mapping concepts, the type and timing of making different map presentations and some presentation suggestions. **Volume 2** contains the step by step instructions on how to make the maps described in Volume 1 using MapViewer Version 2.00.

Other manuals that are completed or near completion include: "Price Analysis for Early Warning Monitoring and Reporting" and "Vulnerability Analysis for SADC Countries: A Suggested Approach for Early Warning Units".

The author would like to thank all people who provided useful comments in the completion of this practical manual.

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ACRONYMS

FEWS	Famine Early Warning System (USAID/ARD)
FSTAU	Food Security Technical and Administrative Unit (SADC)
GIS	Geographical Information Systems
NEWU	National Early Warning Unit
REWU	Regional Early Warning Unit (SADC)
RRSU	Regional Remote Sensing Unit (SADC)
SADC	Southern Africa Development Community
USAID	United States Agency for International Development

Chapter 1

INTRODUCTION TO THIS MANUAL

Introduction

The purpose of this manual is to provide guidance to National Early Warning Systems (NEWS) to improve the presentation of early warning data and information. Thematic maps are a powerful method to illustrate situations that have a spatial nature (e.g., droughts or floods). In these situations maps can more effectively provide a decision-maker with an understanding of an issue. This manual will guide early warning professionals in the following areas:

- Thematic mapping concepts and fundamentals
- What types of thematic maps should be made
- How to make different key thematic maps
- How to know when a map is the appropriate presentational format to use
- To build on past documents and training activities done by the RRSU and FEWS/SA

Using this manual

This manual is intended to be of use to a number of different early warning or food security users, but it is especially designed for those working in National Early Warning Units. Some users will be making thematic maps for the first time, and others will have had some experience. All users are recommended to read Chapter Two where some basic thematic mapping concepts that are necessary to guide the analyst's conceptual thinking are discussed.

Software selection

The concepts in this manual can be used to make thematic maps using any Geographical Information Systems (GIS) software. Still, the decision of which GIS software to use is an important consideration ranging from simple to complex in terms of ease of use and functionality. Although not always true, the simpler to learn software tend to have a smaller range of functions. In terms of making thematic maps (and not actually doing spatial analysis), simpler software that is cheaper and easier to learn is a good choice. An example of this simpler GIS software is MapViewer. GIS software that has a much larger range of functions that permit statistical analysis over space tends to be more expensive and harder to use.

In the appendices of this practical guide are all steps to actually make the maps are described. MapViewer will be used as the GIS software for three reasons. First, this software is relatively easy to learn and use. Although this software does not permit complex spatial analyses, it does provide simple procedures for producing thematic maps. Second, this software is relatively inexpensive compared to software that have a full range of GIS functions. Finally, this software is used by all of the Departments of Meteorology in SADC countries (provided by RRSU). Increasingly, this software has been used for training to staff in NEWUs in SADC countries.

This manual will also be useful to others that do not use MapViewer since it will be oriented towards novice thematic mappers and what types of maps can be made regardless of which GIS software is used.

Organization of this manual

This manual provides a combination of introductory thematic mapping concepts and guidance on how to produce thematic maps that are useful for early warning monitoring for food security. Specific suggestions are provided (for example font type and size). These should be taken as suggestions only, and not the only way these themes could be presented. Making thematic maps is an art, and as one gains experience in making maps it becomes easier to make more effective map presentations. The suggestions offered in this manual should be seen as a starting point for novice users.

This manual is divided into 6 chapters, with each chapter describing and guiding the reader to understand or complete different parts of the process of making thematic maps. The organization is intended to assist the reader to make effective thematic maps for early warning monitoring and reporting.

Chapter 2: Thematic mapping concepts: Topics include an explanation of what thematic maps are, an explanation of the difference between GIS and thematic mapping, some basic thematic mapping concepts, why thematic maps are a useful format for certain presentations, what makes a good thematic map, different types of thematic maps, sources of map data, and some map data issues.

Chapter 3: Making presentable base maps: Topics include different types of base maps, the steps to make useful base maps, suggestions on when to make base map presentations, and examples of some of the types of base maps that could be made.

Chapter 4: Thematic maps to monitor the agricultural season: Topics include why and when to make maps that show the current status and changes in the agricultural season such as weather conditions, the crop situation, or the livestock situation.

Chapter 5: Thematic maps to monitor changes in food security: Topics include when and what types of thematic maps should be made to present the results of current vulnerability

assessment, price analysis, outcome measures of vulnerability, or risk factors to food security.

Chapter 6: Presentation suggestions: Suggestions on making an effective map presentation include font size, working with text, size of a map composition, color and shading patterns, and legends.

Appendix 1: This Appendix presents a bibliography of useful GIS references.

Chapter 2

THEMATIC MAPPING CONCEPTS

Introduction

Thematic mapping is an easy, but powerful tool for early warning and food security monitoring and reporting. Although this manual focuses on the “how to” and “when to” of making thematic maps, some basic thematic mapping concepts are essential to understand how to make effective map presentations.

Other documents that are available in southern Africa (such as the RRSU manual on GIS) provide more background on GIS and thematic mapping. These documents include:

- SADC Regional Remote Sensing Unit Working Paper No 4, “Filename convention” (June 1997)
- SADC Regional Remote Sensing Unit Working Paper No 6, “RRSP CD-ROM (version 1.0)” (March 1998)
- SADC Regional Remote Sensing Unit Training Paper No 3, “Vector files in BNA format” (June 1997)
- SADC Regional Remote Sensing Unit Training Paper No 5, “RRSP GIS Workshop” (June 1997)

Topics covered in this section include an explanation of what thematic maps are, why thematic maps are a useful format for certain presentations, what makes a good thematic map, different types of thematic maps, sources of map data, and some presentation suggestions.

What are thematic maps?

A thematic map is exactly what its name implies. It is the presentation of a particular subject or issue (theme) represented spatially on a map. Thematic maps are only one way to present data and information and are best used to show spatial variation of a situation or condition. If there is no spatial aspect to the situation or condition then a thematic map is not necessarily the best format to use.

What is the difference between GIS and thematic mapping?

Geographic information systems (GIS) and thematic maps are very similar concepts and use the same building blocks to construct their products. To understand the similarities and differences, a simple definition of each is offered:

- A *geographical information system (GIS)* can be defined as a database that captures the spatial relationship between data for both display and analysis. This spatial analysis can range from quite simple to very complex, and requires data that are as precise as possible. The functions of a GIS that are not included in thematic mapping software are map digitizing, database management, and a facility for spatial analysis.
- A *thematic map* is a map presentation that displays a simple subject (theme) to spatially illustrate a specific situation or condition. The situation or condition is represented geographically. Actually, a thematic map is a simple GIS that allows only the presentation aspects of a GIS software. In early warning, thematic mapping is used to show those situations or conditions that represent an improvement or deterioration in the food security status of households or populations.

Although thematic mapping software is a GIS software, it has a more limited functionality. That is why the upper-end GIS software is more complex and more expensive¹. These software packages (e.g., Microstation Intergraph and ArcInfo) are valuable if there is a need for spatial analysis beyond visual inspection. Conversely, a software package that is intended only for thematic mapping (no or limited database and analytical functions) tends to be easier to learn (and use) and much less expensive. It is with this orientation that National Early Warning Units in southern Africa are being instructed in using simpler software (MapViewer) to make thematic maps.

Some basic concepts that are used in thematic mapping

The purpose of this section is to provide enough GIS concepts to permit the construction of clear and concise thematic map presentations. GIS is a complex, but well documented tool. There is more information (and in greater detail and specificity) available in other publications (e.g., RRSU document and others—see Appendix 1 for a selected bibliography): This document will provide just enough to get the analyst started making maps. Readers are encouraged to read other documents and consult a GIS expert for more advanced GIS procedures. The fundamental subjects to cover are what are vector maps, the types of objects in a vector map, and layers.

¹ An additional problem with a GIS is that the error terms of the data associated with each layer in the GIS are added. With the variable quality of some datasets in southern Africa, the precision of many types of spatial analysis would be questionable.

What is a vector map?

Although a complete explanation of the different formats and structures for map data are beyond the scope of this manual, an introduction of these topics is essential to the understanding of thematic mapping concepts. A *vector* map structure is one that has points, lines or polygons that can be digitized. An alternative structure called *raster* is when map data are composed of small uniform grids (an example of this is satellite imagery). This manual concentrates on providing the skills to make vector map presentations, which is what national early warning units need to be able to produce for their readers. Raster images are more related to what a Department of Meteorology is required to produce for their readers and require different software.

Vector maps in southern Africa are available in a format known as BNA, which stands for Boundary ASCII files. These files are frequently used given that they are in a common file format (ASCII) and therefore can be easily imported into almost any commercial thematic mapping software. Another feature of BNA maps for more advanced users are that they can be created or edited within any text editor or word processing software. The Regional Remote Sensing Unit has amassed a comprehensive set of BNA maps for southern Africa that is available on a CD.

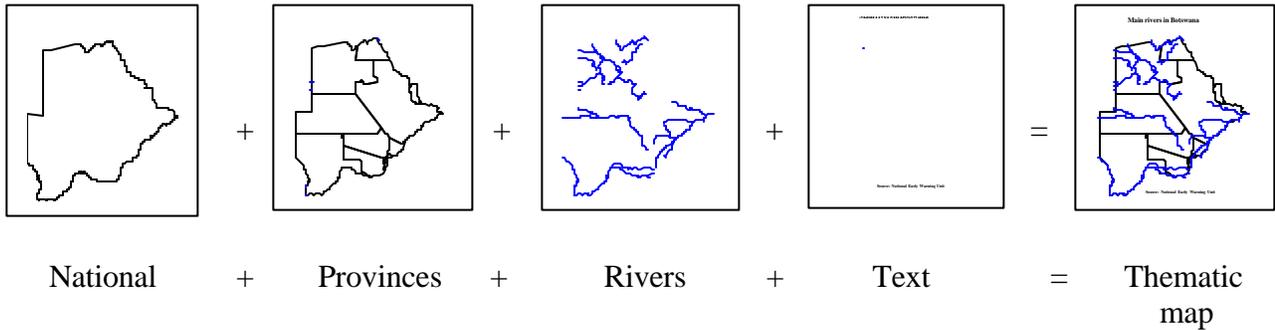
Types of objects in a vector map:

1. *Point*: A point is a single place in geographic space. Some examples of points are cities, airports, markets, ports, storage depots, or rainfall stations.
2. *Line (also called a curve)*: A line is a series of points that do not close (like they do in a polygon). Some examples of lines are roads, rivers, and railroads.
3. *Polygon (also called a region or an area)*: A polygon is a line that closes upon itself (the beginning of the line touches the end of the line). Examples of polygons are national, provincial, and district administrative boundaries.
4. *Symbols*: Symbols can be added to your vector map. These symbols can either represent a situation or condition within the map composition or can be a logo of the organization that produced the map.

Layers

Layers are the building blocks of a thematic map. A useful analogy is that layers are like transparent pages in a book. They contain different data (map or tabular) or text and when viewed from the top all of the data and information on the pages can be seen at the same time. For example, a map that contains a country's national and provincial boundaries (polygon map data), the main rivers (line map data), and some text (titles, sources, and so on) would be four layers that combine to make a thematic map (see Figure 2.1).

Figure 2.1: Components of a thematic map



In the above example, each layer holds a different component of the thematic map. Each map data component (national, provinces, and rivers) is kept on separate layers, including a separate layer is used for text. The purpose for this separation is that it permits each layer to be edited and transformed individually. Also, maps created using thematic software can be exported and used in making other maps or used in other analysis (e.g., to extract remote sensing data).

Why make thematic maps?

Like any presentation format, maps have their appropriate use. Still, maps are only one type of presentation format (others are text, tables, and graphs/charts). The trick is to decide when it is appropriate to use which format. Simply put, a thematic map is the appropriate format if one is trying to show the spatial aspects of a food security issue (e.g., flooding, poor harvest, or crop pest infestation) that would be less clear if just describing it with text, and even less clear in a table or graph. In this situation a thematic map is an effective presentation format (concise and visual). A map can quickly guide a reader to visually identify spatial patterns and suggest further analysis or follow-up. Thematic maps also can group multiple issues relating to a common theme on a single map. For example a harvest prospects map may also include information on flood, drought, and pest damage to explain the harvest outcome.

What constitutes a good thematic map?

Although it was stated earlier, it bears repeating: making thematic maps is an art. The key to making effective thematic maps is to make a map that presents a theme that captures both the event that is occurring (or that has occurred) and the eye and imagination of your target audience. This is more difficult that it sounds. Also, for an effective map to be constructed good data or information should be available. If not, there is a danger that a map may initiate some action or decision that is problematic. Some of the basic components of a good map are:

- *Clear title:* A clear title orients the reader as to the theme of the map, the time frame, the scope (e.g., country or region), and the severity of the situation. This is the first thing that a reader will look at. If this is not clear, the reader may not continue looking at the map.
- *Appropriate map administrative level:* The selection of whether the national, provincial, or district boundary is appropriate for a particular map presentation should be based on the theme and the aggregation of the data or information. One should be careful not to include an administrative boundary that is too specific if it is not necessary as it makes the map look more busy and complicated.
- *Simple concept:* The more concepts the map includes the more complicated and confusing the map becomes. It is recommended that on each map only one or two closely related themes be presented (e.g., flooded areas of Zambia **or** drought prone areas of Namibia).
- *Logical color or shading patterns:* Color and shading can be used to quickly guide the reader to understand the theme behind the map. This is true only if the color and shading patterns are selected in a logical manner.
- *Clear legend:* The legend explains what the symbols and colors (or shading pattern) on the map mean. Clarity here is also very critical.
- *Include sources of data and who prepared the map:* The map has to be attributed to someone or an organization, if only to you or your organization. This guides the reader where more information or data on the theme can be obtained.
- *Appropriate size:* The size of the map presentation can range from less than a quarter of a page to a full page. The decision of the size depends on the importance of the map, the level of detail, and the type of presentation. Larger maps should be used for very important maps, maps with a lot of detail, or if the presentation is to be made orally to a group.
- *Include date produced:* In early warning there is often the need to do certain maps many times during a season. Adding a date to a map guides a reader as when the situation illustrated in the map was appropriate.

Different types of maps

Although there may be many ways to classify thematic map types, this manual will differentiate between two basic types—base maps and theme maps. The difference between these two types of maps is:

- *Base maps*: A base map presentation is a map (or maps) that show a spatial representation of administrative boundaries, infrastructure (e.g., roads, rail lines, clinics, or markets), or physical endowments (e.g., rivers or watersheds).
- *Theme maps*: A theme map is a map presentation that presents a specific theme or situation geographically (over space). Some issues are better presented in a thematic mapping format than others (e.g., pasture conditions or harvest outcomes) since the spatial presentation of the event helps identify patterns and suggests potential explanations for why an event is developing the way it is.

Map data issues

Sources of map data

Sources of map data depend on the type of data desired and whether one is looking at the regional or national level. It should be emphasized that data that already exist should be exploited before deciding whether to digitize data. In southern Africa map data are available on a regional and national level from the following sources:

- *Regional level*: SADC RRSU has a complete digital map database of the SADC member states that includes administrative boundaries (e.g., provinces and districts), transportation (e.g., road and rail), hydrology (e.g., rivers and lakes), and topography. Also crop zones and other land covers (e.g., parks, wetlands, ...) are available for all countries except the democratic Republic of Congo and the Seychelles. The SADC Regional Remote Sensing Unit has coordinated the collection and verification of these digital maps. These digital maps can be obtained by contacting the Coordinator of the SADC Remote Sensing Unit at the Food Security Technical and Administrative Unit in Harare.
- *National level*: All of the digital maps available for a particular country at the SADC FSTAU should be available in that country. Suggested sources are the Department of Meteorology, the Surveyors General, and GIS units. Often there are additional maps available that could be of use in some countries. Also, there are often hardcopy maps that are available, but it is quite costly to digitize them.

Managing digital map data

Managing digital map data is the same as managing any data. The first task is to establish *a logical structure of subdirectories* for data and outputs. The names of subdirectories should refer directly to the contents of the subdirectory. The second task is to establish a simple, flexible, and useful set of *file name conventions* that facilitate the location and identification of what each file contains. Others (e.g., SADC RRSU) may have already done this in your region. The next step of data management is to develop and maintain careful and

comprehensive *documentation of the data and files*. The final data management activity that should be understood is the need to establish a regular schedule to *backup the data and information*.

One valuable piece of advice is to archive (save) maps in the BNA format. In addition to this being a simple and easy to use format it has the added benefit that it can be easily shared with other users. **Also, it is advised to never use the original copy of a map.** It is best to archive (store) the original copy of the digital file separately and use a copy of the map file for your use in making thematic maps. The justification for this is that it is easy in most thematic mapping software packages to alter the map file without providing a way of undoing the changes. These changes are almost always written immediately to disk. Having a back up of the original digital map file is the only way to recover from an accidental change of a base map. In this case it important to have an unaltered set of map data.

Another suggestion is not to store (save) your data or analysis in the same location as the computer software that you are using. It is easy to accidentally delete a key file that runs the software when deleting or moving data or analysis files. It will also be easier to locate a file if the data are stored separately.

Preparation of associated data sets

To make thematic maps data and information must be collected and prepared. An example of these data sets for early warning is agricultural production data. To prepare these data sets for incorporation in a thematic map three steps need to be done. First, these data need to be cleaned and verified. Presumably this is already done for many key data sets, but it is not necessarily true for field reports or other subjective information that can be used in a thematic map. Second, the data sets have to be organized into a single file that contains the data that is going to be included in the thematic map. Finally, the data set needs to be given a geographical code that can then be linked with the map data. Although these geo-codes can be numeric, they are more often alphanumeric (letters). Examples of this are provincial or district names. The geo-codes have to be identical to those contained in the map file or the data will not be properly linked.

Chapter 3

MAKING PRESENTABLE BASE MAPS

Introduction

Base maps are the foundation for all thematic mapping. A base map is the map that other maps are put on top of (overlaid) to present a theme. Still, base maps can be shown by themselves, with no attached theme, to be used as a reference to illustrate the spatial presentation of administrative boundaries, infrastructure (e.g., roads or rail lines), or physical endowments (e.g., rivers). Still, it is necessary to know how to make a presentable base map for your audience since it provides the context to support text in reports or presentations.

This chapter will illustrate three types of base maps: provinces in Swaziland, rivers in Lesotho, and major population centres in Botswana.

Types of base maps

- Administrative boundaries (for example national, provinces, and districts)
- Transportation (for example roads, rail, sea ports, and airports)
- Hydrology (for example rivers and lakes)
- Topology (for example elevation)
- Land use (for example forests, parks, and wetlands)
- Infrastructure (for example bridges, markets, and clinics)

When to make base map presentations

Base maps are the physical context for other information or data that is either reported to us or that we report. These maps can provide a decision-maker with a spatial understanding of an issue or event. These map presentations should be made and stored for use in publications to show the location of events when reporting (either written reports or oral briefings).

An example using provinces in Swaziland

This example uses provinces in Swaziland since there are only four and it is an easy map to make. This map, however simple, is still useful to show the relation of the provinces. If one is reporting on the food security conditions or an emerging problem in a particular province, it can be easily understood. For clarity of reporting (whether in a document or during an oral presentation), the visual illustration of administrative boundaries is useful. Also, in some countries such as Botswana, where the sub-national administrative periodically change, it is important to document these changes by making base maps for the different administrative boundaries for the different administrative configurations.

Provinces in Swaziland

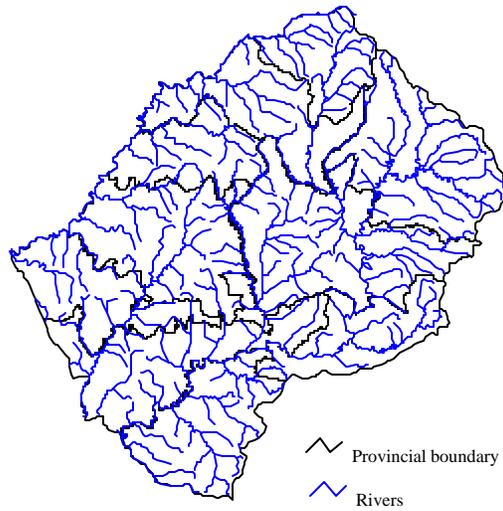


Data source: Swaziland Survey General's Office

An example using rivers in Lesotho

The steps to make this map it is almost identical to the Swaziland provincial map described above. The difference between this map and the previous one is that this map will require that a second digital map (rivers) be placed over top (overlaid) of the administrative map. These maps should be brought into the thematic mapping software on separate layers for ease of manipulation (turn on/off, save, delete). This is a more interesting map than the previous map since it shows a particular physical feature of a country (rivers) in relation to the administrative boundaries. As in the previous example, Lesotho was selected since it has a small number of provinces and rivers.

Rivers in Lesotho

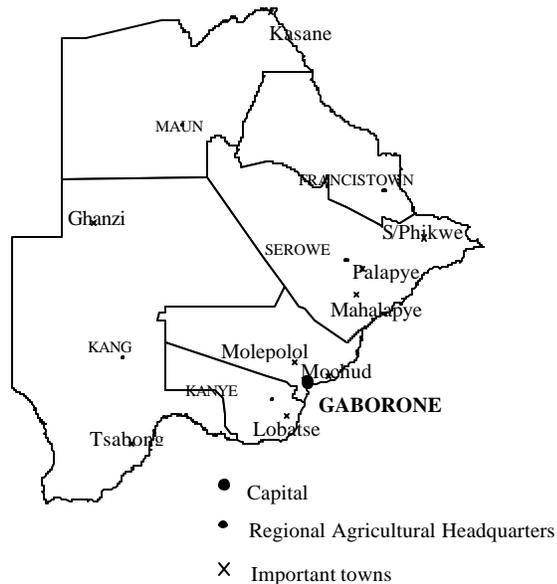


Data source: SADC Regional Remote Sensing Unit
Thematic map: Disaster Management Unit

An example of population centres in Botswana

Another example of a base map is when point data are used to show, for example, cities, markets, and rainfall stations. This is also a very simple map to prepare. This map is useful to give context for early warning and food security monitoring.

Major Population Centres in Botswana



Data source: SADC Regional Remote Sensing Unit
Thematic map: Food Security Section/Ministry of Agriculture

Other examples

Other maps that would be useful include provincial boundaries with major cities, district boundaries (with labels), the transportation network (roads, rail, and ports), major cropping zones, agro-climatic zones, topography (elevation), and land use.

The digital maps needed for these presentations are available regionally and nationally from the sources identified in Chapter 2. Although simple, these maps are powerful in that they spatially show key physical or administrative characteristics of a country.

Chapter 4

THEMATIC MAPS TO MONITOR THE AGRICULTURAL SEASON

Introduction

The making of thematic maps to illustrate the progression and performance of the agricultural season is more complex than was the case with base map presentation. Still, these maps are extremely important to decision-makers. These maps are a simple and quick way to understand the status of the agricultural season from a spatial perspective.

Unlike the base map presentations explained in the previous chapter, the thematic maps discussed in this chapter will require the analyst to have data or information about the condition or event that is to be mapped. This will require close consultation with experts in many other disciplines. In some cases, as with the maps that display weather conditions, it is generally better to rely on experts to generate the maps. Some of the conditions or events will occur by administrative unit (e.g., area planted), and some will not follow the administrative boundaries (e.g., pest problems). Both of these approaches will be covered in this chapter. It is recommended that a base map (either provinces or districts) be printed out when visiting the appropriate expert so that the spatial dimensions of the condition or event can be drawn by hand. This will allow a discussion and an iterative movement to the most accurate representation of the situation that forms the theme of the map.

This chapter will discuss the development of three types of thematic maps to monitor and report on the agricultural season. First, maps that show the current weather situation will be presented (including rainfall anomalies, areas that are experiencing either drought or floods, and cyclone damage). These maps should be done to the extent possible with the national Department of Meteorology. Second, maps that show the crop situation will be presented (including start of the agricultural season, area planted, crop development, crop pest assessment, pest problems, projected harvest prospects, and actual harvest outcome). These maps will provide a useful summary of different critical aspects of the crop development and performance for decision-makers. Finally, maps that show the livestock situation will be presented (including animal health and pasture conditions). These maps are very important in specific parts of SADC—most importantly Botswana, Namibia, and southern Mozambique—because of the contribution of livestock to rural household income.

Weather conditions

Data and information on weather conditions should be available from the national Department of Meteorology. These maps should be done to the extent possible jointly with the national Department of Meteorology. In all cases any maps made about weather conditions should be discussed with the Department of Meteorology in your country before you include them in a publication.

1. Rainfall

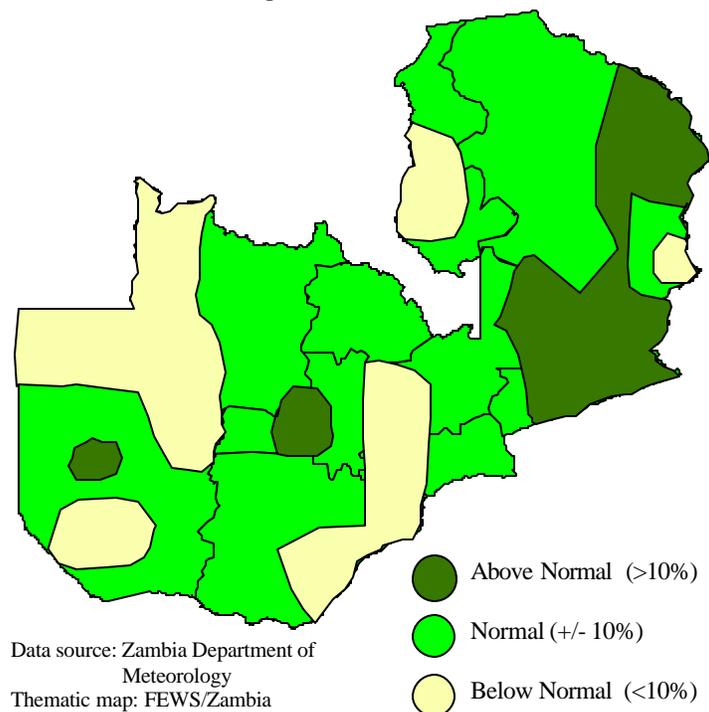
Rainfall maps level should be available from the Department of Meteorology in your country. There are occasions that you might want to reproduce such a map (giving credit to them or working together) for a presentation or report.

Why produce this map? The reason to make this map is that it provides a spatial look at the deviation of the cumulative rainfall compared to average. Unlike many data sets that are available, rainfall statistics have been kept for many years (e.g., in Zimbabwe rainfall data go back to about 1900). Therefore, the mean rainfall is a good measure of central tendency and contextual measure. In the Sahel, rainfall has a cyclical mean and a shorter-term mean is more representative of current conditions.

When and how often should this map be produced? This map should be done every week or ten days—depending on the reporting schedule of the Department of Meteorology—during the entire agricultural season.

Associated maps: Similar maps could also be made to compare on period (e.g., dekad) to another period (e.g., the same dekad for the 30-year average) or to show areas that have received insufficient rainfall for planting for a certain date.

**Cumulative rainfall situation through the second
dekad of November (1997)**
(produced 10/12/97)



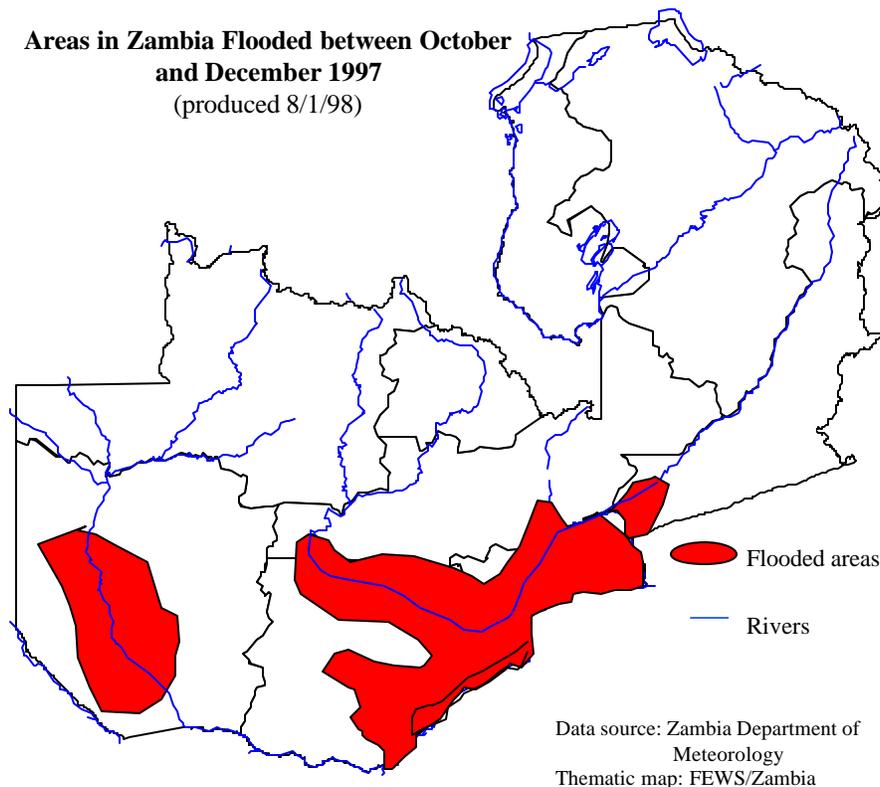
2. Areas of droughts or floods

The making of a map that shows areas with flood or drought problems is exactly the same procedure as making the previous map. The only changes are that a different national boundary map, a river map is imported to a separate layer, and that there are different shapes to the area (polygon) that is drawn on a separate layer. Importing a river map is important in this example because they provide the required context. Although flooded areas in Zambia is used as an example, the procedure is also exactly the same for drought affected areas.

Why produce this map? The reason to produce this map is that it clearly indicates where a drought or flood has the potential to affect household food security. The result is a tool for decision-makers to focus on a specific problem in a specific area and decide whether or not intervention is required.

When and how often should this map be produced? These maps are not done routinely, only when an event like this occurs. If there is no drought or flood affected areas, there is no need to produce this map.

Associated maps: A similar map could also be made of areas with drought or fire damage.

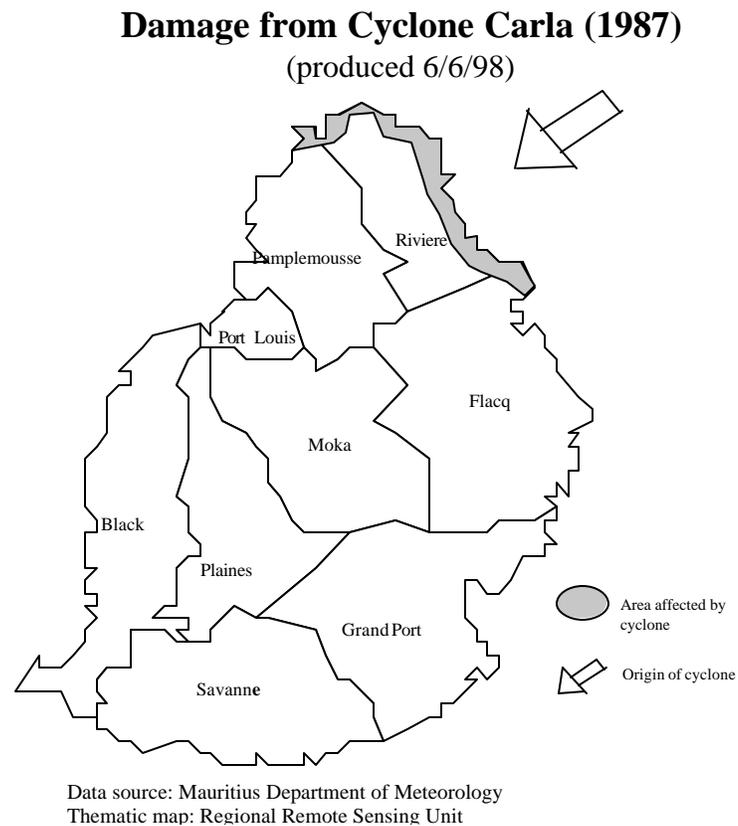


3. Cyclone damage

Although Mauritius has a small agricultural sector, it is one of the few countries in the SADC region that is regularly affected by cyclones (the other countries that are affected are Mozambique and southern Tanzania). Data and information about cyclones can be obtained at the Department of Meteorology.

Why produce this map? The reason to produce this map is that it shows a clear indication of where a damage from a cyclone has the potential to affect household food security through the damage to crops and personal possessions. This type of map assists decision-makers understanding where and the extent of damage so that they can take action.

When and how often should this map be produced? These maps are not done routinely, only when an event like this occurs. If there is no cyclone damage, there is no need to produce this map.

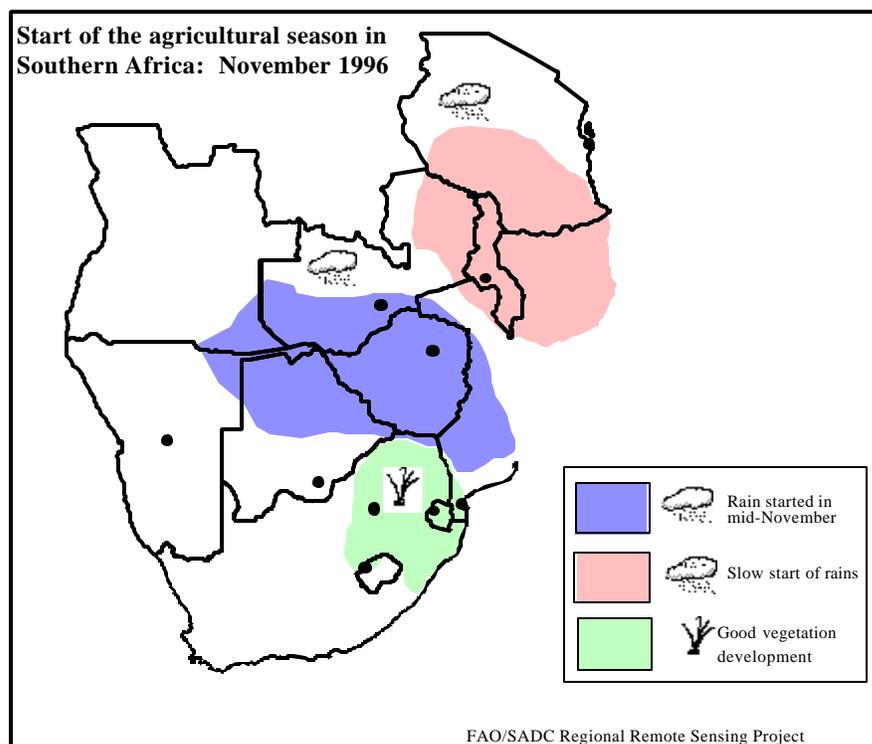


Crop situation

1. Start of agricultural season

Why produce this map? The start of the agricultural season is a very important aspect of early warning monitoring. First, there tends to be more variability at the beginning of a season than at the end the season in rainfall. The implication of this is that those areas that begin an agricultural season late have a higher probability of having a truncated season (if the rains stop on schedule). This would result in losses that range from a slight decrease in yield to heavier losses. Second, it is important to monitor the start of the agricultural season to compare it to the season forecast and to previous seasons (e.g., a drought year or a good year).

When and how often should this map be produced? This map should be produced after the agricultural season should have begun (e.g., planting crops normally begins in December for most of southern Africa and in January for Namibia). This map should be made one and then two months after the normal planting date.



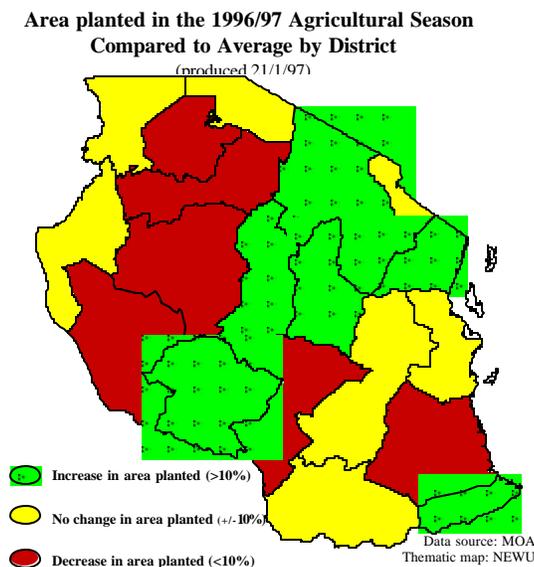
2. Area planted

A map of the area planted is important to give an early indication of what the potential production could be under different yield scenarios. Also, this is the first map in this manual that it is important to discuss comparison to a benchmark to put the available data (area planted) into the proper context. The benchmarks that are most useful are average, a particularly bad year (e.g., the 1991/92 agricultural season), or a particularly good year (e.g., the 1992/93 agricultural season). The data by themselves are not as powerful as when they are compared to a benchmark.

Why produce this map? As mentioned this map shows the spatial picture of the area planted for the current agricultural season. In early warning, an early as possible understanding of the area planted (compared to previous years) will provide an indication of potential agricultural production when combined with indicators of how the crops are doing. Measures of crop performance can be obtained from satellite imagery (e.g., Normalized Difference Vegetative Index—NDVI) or crop reports. The amount and distribution of area planted is a key component into an understanding if a food security problem is developing.

When and how often should this map be produced? This map should be produced each time an official measurement of area planted is made. The timing is different for different countries in southern Africa. Separate maps should be made for all important staple and cash crops.

Associated maps: Another equally important analytical activity would be to take the area planted estimates, multiply them times low, average, and high yields to get a range of production estimates. In addition to getting the total amount of production, a district-level comparison of the calculated production estimates under the different scenarios and compare then to the average production estimates. This would give decision-makers an early indication of the range of possibilities of the harvest outcome for the agricultural season.



3. Crop development

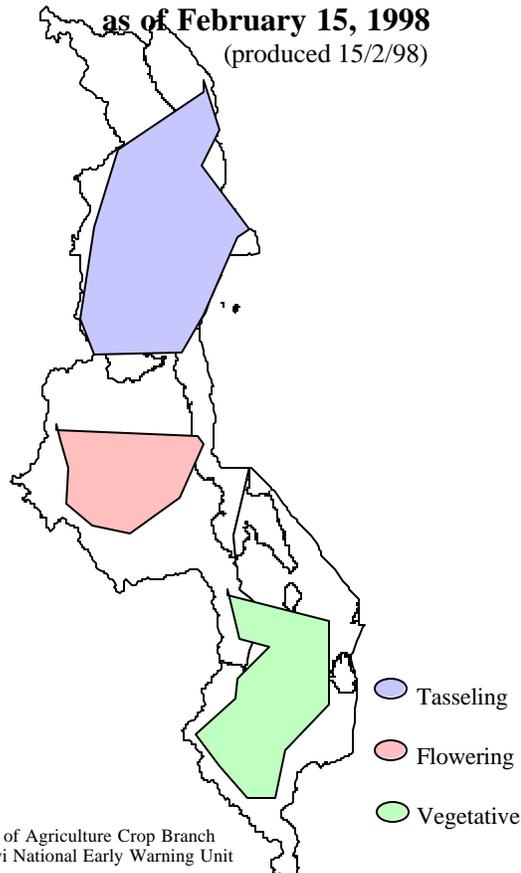
Another important aspect of early warning monitoring and reporting is the development and condition of crops. During the agricultural season this monitoring is central to early warning activities.

Why produce this map? There are two reasons to make these maps. First, the users of early warning information will appreciate this information in map format (easier to see spatial variability). Second, it will provide a temporal view of the season that will be useful to assess the current season, and will be a useful archive of the season for future comparison.

When and how often should this map be produced? These maps should be constructed every month.

Status of crop development in Malawi as of February 15, 1998

(produced 15/2/98)



Data source: Ministry of Agriculture Crop Branch
Thematic map: Malawi National Early Warning Unit

4. Crop pest assessment

Another aspect that impacts on agricultural productivity, and therefore important to household food security is crop pests. Crop pests include diseases, harmful insects, and other harmful animals. The example below shows a greyleaf disease problem during the 1996/97 agricultural season in Zimbabwe. Other reoccurring crop diseases are black smut (maize), rust (wheat), and mealie bug (cassava).

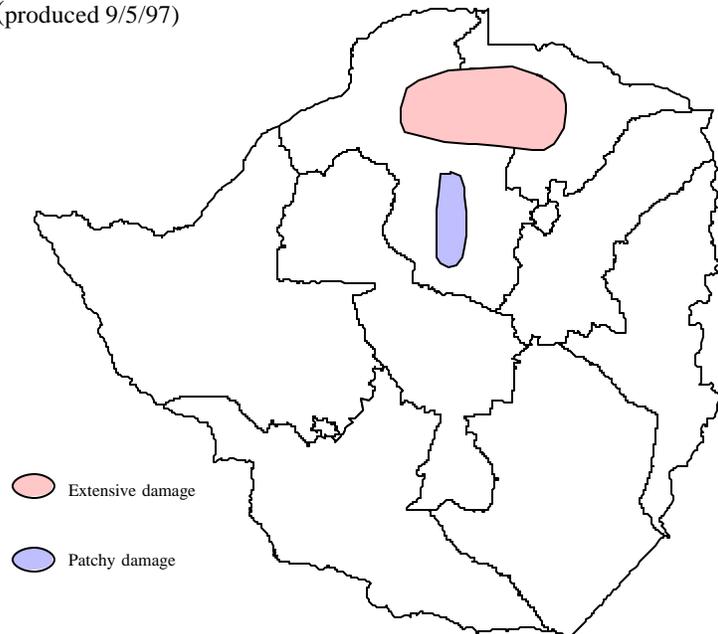
Why produce this map? The reason to produce this map is that it shows a clear indication of where there has been crop damage as a result of disease. Pest problems can seriously affect rural household food security through crop losses (and therefore reduced income). It is important to constantly monitor for pests; especially in areas that repeated have pest problems.

When and how often should this map be produced? These maps should be made when a pest problem is identified. Once a pest problem is identified, these maps should be updated monthly until the problem subsides. If there are no pest problems affecting crops, there is no need to produce this map.

Associated maps: Similar maps could also be produced showing damage from harmful insects (e.g., red locusts, armyworms, grasshoppers, and aphids) and animals (e.g., birds, monkeys, and elephants).

Greyleaf Affected Areas in Zimbabwe (May 1997)

(produced 9/5/97)



Data source: Agritex
Thematic map: FEWS/Zimbabwe

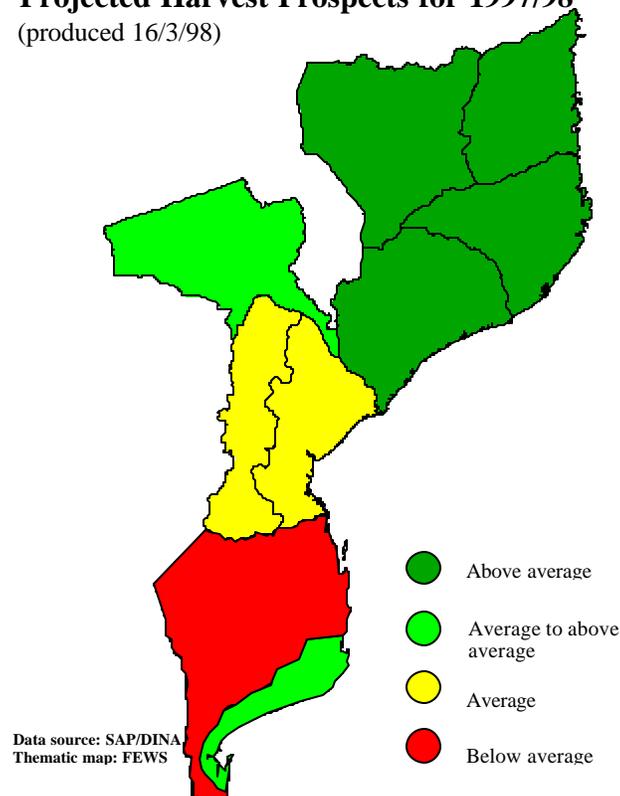
5. Projected harvest prospects

It is important to provide a decision-maker as early as possible the projected harvest prospects. Although it is impossible to perfectly identify in the early or middle part of the season the exact amount of a crop that will be produced, early estimates of the projected harvest outcome with the assumptions used to generate the estimates is important information. It is also important that as key pieces of information—such as area planted or occurrences that affect yield (e.g., rainfall, disease or pest problems)—become available the projected harvest estimates be revised.

Why produce this map? A project estimate of the country's harvest provides an early indication of where there will be a production surplus or deficit, and whether there will be a need for intervention or not. Although not definitive, this provides decision-makers a basis to begin planning.

When and how often should this map be produced? These maps should be done monthly starting in mid season when the first area planted estimates are made available (e.g., January/February in southern Africa). Initially these maps will present imperfect information since although the area planted information will be available, estimates of yield will be less reliable. Still, these maps provide an early indication of the potential agricultural prospects. As more accurate information is available (e.g., with the first crop estimate) these maps should be updated.

Projected Harvest Prospects for 1997/98
(produced 16/3/98)



6. Actual harvest outcome

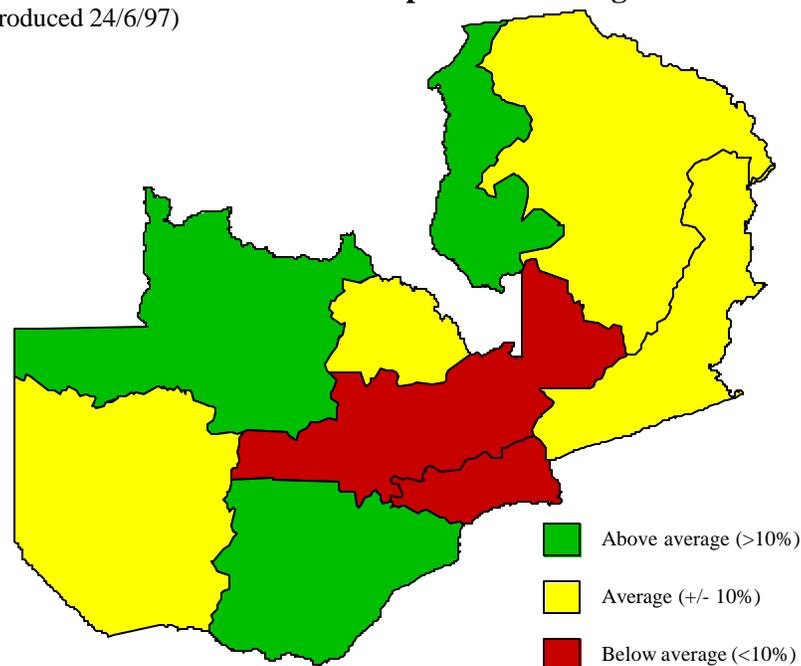
The importance of estimating the actual harvest outcome is obvious for early warning and understanding household food security. Rural households depend, either directly or indirectly, on crop production to earn income. A poor agricultural production season can signal a decline in household food security. The amount of crop production should always be compared to a reference year or average. When selecting a specific year to be used as a reference for comparison, the year or aggregate of years should be recent so that the decision-maker looking at the map can understand quickly the point of the thematic map.

Why produce this map? An estimate of the country's actual crop production forms the basis for determining where in the country there will be production surplus or deficit areas, and whether there will be a need for intervention. Also, national level production estimates will signal the private sector and government whether imports will be necessary. Finally, the information generated from this analysis combined with other information forms the basis to assess where there are improvements or deterioration in household food security.

When and how often should this map be produced? This map should be made after the final crop estimate.

Associated maps: Although the example below compares maize production to average levels, maps should also be made comparing the current estimates to other key reference years (e.g., compare to the 1991/92 drought year when there is a poor year and compare to a very good year when there is an above average year).

1996/97 Maize Production Compared to Average
(produced 24/6/97)



Data source: National Early Warning Unit, MAFF
Thematic map: National Early Warning Unit, MAFF

Livestock situation

1. Livestock health

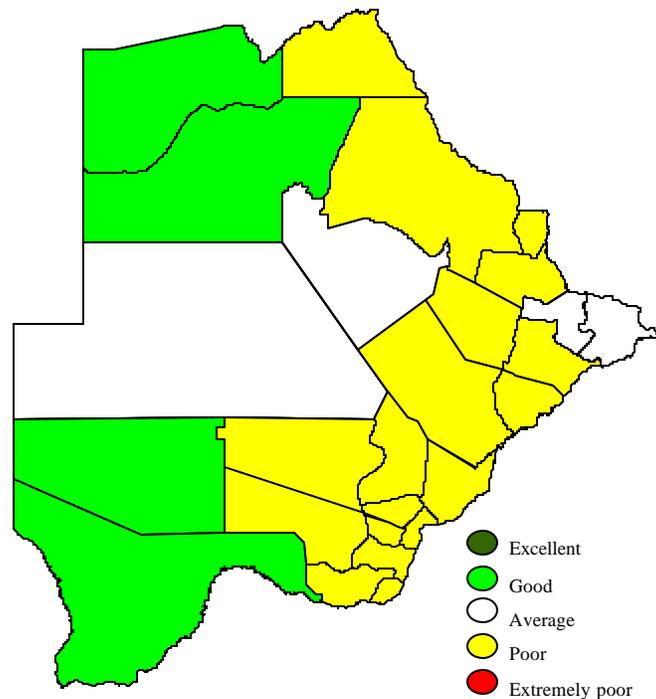
Another aspect that impacts on household income, and therefore important to household food security is livestock health. The health of livestock should be closely monitored in all parts of the region since households rely on animals as a store of wealth, their contribution to household income, and their contribution to diet/nutrition. It is important to constantly monitor the condition of livestock, especially in areas that repeatedly have livestock disease problems or poor pasturage.

Why produce this map? The reason to produce this map is that it shows a clear indication of livestock conditions, especially to spatially where the conditions are poor to extremely poor.

When and how often should this map be produced? These maps should be done routinely based the frequency of reporting (e.g., monthly in Botswana and Namibia). In countries where livestock plays a relatively minor contribution to household income, the frequency of reporting could be less, and intensified when a problem develops.

Associated maps: In some areas (e.g., the Sahel) livestock are very mobile, and therefore a map showing herd movements would be useful.

Livestock conditions in Botswana (May 1993)
(produced 5/5/93)



Data source: IMDC report
Thematic map: Ministry of Agriculture

2. Pasture conditions

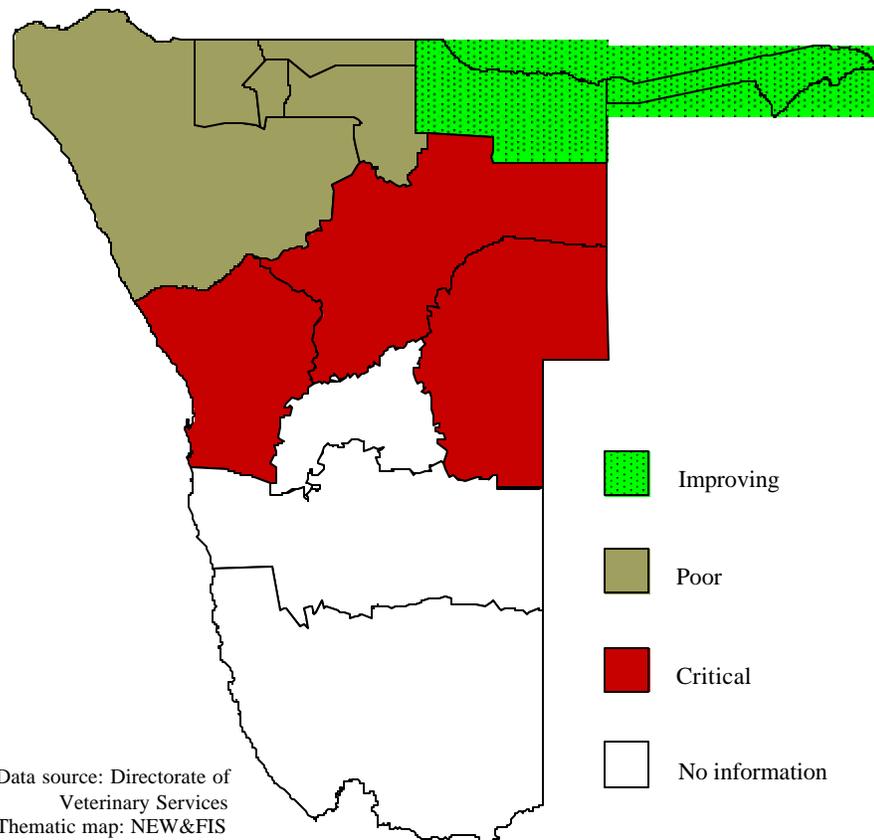
In some countries (e.g., Namibia and Botswana) and in some parts of other countries (e.g., the southern part of Mozambique), the condition of pasture is critical to the well being of households as a result of its large contribution of livestock holdings to household income. It is therefore important to closely monitor and document the change of pasture conditions.

Why produce this map? The reason to produce this map is that it shows a clear indication of the current and future prospects of livestock conditions, especially to spatially where the conditions are poor to extremely poor.

When and how often should this map be produced? These maps should be done routinely based the frequency of reporting (e.g., monthly in Botswana and Namibia). In countries where livestock plays a relatively minor contribution to household income, the frequency of reporting could be less, and intensified when a problem develops.

Pasture conditions as of January 18, 1996

(produced 24/1/96)



Chapter 5

THEMATIC MAPS TO MONITOR CHANGES IN FOOD SECURITY

Introduction

In the previous chapter the focus was on making maps that monitor the agricultural season, including the weather as well as the progression of the agricultural season. This chapter suggests other thematic maps that need to be done to monitor changes in food security. Topics that will be covered include current vulnerability assessments, price analysis, outcome measures of food security, and risk factors.

Vulnerability assessments

Developing a current vulnerability assessment map requires considerable analysis using a rigorous methodological approach. The FEWS Project has been implementing assessments of vulnerability to food insecurity for nearly a decade. The analysis seeks to determine what segments of the population are at greatest famine risk, the degree of their risk, their location and any other important consideration(s) influencing their level of vulnerability. Documentation describing the general FEWS approach can be obtained upon request.

In Southern Africa there are written materials² and technical assistance available at SADC Food Security and Technical Administrative Unit (Harare) if there is a desire to undertake a vulnerability assessment. At the present time, vulnerability assessments are being carried out—with the cooperation of the National Early Warning Units—in Zambia, Zimbabwe, Mozambique, Malawi, Tanzania, Lesotho, and Botswana.

Current vulnerability assessments are conducted to describe, and classify in the most concrete terms possible, the degree to which populations and areas are vulnerable to food insecurity. Additionally, these assessments provide a basis for determining where concerted monitoring and possible interventions - including emergency donor assistance - may be needed.

The objectives of a current vulnerability assessment are to:

- *Quantify food availability* at the national level from production, stocks, and net commercial imports, in terms of consumption requirements.
- *Evaluate food access* for different areas and socio-economic groups in the country, quantifying to the extent possible the population's access to sufficient, safe and nutritious foods that meet dietary needs and food preferences for an active life [SG1].

² A manual entitled “Vulnerability Analysis for SADC Countries: A Suggested Approach for Early Warning Units” is available from SADC FSTAU.

- *Determine the food security* of the populations in different areas and socio-economic groups in the country in terms of food availability and access.
- *Evaluate vulnerability* by providing an objective basis and fundamental context for measuring and understanding the impact of potential shocks to food access conditions in the country, especially in the near term.
- *Facilitate monitoring* by providing a basis for prioritizing where to focus more detailed food security monitoring (e.g. food needs assessments).
- *Facilitate targeting* by identifying the nature and relative magnitude of food insecurity problems and discussing potential responses to conditions.

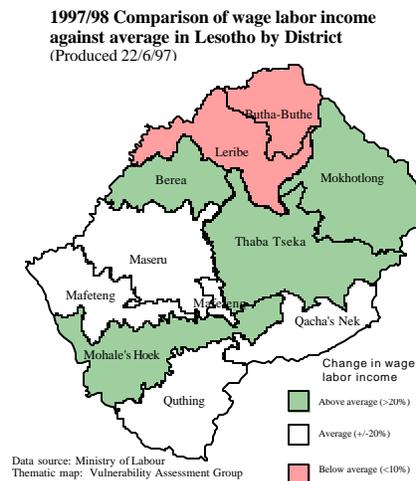
There are a series of thematic maps that should be produced when conducting a current vulnerability assessment, all of which will be described in this chapter. First, intermediate maps should be produced that show the comparison of individual income sources compared to average or a minimum standard. Second, the results of the summation of income sources by administrative area to show current food access should be mapped. Third, if possible the results of an socio-economic assessment of vulnerable populations could be mapped. Finally, an assessment of the chronic (long-term) vulnerability describing why different areas are continually food insecure should be made.

1. Comparing individual income sources to a standard

Although an example of this map can be found in the previous chapter (the actual harvest outcome), the presentation in this section all major income sources (not just agricultural production) are included.

Why produce this map? The reason to produce this map is that it provides a spatial comparison of the current income from an individual source to a historical average. This is important in determining if the contribution of this income source is more, about the same, or less than average.

When and how often should this map be produced? These maps should be done as part of a current vulnerability assessment, which are conducted annually.



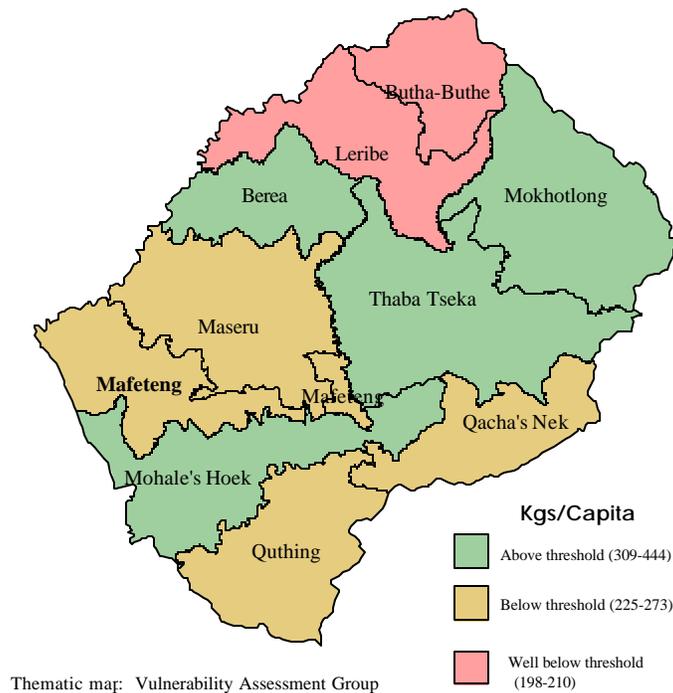
2. Current food access

The current season food access examines whether households have or will have sufficient income or assets to meet a minimum level of consumption during the marketing year. Administrative unit (e.g., district) or socioeconomic group can be used for this analysis.

Why produce this map? The reason to produce this map is that it shows a clear indication of the spatial nature of current household food access, which can be used as a basis to determine where to intervene given scarce public resources.

When and how often should this map be produced? These maps should be done as part of a current vulnerability assessment, which are conducted annually.

1997/98 Current Food Access in Lesotho by District (Produced 22/6/97)



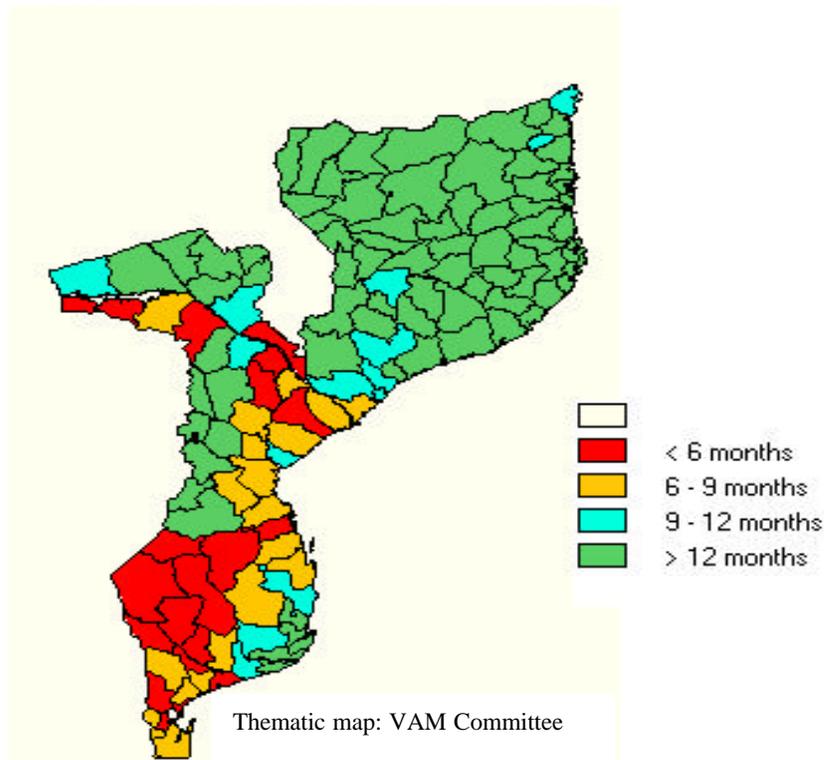
3. Food availability by month

One important output of a vulnerability assessment is to know how long the agriculture production on a per capita basis will last.

Why produce this map? The reason to produce this map is that it shows how long the agricultural production will last. This provides decision-makers with an idea when intervention, if required, will have to begin.

When and how often should this map be produced? These maps should be done as part of a current vulnerability assessment, which are conducted annually.

District Food Availability by Month (1996/97)



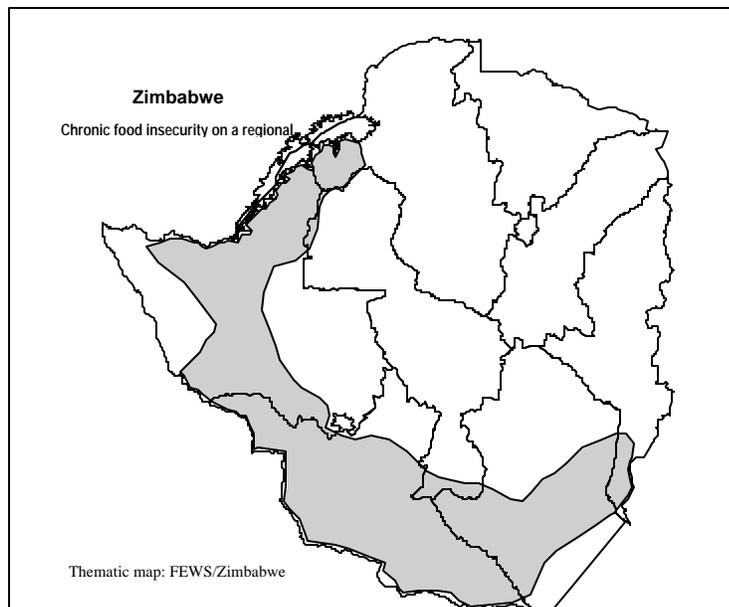
This image has been calculated from 1996/97 production and population figures based on 80% kcal needs from crop sector and 20% kcal needs from other sources. Note that production is converted into kcal for all crops and then divided by the total population to arrive at the number of months.

4. Chronic vulnerability to food insecurity

Chronic season vulnerability examines whether households (aggregated by administrative unit) historically have sufficient income or assets to meet a minimum level of consumption during the marketing year. This analysis requires time series data that permits trend analysis. A map of chronic vulnerability could be made in exactly the same way as the current food access map. Alternatively, this map could be made such that the areas of chronic vulnerability do not strictly adhere to administrative boundaries.

Why produce this map? The reason to produce this map is that it shows a clear indication of the spatial nature of chronic food security problems, which can be used as a basis to determine where to intervene given scarce public resources.

When and how often should this map be produced? These maps should be done as part of a vulnerability assessment, which are conducted annually.

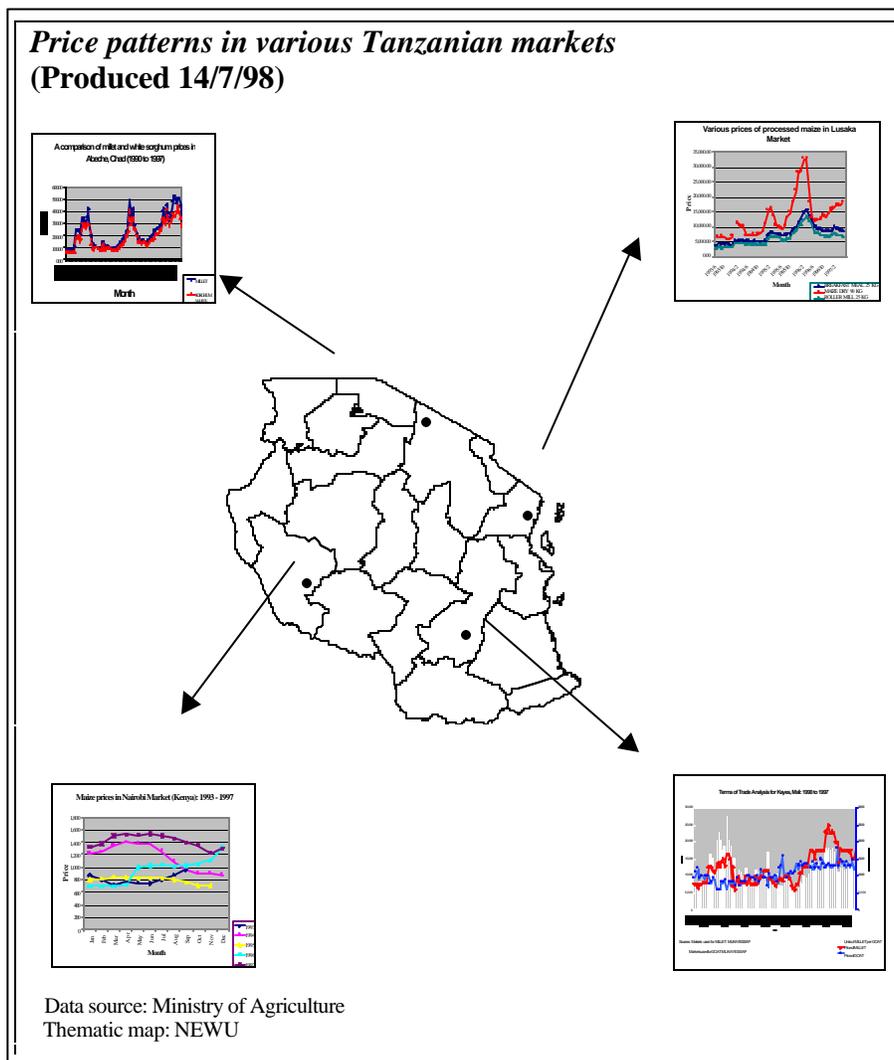


Price analysis

There are various maps that can be made to illustrate the spatial distribution of prices. A joint SADC/REWU and FEWS publication entitled “Price analysis for early warning monitoring and reporting” that discusses these maps is available from SADC FSTAU. Often the thematic map combines a map and graphs as illustrated below.

Why produce this map? The reason to produce this map is that they provide a spatial understanding of price patterns.

When and how often should this map be produced? Although price analysis for early warning should be done as often as price data are made available, these maps should be done when an important problem is developing.



Outcome measures of vulnerability

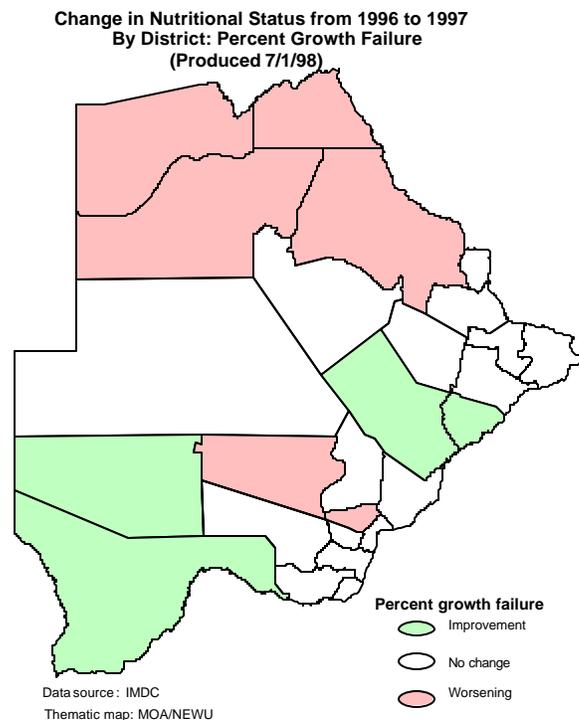
It is also important to present data from different outcome measures of household vulnerability to food insecurity, including health and nutrition indicators³. Although these measures can be presented in their original form, this would probably not best illustrate the dynamic nature of food security. It is better to compare the current indicator against a measure of acceptability (a WHO standard) or previous level (e.g., the previous year). Both maps will be demonstrated in this section.

1. Comparing nutrition in 1997 with 1996

One of the best comparisons between outcome measures of one year are with the previous year.

Why produce this map? The reason to produce this map is that it shows a clear indication of the spatial nature of health problems, and can suggest where the situation is getting worse.

When and how often should this map be produced? This map should ideally be done on a regular basis depending on the frequency of reporting and the availability of a historical data. In the absence of regularly reported information, these maps should be produced when a problem is identified.



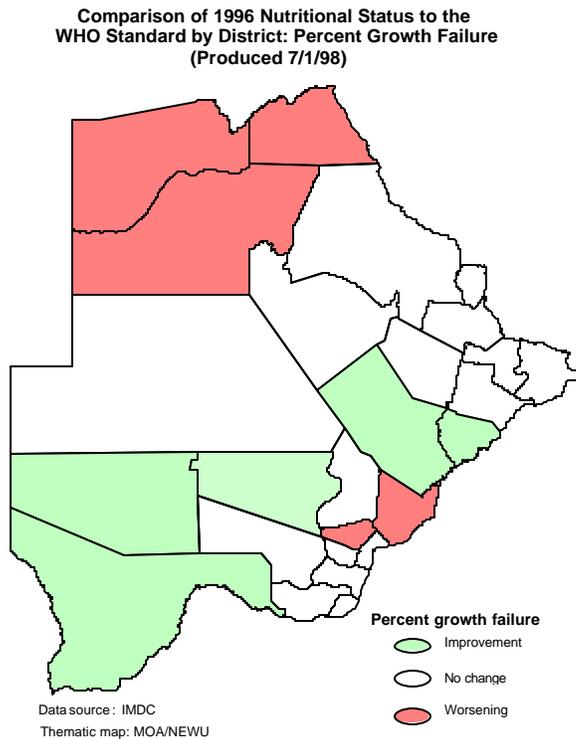
³ It should be cautioned that these measures of outcome and vulnerability are not always correlated. The reasons for this is that there are many other reasons why some individuals in households, especially children, do get an adequate diet.

2. Comparing nutrition in 1997 with an absolute standard

This map uses the same steps as the previous map with the exception of the standard for comparison. In this case the WHO percent growth failure standard will be used.

Why produce this map? The reason to produce this map is that it shows a clear indication of the spatial nature of health problems, and can suggest where the situation is getting worse compared to an international standard.

When and how often should this map be produced? This map should ideally be done on a regular basis depending on the frequency of reporting and the availability of a historical data. In the absence of regularly reported information, these maps should be produced when a problem is identified.



Risk factors

1. Changes in vulnerability due to a short-term shock

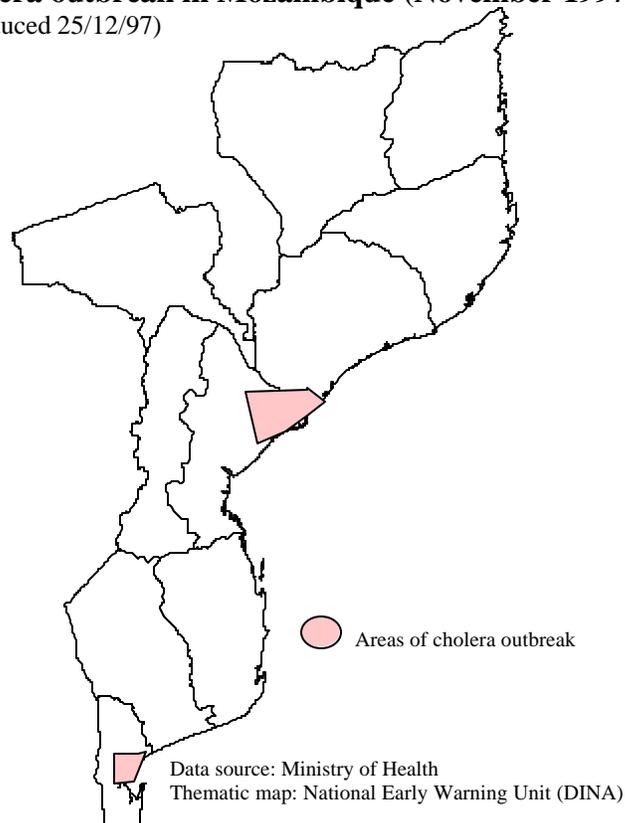
Although most shocks that affect household vulnerability to food insecurity are slow onset events (e.g., drought), there are some shocks that occur more rapidly. Some examples include cyclones (described earlier), civil insecurity, and outbreaks of human disease (e.g., cholera).

Why produce this map? The reason to produce this map is that it shows a clear indication of where a short-term shock has occurred and the extent of the impact of that event. The result is the ability of decision-makers to focus on a specific problem in a specific area for action.

When and how often should this map be produced? These maps are not done routinely, only when an event like this occurs. If there is no change in vulnerability status as the result of a short-term shock, there is no need to produce this map.

Cholera outbreak in Mozambique (November 1997)

(Produced 25/12/97)



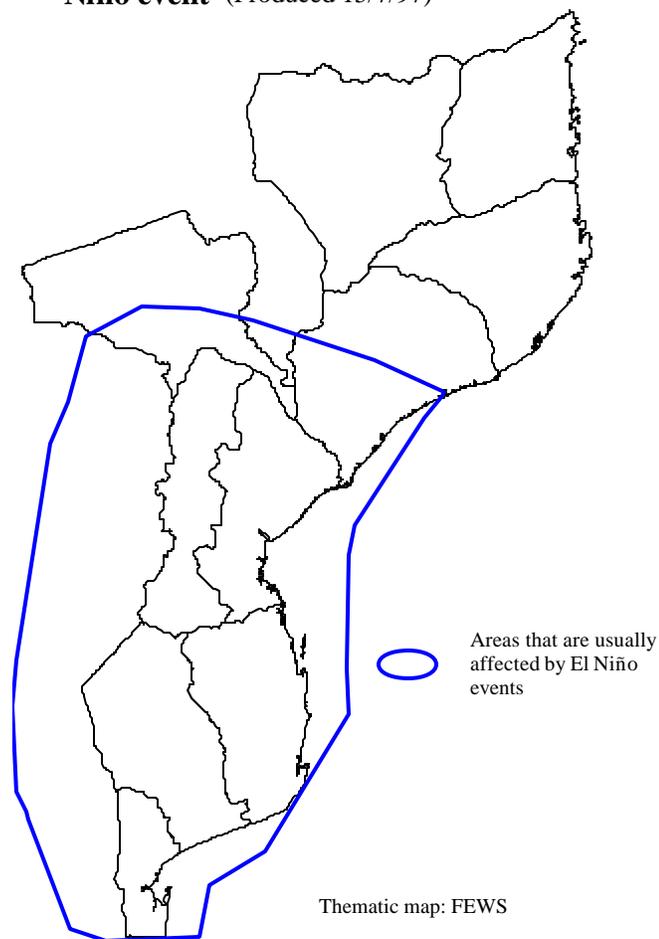
2. Potential changes in vulnerability as a result of an anticipated shock

Sometimes there is advanced information that a shock will occur. An example of this expected occurrence was the advanced warning of the El Niño event in June 1997. It should be noticed in the thematic map below that there is only a general indication of where the area of impact will be. It is unwise to provide more specificity unless you are certain you know more about where the impact will occur.

Why produce this map? These external shocks can affect the ability of households to acquire sufficient amounts of food and other necessities. In these circumstances, early warning experts are expected to provide an assessment of the potential damage or area of impact of the shock.

When and how often should this map be produced? These maps are not done routinely, only when an event like this is anticipated.

Area of expected impact of the 1997 El Niño event (Produced 15/7/97)



Chapter 6

PRESENTATION SUGGESTIONS

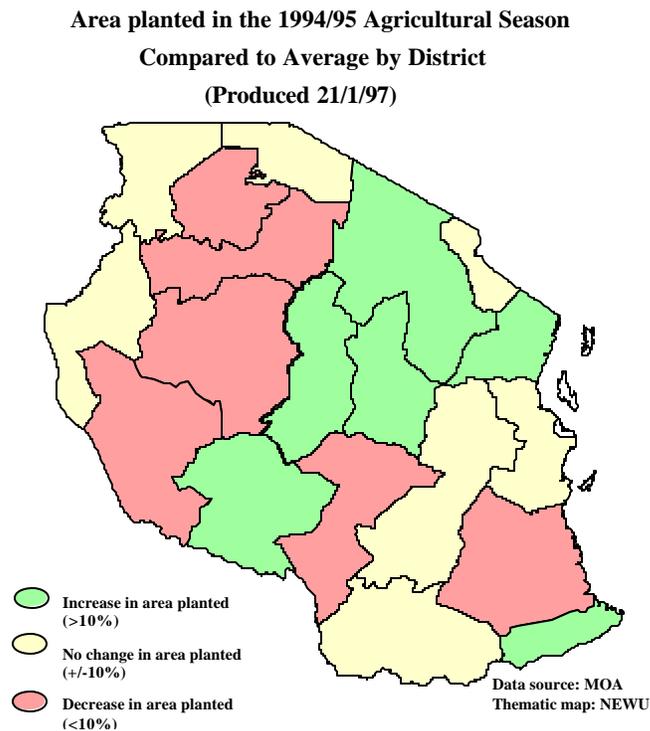
Introduction

A good map presentation should provide information that can be easily understood by the reader to identify and highlight emerging early warning food security problems. The key is to guide the reader of the map (and associated text) to understand the issue and its magnitude quickly. Decision-makers do not have a lot of time so the presentation has to assist them to understand the issue portrayed in the thematic map. The map composition should be complete and stand on its own with the document. If the map composition were to fall on the ground and someone were to pick it up, they should be able to understand the theme of the map, who produced it, the time period that the theme was referring to, the severity of the issue being presented.

The purpose of this section is to provide practical suggestions on presenting map compositions. The organization of this section will follow the components of a map composition, namely text (title and source), administrative level, color/shading, and the legend.

Components of a map composition

An example of an effective map composition is presented below.



Text

The text in a map, primarily the title and the legend, should guide, and not distract, the reader. The selection of fonts is an important issue. Here are some suggestions:

- Keep the **number and types of fonts** simple (just because you have a bamboo font does not mean it should be used!).
- Use a **similar font** throughout the entire map composition.
- There should also be a size **hierarchy of fonts** depending on the importance of the text (the title should be bigger than the labels and legend, which should be bigger than the source).
- The **size of text** should be relative to the administrative level, with smaller text as the level of administrative unit gets larger.
- Include the **minimum amount of labels** than required to illustrate the theme. Too many labels will make the map presentation too busy.

Size of the map composition

The **size** of the map composition should vary (and certainly not take a full page always per map composition). Not all maps require a full page to present them in a useful way, especially if there is little detail and the map is only for reference. The size depends also on the purpose (a small map may be appropriate for a document, but a full page is always useful for an overhead as part of an oral presentation).

Colors and shading patterns

Another important decision to make is whether maps are going to be produced in color or with shading patterns (often called hatching). The best solution is to make maps always with **both** color and shading patterns. The reason is that the map can be effectively printed either with a color or black/white printer.

Still, there are times when it makes sense to make maps in color or shading. Here are some simple decision rules for determining whether thematic maps should be presented in color or shading patterns:

- *Select color when:* There are few maps to be made, if there is a really important issue that needs to be highlighted, or for an oral presentation (briefing).

- *Select shading patterns when:* Shading should be used when there are a lot of copies of the map (or the document containing the map) are to be made or when the map is intended to background or context.
- *Alternative suggestion:* An alternate solution is to have a combination of color and shading patterns such that it looks good in both color and black/white. A good example is Figure 6.1. To demonstrate the point, the reader can photocopy Figure 6.1 to see that the message is not lost.

Selecting the appropriate color or shading pattern scheme is also an important challenge that can either improve or ruin a map composition. Here are some simple suggestions for selecting a color of shading patterns:

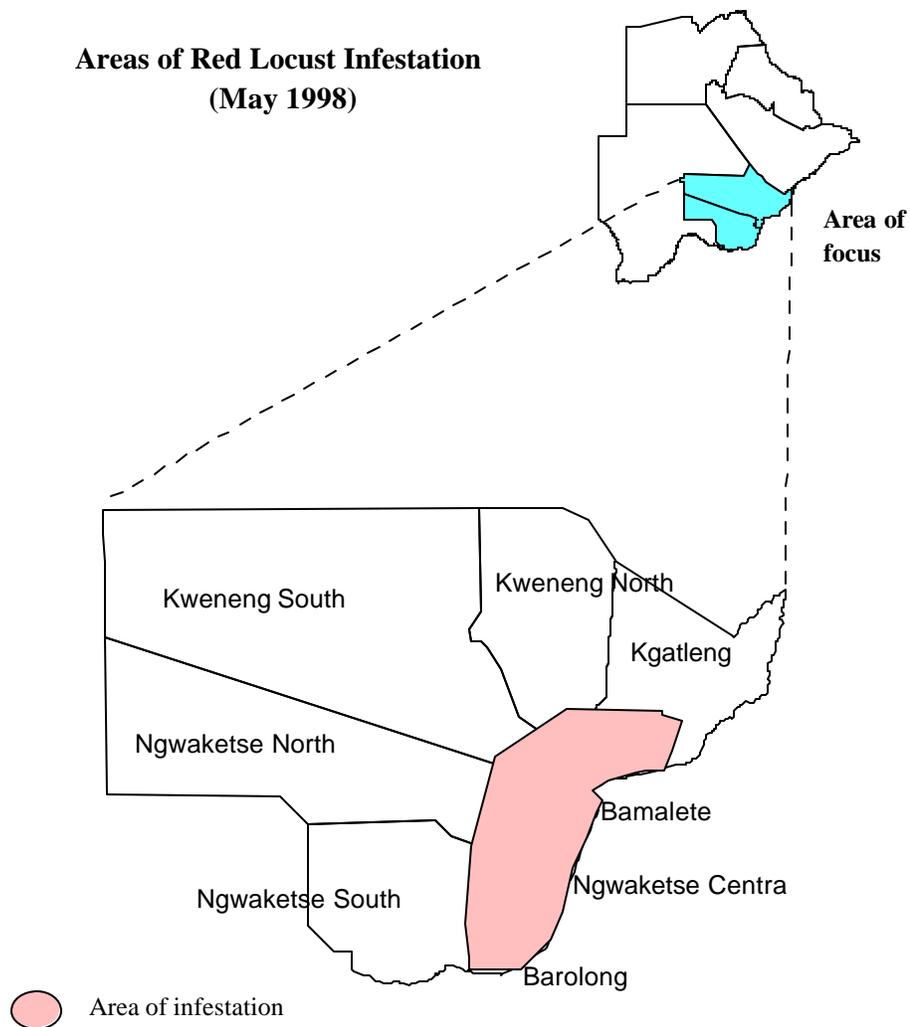
- *Color:* Color patterns should be such that the colors imply the same meaning that is intended. An easy example is to choose dark green for above average production, light green for average production, and red for below average production. It would be confusing for someone to see red in a map composition representing above average production.
- *Shading patterns:* Shading patterns should also be such that the shading implies the same meaning that is intended. In the shading patterns, more density should mean more of that particular situation (e.g., production levels or available pasturage) and less density should mean less.

Legend

Although this was discussed already under text, the legend is more than text. The legend contains critical information about the meaning of the color or shading patterns. The selection of the labels for the different patterns is very important. They should be brief but sufficiently descriptive. The size of the legend and type of fonts should not distract from the message that the map composition is trying to convey.

Highlighting a portion of a country

When a problem is very localized in a particular part of a country it is more effective to show a magnified (called zooming in) portion of that area to highlight that problem. Still, just showing a small portion of a country can be confusing since it does not show how it fits within the entire country. The solution is to make a map that shows a magnified a portion of the country **and** where that area is located with the country. The entire country can be included in a smaller map with the area with the problem made larger. An example of this can be seen below:



Other presentational suggestions

Some additional suggestions that need to be considered when making thematic maps are:

- *The thickness of lines in a map:* The thickness of lines in a map, whether it is for administrative units or key features, is important to guide the reader. The thickness of lines should reinforce the hierarchy of the object in the map. For example, the national administrative boundary should be thicker than the provincial boundary. Another example is that the line that represents the main tarred road should be thicker than that of a secondary road.
- *The use of text boxes:* Text boxes can be a useful way to add important text that is too long to be incorporated in a legend, but should accompany a map presentation.

- *The use of zoomed elements of a map:* Often there is a need to focus on an issue that is located in a specific part of a country. In this circumstance a national map is too coarse of a level to accurately illustrate the theme of the map.

Appendix 1: Selected bibliography

Burrough, P. 1986. Principles of Geographical Information Systems for Land Resources Assessments, Clarendon Press, Oxford

Eastman, R. 1995. Idrisi for Windows: Student Manual, Version 1,0, Clark University

Environmental Systems Research Institute. 1990. Understanding GIS: The ARC/INFO Method, Self-study workbook

Gaughan, T. "Roads Scholar: A quick Lesson in Mapmaking", *Publish*, October 1993

SADC Regional Remote Sensing Project Working Paper No 4., "Filename convention" (June 1997)

SADC Regional Remote Sensing Project Working Paper No 6., "RRSP CD-ROM (version 1.0)" (March 1998)

SADC Regional Remote Sensing Project Training Paper No 3, "Vector files in BNA format" (June 1997)

SADC Regional Remote Sensing Project Training Paper No 3, "Vector files in BNA format" (June 1997)

Szymanski, W. "Integrated Geographic Information Systems: Back to the Future", *Geo Info Systems*, September 1993

Van der Harten, C. "An introduction to the use of GIS", note prepared for the SADC/FAO Regional Early Warning System 1994 Annual Organisational Meeting