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Observations on Zambia's Crop Monitoring and Early Warning Systems

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Abstract

A good early warning system is one that provides timely planning information to a diverse set of stakeholders. While policy makers need very concise messages for quick decisions, aid and development agencies need very specific and detailed information which can help them in programming at grass-roots level. This paper reviews Zambia's crop monitoring and early warning systems and suggests practical ways to improve its efficiency and effectiveness, taking advantage of existing and potential synergistic and institutional opportunities.

Keywords: early warning systems, crop monitoring, crop production forecasts, Zambia

1. Introduction

Impacts of disasters on society often are huge and tend to be exacerbated by society's inability to fully adapt their livelihoods and frameworks of development to the environment around them. Inability to fully anticipate and deal with such crises can be partly attributed to the paucity of early warning information. It is argued that the combined effect of inadequate information, inadequate response mechanisms, and policy weaknesses account for frequent food shortages in much of sub-Saharan Africa. This is so even though the precursors are largely the same - adverse weather.

In much of southern Africa, existing early warning information systems often are inadequate and not timely enough. The observed levels of vulnerability to weather-related shocks are also very high and tend to be exacerbated by a number of underlying factors, including poor access to basic inputs such as seed and fertilizer; loss of livestock, draught power and other production inputs; the devastating effects of HIV/AIDS on the households; and inadequate extension services. Food shortages are frequent and, quite often, very serious.

The need for a quicker and cost-effective season and crop monitoring system is fully recognized by the governments and their cooperating partners. Donor-supported efforts in early warning systems of ministries of agriculture, such as Zambia's FAO-supported Crop Monitoring Survey Project (CMSP), have helped fill some of the information gaps. However, it is recognized that such arrangements are of limited value unless they are part of and facilitate strengthening of existing institutions.

These and other such initiatives present a unique opportunity to draw lessons for building national and regional capacities to develop effective early warning systems. This paper summarizes the experiences associated with past and existing early warning initiatives with emphasis on lessons for improvement. In the rest of the paper, we first review conceptually the need for an effective early warning system (Section 2), followed by a summary of the existing crop monitoring systems in Zambia (Section 3) and suggestions to improve existing systems (Section 4). Section 5 presents some concluding remarks and recommendations.

2. The Need for an Effective Early Warning System

An effective early warning system needs to have four inter-related elements (Figure 1): i) Continuous monitoring of the precursors (or indicators), which is critical for understanding the risks from both the hazards and people's vulnerabilities; ii) forecasting of a probable event, and, if the probability is high enough; iii) appropriate measures need to be taken to warn all the relevant stakeholders; and iv) an effective and highly collaborative response mechanism by the various stakeholders.

As Figure 1 illustrates, continuous monitoring (Phase I) and forecasting (Phase II) are continuous processes that are supposed to be carried out throughout the relevant period (December through May) regardless of the character of the agricultural season. If the forecast indicates a normal season (Answer is 'No' in Phase II), then the first two phases are all that the early warning system (EWS) will do. The important thing to bear in mind is that an effective EWS is not a reactive process but one that is continuous and designed to support preparedness. Continuous monitoring and measurement of the precursors and vulnerability trends and dynamics will make it possible for the bad seasons to be identified early enough for contingency plans and stakeholder response mechanisms to take effect in a timely manner. The key word in Phase IV (Figure 1) is *anticipated*, made possible only if Phases I and II are comprehensive enough. In general, an effective EWS requires substantial amounts of resources and a strong technical base (human capital), both arguably requiring serious attention in the Zambian crop monitoring system (Mukhala & Kwendakwema, 2005). At no stage is this more the case than in the execution of phases I and II.

For an agriculture-related EWS, precursors would include weather-related hazards (rainfall pattern, floods, drought, etc) and agricultural and livelihood vulnerability indicators (land area planted to crops, access to inputs, livestock asset base, and pest and disease incidences, sources of income, etc). The diversity of these elements identifies the need for a multi-disciplinary and multi-sectoral approach, taking into account the relative strengths of the various departments and organizations (Masdar, 2004; Mukhala & Kwendakwema, 2005; Tembo, 2006).

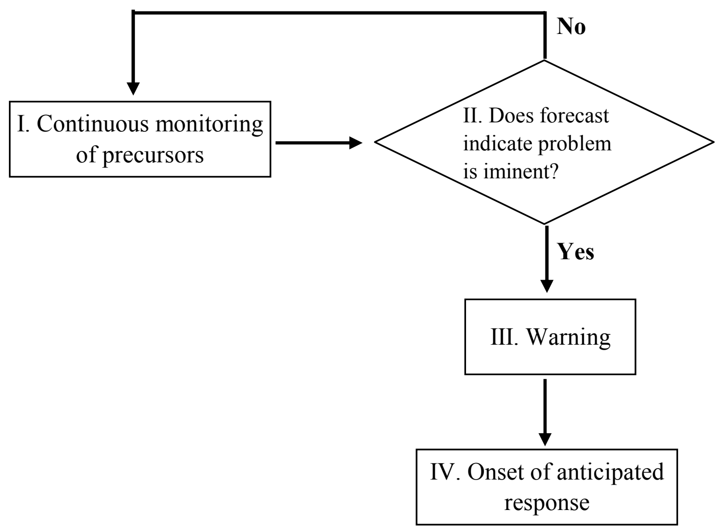

Figure 1. Phases and elements of an effective early warning system

Source: Adapted from De Leon, Bogardi, Dannenmann & Baster (2006).

3. Materials and Methods

This study relied on desk review and stakeholder consultations, involving partners at national, provincial and district levels. These stakeholder consultations were done within Lusaka; through visits to selected districts and provincial centres (Mongu, Senanga, Chipata, Mambwe, Livingstone, and Kazungula); and two stakeholder workshops held in Lusaka. A checklist was used to guide the stakeholder interviews. Emphasis was placed, among other things, on assessing the usefulness of the existing crop monitoring systems, how they can be revised to make them even more relevant to the needs of the stakeholders, and how best to fit the Crop Monitoring System (CMS) with other existing information systems, such as the crop forecast survey (CFS), National Vulnerability Assessment Committee (NVAC) and Agromet models. Perceptions about the reliability of the estimates provided by the district agricultural offices, especially those on the area planted, were also discerned.

Several documents were reviewed in the process, including dekadal crop weather bulletins from the Zambia Meteorological Department (ZMD), previous CMSP monthly reports, policy briefs by other organizations such as USAID's FEWS NET, the Food Security Research Project (FSRP), and several other publications on early warning systems in Zambia (for example Masdar, 2004).

4. Existing Crop Monitoring Systems

In Zambia, crop monitoring and forecasting has traditionally been the responsibility of the ministry of agriculture. Prior to 1990 the ministry performed this function exclusively through crop monitoring surveys (CMS) implemented by its field staff in the districts and camps. Since 1990, the ministry has been implementing two parallel monitoring systems: district-level CMS, as before, and through crop forecast surveys (CFS). Unlike CMS, implementation of the CFS is largely contracted out to the Central Statistical Office (CSO) (Note 1). The CFS is also based on probability sampling (see Megill, 2000; 2004) and is designed to produce valid production forecasts at national level.

However, at least three constraints render the CFS inadequate for early warning and intervention programming: i) inherent delays do not leave much time for planning and reaction, ii) sample size is not large enough to produce reliable estimates at district or lower levels (Note 2), and iii) as a one-time annual activity, it is useful only as a source of the final production forecasts (Note 3). Owing to these limitations, among other things, district offices have continued and/or have re-initiated their own monthly crop monitoring systems though less comprehensive and on much smaller budgets.

In recent years, district-level CMS activities have received support under the overall umbrella of the National Early Warning Unit (NEWU) facilitated by donor funding through the FAO/DfID crop monitoring survey project (Food and Agriculture Organization [FAO]/Government of the Republic of Zambia[GRZ], 2006). One advantage of a district-based monitoring system is that it can be inexpensive – as it uses staff who are based within the districts and camps – and is more useful for generating disaggregated data and qualitative information suitable for district-level planning (Note 4). Also, by collecting data at several points during the season (on a monthly basis), the CMS provides the means to monitor the season as it progresses. However, in practice, district-level crop monitoring is also not constraint-free. In the rest of this section, we highlight the key features of the CMS system with the view to identifying areas that need improvement.

4.1 Agricultural Inputs Monitoring

The existing CMS system collects district-level information on input prices and availability from the Department of Marketing (DoM). Types and quantities of seeds and fertilizers, and numbers of farmers in the district are also monitored. The District Agricultural Coordinators (DACOs) are generally confident with the figures obtained from government programmes, whereas activities of private traders and non-governmental input support programmes present greater challenges. Private supplies are especially difficult to document due to the fact that there are usually many private suppliers, including some hard-to-trace small-scale ones. Consideration of potential tax repercussions on the part of the trader further diminishes the prospects for accurate information on private stocks and activities.

Seed retentions and intra-community exchanges are not captured in the CMS. Yet, for the majority of the smallholder farmers, these constitute the primary sources of seed. Therefore, availability statements based on observations at the district central market might not be exactly accurate. Moreover, using retail prices at the central market to judge scarcity of the commodity at community level assumes that the two markets are adequately integrated. For many remote areas, this may not be the case. Thus, prices in local communities would be more relevant to the households in them than prices from central district markets. In some markets, such as border towns, central market prices reflect more the extent of trade with the neighboring districts and countries.

4.2 Area Planted

Land area planted is a very important variable for the crop monitoring process. Yet it is arguably one of the least reliable data generated by the CMS. The most traditional way to estimate area planted is to ask the farmers directly and aggregate over all of them (Note 5). This approach, however, is possible only if one has the luxury of complete enumeration or a scientifically designed sample survey. In the event that neither is possible, as has been the case so far, the districts have had to rely on their own best guesses, in most cases with the aid of information from some baseline period. For example, some districts estimate the area planted by first estimating the size of the departure from the baseline figure. This is done by *guestimating* the proportion of farmers that have broken new land and the proportion that have cultivated less than their long-term average. The difference between the two proportions is then used to estimate the land area planted:

$$Area = \mathrm{A}\left(1 + \{\beta - \alpha\}\right) \tag{1}$$

where *Area* is land area planted to the crop of interest in hectares, α is the proportion of the interviewed farmers whose area has gone down, β is the proportion that have increased their hectarage, and A is the baseline hectarage.

The reliability of the estimates based on Equation (1) depends on the reliability of the three unknowns –α, β and A. Unfortunately, in most cases, almost all the three are of questionable credibility. First, the proportions α and β are estimated based on a conveniently drawn sample and are, thus, not a representation of the district as a whole. Second, the baseline hectarage, A, often is based on very old data and some other crude estimation processes. Some districts still use information from a baseline survey that was done in the early 1980s (Note 6).

Different approaches have been used by different districts to try and update this old and outdated baseline cultivated land area estimates, some more systematic than others. Livingstone and Kazungula, for example, use the latest household census figures to update the baseline cultivated land area. Using a population of 75,000 people, and assuming an average household size of 6, and an average cultivated area of just under one hectare per household, they estimate the baseline area planted to be about 11,000 hectares (Note 7). Recent attempts to use Camp Extension Officers (CEOs) have not been very successful owing to the CEOs' limited mobility (Shibulo, 2006).

Other districts have employed varying but equally crude strategies to estimate area planted, most limited by the amount of travel that they can possibly do within the available resources and a poor sampling strategy. One approach that has been considered but not really implemented is to estimate area planted using quantity of seed planted and known average plant population (see examples of recommended plant populations for selected common crops in Figure 2).

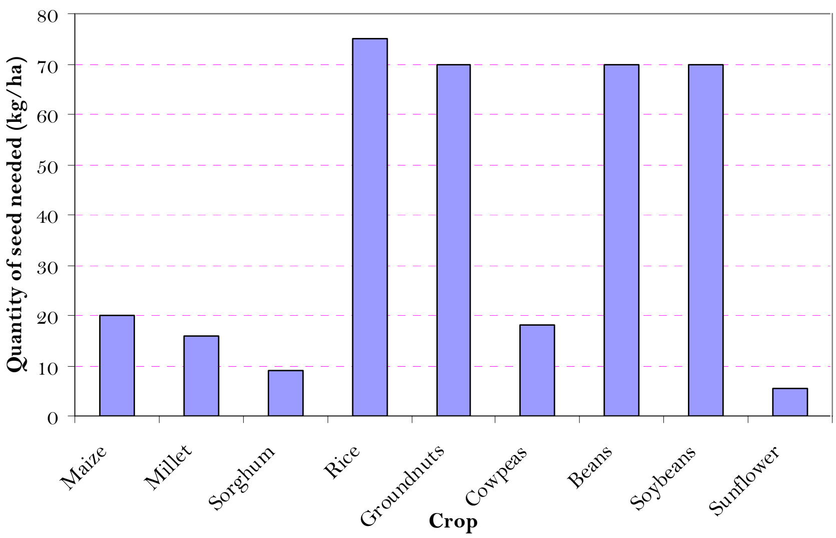

Figure 2. Average plant population for selected crops

Source: Data from the DACO's office for Livingstone and Kazungula, September 2006.

Under this approach, one has to ensure that all sources of seed are fully accounted for, including commercial purchases, input support programmes (ISPs), friends and relatives, and own retained seed. Two problems make this daunting task nearly impossible:

i) With the exception of government ISPs, all other ISPs are not easy to trace fully. Even if they are traced, private traders have an incentive to under-declare their sales.

ii) There is no way of fully accounting for own retentions and intra-community sharing of seed unless through a census or a scientifically valid sample survey. The post-harvest survey (PHS) for the previous season could be considered but its small sample size limits its usefulness at district level.

It should be noted that a comprehensive assessment of the reliability of these different methods will require quantitative comparative analysis. However, although post-harvest and agricultural census data may be available and used for this purpose, comparable data on the methods actually employed by the district agricultural offices are not consistently available. Gathering this across the districts and sifting through PHS and census data requires more effort and resources than were available at the time this paper was prepared.

4.3 Rainfall

Much of Zambia's agriculture is rain-fed. This makes rainfall one of the most important determinants of yields and rural welfare. However, the existing crop monitoring systems do not fully factor rainfall in. The qualitative assessments often included in crop monitoring questionnaires are inadequate. While the MD already monitors rainfall and other weather variables, these are not fully incorporated in the crop forecasts.

4.4 Sample Design

All the districts that are still undertaking the CMS, with or without the support of the CMS Project, collect their data from purposively selected camps with accessibility and convenience as the key selection criteria. This is at variance with the kinds of conclusions that most interested stakeholders would like to be drawing on the basis of these data.

In most of the CMS documentation, it is implicitly assumed that the District Agricultural Coordinator's (DACO's) office is able to employ complete enumeration. With the network of camp officers and the infrastructure already in place, it is compelling to think that complete enumeration is a possibility. However, in practice, this has not been possible due, mainly, to poor staffing levels and inadequate logistical support. Logistical support includes, among other things, reconstructing camp offices and houses, both of which have been run down over the years (Note 8).

Some districts have tried some form of sampling, stratifying the camps by agro-ecological region. Livingstone and Kazungula, for example, collect monthly information from 9 of the 21 agricultural camps drawn from the three agro-ecological regions (three camps per region) (Note 9). Apparently, Livingstone and Kazungula are able to do this in part because the distances are relatively short, compared to most other districts. Even then, the selection of the sampled camps and of the interviewed farmers is at best purposive. Moreover, the district team also goes to the same camp from month to month and year to year (Note 10). Both leave the sampling-related concerns pretty much active, even for these 'role model' districts.

The relative ease of sampling and field visits observed with respect to the Livingstone/ Kazungula team cannot be generalized to many other districts with relatively more difficult physical terrains. Mongu, for example, has some of the most inaccessible camps owing to a poor road network and deep Kalahari sands. In general, smaller districts with relatively more accessible camps are able to accomplish their tasks more comprehensively as they require less fuel and fewer days to cover a reasonable sample of camps. This disparity in the sizes of the districts and in the accessibility of the camps across districts implies that the logistical requirements and associated costs will also differ. This fact is, however, not taken into account in existing budgetary allocations.

Another sampling-related issue is the fact that the CMS does not include large-scale farmers in its sample (Note 11). Although, by design, the CFS is meant to interview all the large-scale farmers in the country, this has never been achieved in practice. There is need for a more detailed review of the performance of the CFS with respect to the large-scale category of farmers and whether probability sampling should be considered.

5. Suggestions for Improving Crop Monitoring

5.1 Input Demand Surveys

In the past, the district agricultural office used to conduct input demand surveys, which were used to project types and approximate quantities of inputs expected to be demanded by the farmers in the approaching season. It is believed that the input demand estimates from these surveys were reasonably accurate, and perhaps has the protential to avert some of the existing input monitoring challenges. The input demand survey typically used to be done just before the season began, around August/September. However, this is considered a little too late. It appears June/July would be more appropriate for such a survey as it would allow more time to prepare the input demand report and inform the government, private players and other stakeholders of expected input demand.

5.2 Synergies with Existing Information Systems

The usefulness and sustainability of any EWS are functions, among other things, of the quality, timeliness and accuracy of its messages, and its ability to build on the strengths of existing information systems. One of the weaknesses of the CMS is that its reports are excessively descriptive and qualitative even on variables that are inherently quantitative. In many cases, this over-reliance on qualitative and perception-based analyses does not necessarily reflect scarcity of information but rather merely inadequate collaboration with organizations whose strength and preserve is precisely generation and interpretation of such kinds of information.

In Zambia, it is important that any crop monitoring system builds upon and benefits from existing and potential synergies with the Meteorological Department's (MD's) AgroMetShell (AMS) and the national vulnerability assessment and analysis (NVAC).

5.2.1 The AgroMet System and AgroMetShell

The Meteorological Department (MD) of the ministry of agriculture collects rainfall data on a daily basis and reports it on a dekadal (10-day) basis in Crop Weather Bulletins (MCT, 2003-2006). The crop monitoring system needs to take such information into account in developing judgments about the season and production forecasts. Moreover, the MD also runs its own national early warning card system, which, if not integrated in the CMS, amounts to duplication of effort.

The advent of the AgroMet System (AMS), a water balance crop growth model developed by the FAO (Note 12), presents a real opportunity to extend the usefulness of the MD by transforming observed weather conditions through well-established agronomic relationships into yield forecasts. The AMS model uses historical rainfall data (over 30 years of data), soil conditions, and other agro-ecological conditions to estimate 16 indices that are relevant for understanding crop performance at the various stages of crop development (Note 13). Principal components analysis is then used to further narrow the number of variables/indices to a few most important ones (Note 14). This information is then used, in combination with observed rainfall conditions, to forecast expected yield, which could in turn be used to forecast production:

$$\text{Production} = \text{Yield} \times \text{Area} \tag{2}$$

Thus, with the AMS, the challenge of forecasting production reduces to accurately estimating area planted. Because estimating area planted is one of the key functions of both the CMS and the MD's national early warning card system, implementation of Equation (2) demands stronger collaboration between the CMS and the MD. This could entail optimizing the use of field staff from the two departments to estimate area planted and to interpret crop condition.

This AMS model has been used with some success in several countries in the region under the overall coordination of the Southern African Development Community (SADC). The SADC has been organizing training of national experts on the mechanics of the AMS model.

It should be stated that, like most government departments, the MD also faces a number of operational challenges, including inadequate and dilapidated equipment in some districts. There are strong sentiments that the MD has not received the attention it deserves. As a result, although meteorological data are generally supposed to be very reliable, in Zambia the predicting models have not been fully developed and applied. Moreover, such models' predicting strength depends heavily on agricultural data (planted area, etc), which are themselves unreliable. However, recent acquisition of rain gauges by the Department of Water Affairs (DWA) and the Zambia National Service (ZNS), and recent support to the MD by the EDRP project are some of the positive developments that need to be exploited (Mukhala and Kwendakwema 2005). The MD also supplements the data collected from its stations with data from voluntary stations, littered all over the country.

5.2.2 The NVAC System

The National Vulnerability Assessment Committee (NVAC), under the overall coordination of the Disaster Management and Mitigation Unit (DMMU), is part of a regional initiative to monitor the dynamics of vulnerabilities and to identify priority areas and modes of intervention if need be. An effective and continuous EWS such as the CMS would, therefore, be a valuable source of information to support the activities of the NVAC and to identify areas that need following up and more detailed vulnerability assessment.

The Zambia NVAC, like other NVACs in the region, does from time to time carry out annual vulnerability assessments. The information from the CMS could be combined with the NVAC livelihood zonal information to refine the stratification and sampling process for such assessments. It should not be difficult to align the needs of the NVAC with the CMS and vice versa as the two have quite a sizable intersection set of members. The NVAC's comprehensive vulnerability assessment and analysis (CVAA) survey presents great opportunities for crop monitoring as it could serve as a source of baseline information. The advantage of the CVAA, unlike CSO's annual CFSs, is that it is planned to have a large enough sample to warrant district-level inferences.

5.3 Opportunities to Optimize Resource Use

5.3.1 Existing Farmer Organizations

In addition to existing information systems, the crop monitoring system could optimize the use of available resources by recognizing and taking advantage of existing organizational structures and farmer groupings. The Zambia National Farmers's Union's (ZNFU's) network of District Farmer Associations (DFA) and Area Farmer Associations (AFAs), for example, could be utilized to reduce the cost of collecting early warning information. Some of these organizations already collaborate with the DACO's office and perform duties similar and/or relevant to what the crop montitoring system is doing.

Mongu District Farmers' Association (MDFA), for example, takes weather and market information, inputs, and extension services to the farmers through the AFAs and with the support of the DACO's office and some NGOs like Concern Worldwide, World Vision International (WVI), and Programme Against Malnutrition (PAM). The DFAs also do needs assessments, which could be synchronized with the qualitative information gathering for early warning purposes. However, it should be recognized that, for most farmer organizations, the capacity to integrate all these information sources may be a real constraint. Thus, there may be need to assess capacity needs and develop capacity-building initiatives.

5.3.2 Operational Efficiency and Role of NGOs

To improve operational efficiency and reduce the costs of data collection and transmission, the early warning data collection mechanisms need to be designed on improved coordination with existing development activities in the district. Several innovative models can be considered. Models that have worked in other places in the past and/or new ones that seem to be supported by existing conditions may be considered and experimented.

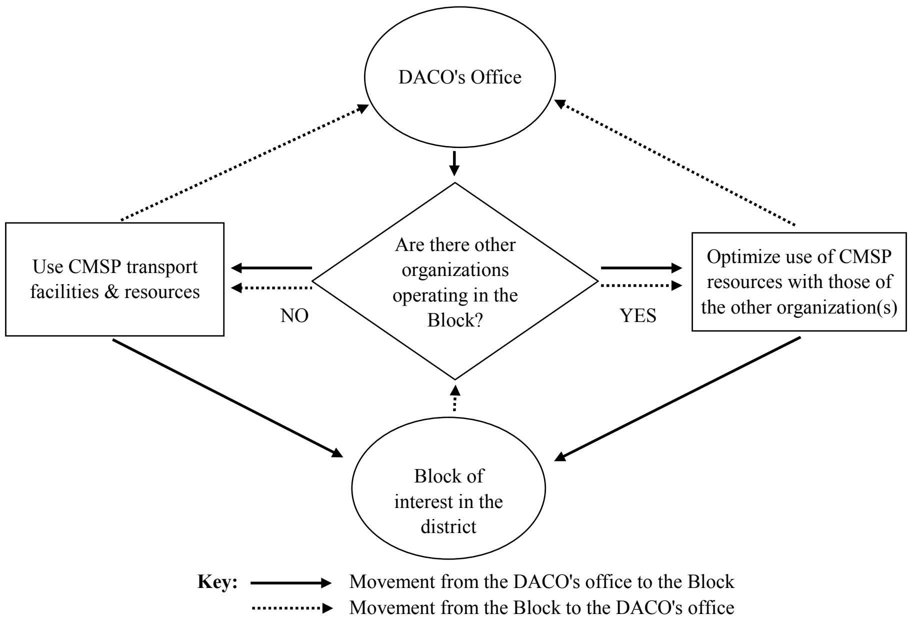

Figure 3. A highly synergistic district-level early warning model

Source: Author's own analysis.

For example, if another department or organization operates in and makes regular visits to a particular agricultural block, the DACO's office could have a standing arrangement to have an officer join that organization's team on crop monitoring duties in those areas (see Figure 3).

Some DACOs already have the responsibility and facilities with which to implement projects on behalf of NGOs and/or bilateral and multilateral development agencies. But often the financing agencies demand that use of such facilities be restricted to their own projects. With increased coordination, lobbying and collective bargaining at district level, through fora such as the District Development Coordinating Committee (DDCC) meetings, it is possible that the crop monitoring activities could be allowed to use such facilities. A well-coordinated schedule could be developed, which is flexible enough to permit adjustment whenever the stakeholder composition and spatial focus change. Moreover, in some cases, the DACO is also the DDCC chairperson. A few other natural experiments for increasing collaboration should be identified on a case by case basis.

Perhaps one more practical model could be to explicitly task the NGOs to collect crop monitoring data and submit regular reports. Internalizing this activity in the NGOs' work plans could help to minimize interference from the crop monitoring demands. The NGOs can be appraised on the nature and importance of the data that they collect on a regular basis. This can serve as a launch-and-report-back session, to bring all district stakeholders together and, with their participation, define roles and set targets. This arrangement can be formalized as a DDCC sub-committee.

However, the presence of NGO activity should not be used as a basis for selecting operational areas for crop monitoring. Such an approach would be especially detrimental in districts where NGOs operate only in camps that satisfy certain characteristics, such as accessibility. Although using NGOs as a link between the DACOs' offices and Lusaka has worked relatively well in the past, the real future and potential for substantial gains in operational efficiency lie in developing an electronic communication network.

6. Conclusions and Recommendations

This study has reviewed the existing crop monitoring systems with the view to identifying areas for improvement. While the CFS is a valuable mechanism for generating national production forecasts, owing to a statistically valid sampling scheme, its small sample size renders it unsuitable for generating estimates for district-level planning. District-level agricultural monitoring survey is generally regarded as one of the means for filling this gap.

Several challenges impede effective collection and delivery of early warning information in Zambia. First, all crop monitoring efforts could benefit greatly from increased and reliable public funding during the critical months of December through March. Late and unreliable funding are some of the reasons the CFS is often late. The situation is worsened by the fact that the critical period for crop monitoring (December through March) coincides with the period during which the government is switching from one financial year to the next.

Suggestions have been made for the government to create special provisions that will ensure CFS funds are available at the time they would make the most impact. Similarly, district funding for crop monitoring activities should be activity-based and responsive to the size of the district both in terms of the numbers of households and the distances. For the field staff to cover the entire camp in 30 days, they need to be well equipped with transport facilities and other operating resources.

Because it is costly and practically impossible to attain 100 percent enumeration of all households in the district, sampling should be an important component of the crop monitoring system. The sampling process should recognize and take into account inherent variations in farming systems and agro-ecological conditions. The exact stratification scheme is likely to differ from district to district, depending on each district's specific spatial characteristics.

Emphasis needs to be placed on optimizing resource utilization by, among other things, identifying and utilizing synergies with existing systems, including other early warning information systems such as the AgroMetShell, and the NVAC systems. AgroMetShell analysis, which could be done on a continuous basis during the planting period, could facilitate not only point forecasts but also indications of the time path of the season. Remote sensing is also appropriate if high-resolution data for Rada sat are available.

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Notes

Note 1. CSO implements the CFS in close collaboration with the early warning unit of the Ministry of Agriculture but much to the exclusion of staff in the provincial and district agricultural offices.

Note 2. District agricultural coordinators (DACOs) justify their continued implementation of district-level monitoring (alongside the CFS) based on the argument that the CFS almost always produces wrong production estimates for their districts.

Note 3. With a sample of 8,000, the CFS is designed to accurately draw inferences at provincial and national levels whereas district-level estimates would be characterized with large margins of error (Megill, 2000).

Note 4. However, its accuracy is sometimes doubted due to over-dependence on historical trends to the exclusion of other relevant covariates, such as variations in input use, production technology, and policy thrust.

Note 5. Even if the respondent may not be able to provide the area, the personal interview environment allows for several other alternatives. For example, if the respondent presents an estimate of the size of the field in terms of 'number of lines', the enumerator may probe to get a feel of the length of each line/row and the number of such lines/rows. The enumerator can also attempt to get a feel of the distance between rows (inter-row spacing). Using all this information the enumerator can then estimate the area of the field. For another example, the farmer could present the size of the field in terms of "number of steps", e.g. 40 steps by 80 steps. If this is the case, the enumerator can estimate roughly the length of the farmer's step in metres and multiply this by the number of steps to get the distance in meters, which then can be used to compute the area in meter squared.

Note 6. With donor support during the first half of the 1980s, a comprehensive survey was conducted throughout the country in which actual area cultivated was measured (Shibulo, 2006).

Note 7. This is almost double the figure in the 20 year old baseline (5,700 hectares).

Note 8. The lack of accommodation at camp level is one of the key constraints that have hampered staff recruitment efforts. It was learnt that in some instances, staff meant for the camps have been housed at the district office, greatly defeating the idea of reducing field costs by having staff in the camps. However, MACO has recently received support from the ADB and International Monetary Fund (IMF) to facilitate recruitment and infrastructure rehabilitation and construction.

Note 9. Livingstone and Kazungula, still being administered by one DACO office, are together divided into three agro-ecological regions – 1, 2, and a transitional region that demarcates the two. The DACO's office samples three camps in each of these regions and interviewing 5 farmers per camp. This is an impressive coverage, given the resources

Note 10. However, the DACO's office argues that, despite not re-sampling, the estimates obtained are a lot more reliable than those obtained through CEOs.

Note 11. The CSO defines large scale farmers as those that cultivate more than 20 hectares per year.

Note 12. The AgroMetShell (AMS) was initially known as the FAO Index.

Note 13. The AgrometShell model identifies and uses four crop growth stages to make judgments about crop performance: i) Initial stage, ii) Vegetative stage, iii) Flowering stage, and iv) Ripening stage.

Note 14. In most cases, only three of the 16 indices (3 per crop development stage), are used.