*The development and applications of a Drought Early Warning System in Botswana**

Richard Morgan

c/o Ministry of Finance and Development Planning
Private Bag 008
Gaborone
Botswana

This article describes the indicators and data sources used by the Botswana Drought Early Warning System formally established in early 1984, the main uses of the indicators in the assessment of drought conditions and the design of relief programmes are outlined. Limitations of the sources of data available are discussed, as is the feasibility of adding some possible further indicators. In conclusion, the importance of a functioning Early Warning System in a country highly susceptible to repeated droughts is stressed, in the context of the current effort to elaborate a comprehensive National Food Strategy and to establish a Regional Early Warning System for Southern Africa.

Key words: Botswana; Early Warning System; Inter-ministerial Drought Committee; Nutritional surveillance; Agricultural indicators; Agrometeorology; Drought assessment; Relief programmes; National Food Strategy.

DROUGHT-PRONENESS IN BOTSWANA

The occurrence of rainfall shortages with negative effects on agriculture and rural life, defined as "drought," is a constant possibility in Botswana, and one which must be anticipated in order to minimize economic losses by the Government and by rural households themselves.

Botswana's Independence from its colonial protectorate status was achieved in the middle of a period of successive droughts in the early to mid 1960's. Whilst thereafter an almost unbroken spell of favourable rainfall conditions prevailed until the 1978/1979 season, four of the following six seasons have seen the declaration of a national state of drought emergency. A partial regional drought was declared in the fifth season in the North West part of the country, which was exacerbated by a ban on cattle marketing due to a local outbreak of foot and mouth disease.

Given the fragility of Botswana's ecology, the marginality of much of its soils for arable production and the low carrying capacity of its extensive rangelands for livestock, it is important to understand the rainfall variations over a season that can be classified as generally "below normal" for its effects to be determined. Total precipitation has recently been known to reach above-average levels on a national scale, but due either to erratic time distribution or to large variations even between adjacent localities, severe losses in crop production have resulted, whilst livestock numbers and productivity may remain stable if grasslands recover at either end of the rainy season. For illustration, output of basic crops (cereals and pulses), which in Botswana comes largely from rainfed cultivation on smallholdings, fell from levels between 45,000 to 60,000 metric tonnes in the relatively favourable seasons of 1979—1980 and 1980—1981 to below 20,000 tonnes in the two following seasons and to as low as 7,000 tonnes in 1984. This represents a decline in food production per farming household from roughly 715 kg to 100 kg, or an estimated income loss for such households of Pula 16.5 million (about 11.5 million U.S.$). Meanwhile, imports of cereals increased rapidly from less than 110,000 tonnes to levels above 160,000 tonnes annually. About 60% of this increase was attributable to increases in food aid for relief purposes.

Reductions also occurred in the availability of wild plants and animals on which poorer families and those living in remoter settlements to a considerable extent depend. Mortality rates and offtake among the cattle herds, which number almost three million animals and form the principal source of rural wealth in the country, also rose, but consequent losses in total numbers and income were less dramatic than in the arable sector. They were however proportionately much heavier amongst the smallest herds. Poorer households were thus affected more seriously and perhaps permanently, by the destruction of their sources of draught power for ploughing.

A major outcome of these effects has been a significant rise in the incidence of undernourishment found in young children, suggesting shortages of a number of basic foods, including cereals, milk, meat and wild or domestic fruits and vegetables.

THE CONTEXT FOR THE INTRODUCTION OF AN EARLY WARNING SYSTEM

Botswana therefore represents an example of a nation under the constant threat of drought conditions, erratic and unpredictable in their occurrence, but comprehensive in their consequences in the sense of tending to affect all citizens, to a greater or lesser degree. This includes the 20% classed as urban dwellers, virtually all of whom retain ties to the rural economy through family obligations, livestock holdings, and in an indirect way through the ploughing activities of their relatives. It has naturally been incumbent upon the Government to devote considerable efforts and resources during the current drought period (which fortunately has coincided with the achievement of sustained surpluses on the national budget mainly due to increased

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diamond export earnings) to the alleviation of the effects of drought. Gradually, an awareness of the importance of and the potential for contingency planning for drought and the monitoring of its incidence and effects has grown at the national planning level. As the organization of relief efforts has improved over time, so it has been possible to allocate increasing resources of scarce time and personnel to responding to such emergencies and also to anticipating their occurrence.

At a symposium on drought organized in 1978 by a private forum, the Botswana Society, national planners had been alerted by analysis of the long-term rainfall trends in Southern Africa to the strong possibility of drought conditions throughout much of the 1980's, as had been the experience in the 1960's. In 1978, an Interministerial Drought Committee (IMDC) was established under the co-ordination of the Rural Development Unit in the Ministry of Finance and Development Planning, and local government authorities were encouraged to form their own District Drought Committees to plan for and co-ordinate implementation when necessary of relief programmes. At the national level, therefore, the IMDC, which now includes in its membership all the main Ministries and Departments involved with the implementation of relief and the monitoring of drought conditions, is responsible for drought assessment, making policy recommendations to the Cabinet on the need for relief measures, securing resources for them from both donor and domestic sources, and the monitoring of relief measures. A close link is maintained between the IMDC and the District Drought Committees, in order to ensure the quick passage of information and feedback on problems and progress in the implementation of agreed measures.

For several years, and during the implementation of various relief programmes, the IMDC relied for monitoring purposes on presentations of drought-related data at its main committee meetings, occurring every two to three months. This did not allow for available data from different information systems to be analyzed comprehensively or systematically, and within a relatively large forum it proved difficult to extract interpretative conclusions from such data-sets. Recognizing this, and conscious of the rapidly mounting cost of the relief programme, the IMDC established at the beginning of 1984 a small Early Warning Technical Committee consisting of a few key members as a subgroup; this now meets on a monthly basis to review rainfall and agrometeorological data, reports from the Nutritional Surveillance system, and the Agricultural Situation Reports issued by the Agricultural Statistics Unit in the Ministry of Agriculture. Regular assessments of the incidence of drought and its effects are produced in this way and recommendations for policy actions submitted to the IMDC as the relief management agency and to political decision-makers with responsibility for the allocation of national resources. The Early Warning Technical Committee also monitors the availability of foodstuffs both for the relief programmes and for the Strategic Grain Reserve held on behalf of Government by the Botswana Agricultural Marketing Board, thus covering the area of short-term food security for the nation. Data from the Early Warning System is entered on microcomputer and updated on a regular basis. Monthly reports summarizing the most recent data are produced by the Rural Development Unit, which since 1983 contains an officer for the overall co-ordination of drought relief and food policy. These reports are intended for the use of Government decision-makers, international aid agencies and district authorities. Because of this diversity of users the reports concentrate on a few key indicators and trends, illustrating them by brief verbal descriptions, maps and tables, with a view to providing the available information in a concise and easily-understood format.

DATA AND INDICATORS USED IN THE EARLY WARNING SYSTEM (EWS)

Human nutrition

The main indicator of changes in the wellbeing of Botswana's human population used by the drought Early Warning System is that of the prevalence of undernourishment in children under five years. This is defined as attaining less than 80% of expected weight for age according to the Harvard Standard. Large numbers of children are weighed every month at health facilities throughout the country. Whilst there are important difficulties in the reliability of data, the sheer size of the sample — in 1984 exceeding 115,000 children monthly, around 60% of the total age group — and the reasonably good geographical coverage provided by the weighing points allow interpretations to be made with high degrees of confidence of trends in the data at national level. To a lesser extent, with much more discounting of monthly fluctuations, interpretations can be made of trends at district level as well. It has clearly emerged that, whereas in non-drought years in the period since Nutritional Surveillance began (1978) prevalence of undernourishment was found among 23—26% of children under five, this has risen to between 28 and 32% during the recent and current droughts (see Figs. 1 and 2 and Table 1). Clear seasonal and regional variations are also apparent, with certain geographical and ecological regions (e.g. remote rural areas and low income urban areas) showing persistently higher than average rates, and prevalence tending to decline in the months following

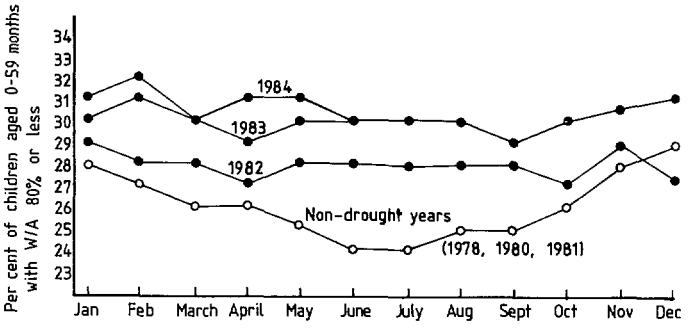

Fig. 1. National prevalence rates of underweight children.

Table 1. Prevalence rates by health region

Region	1984			1983
	May	June	July	July
Molepolole	39%	42%	37%	41%
Ghanzi	37%	32%	36%	33%
Lobatse	34%	34%	36%	31%
Tutume	30%	30%	31%	27%
Kgalagadi	32%	30%	30%	29%
Mahalapye	30%	30%	29%	34%
Serowe	29%	29%	29%	29%
Maun	28%	30%	29%	25%
Chobe	26%	28%	28%	29%
Francistown	29%	28%	27%	33%
Gaborone	30%	27%	26%	27%
Selebi-Phikwe	27%	21%	25%	23%
Botswana	31%	30%	30%	30%
No. of children	118,109	120,702	117,941	91,084

the harvest and milk-producing periods, particularly in non-drought years. By the middle of 1984, analysis started of the incidence of children experiencing severe malnutrition (defined at below 60% of expected weight for age), which facilitates the targetting of additional measures by the Government in response to the malnutrition problem. Fortunately, cases of severe malnutrition are relatively rare so far and number just under 1% of the sample.

Agricultural indicators

Whilst nutritional status is the main "outcome" indicator used by the EWS for the human population, assessment of conditions relating to crop production is an intermediate stage which allows predictions to be made of changes in food availability for rural households. Such assessments are made in the monthly reports of Agricultural Field Services staff in about 120 extension areas throughout the country,

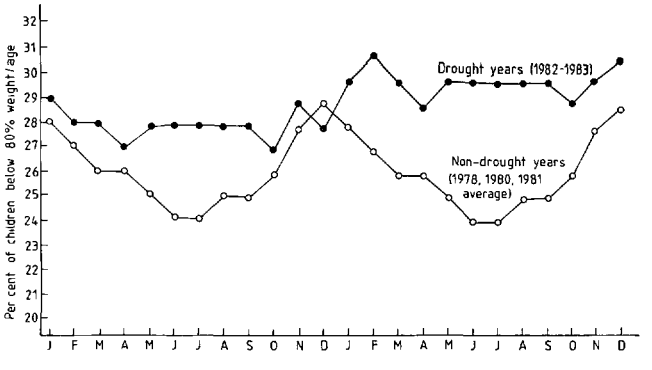

Fig. 2. National at-risk prevalence figures during drought period 1982—1983 compared to at-risk prevalence figures during non-drought period. Source: Government of Botswana, Central Statistics Office.

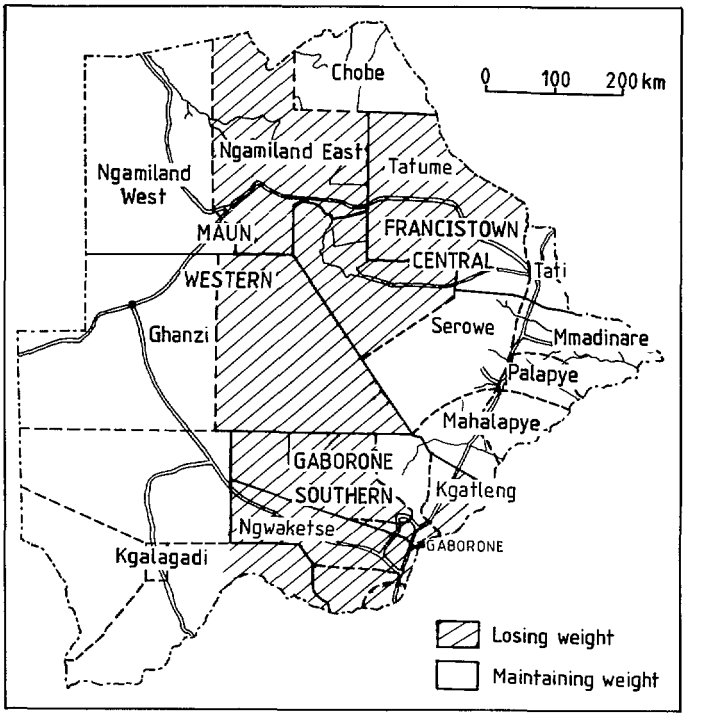

Fig. 3. Livestock condition at August 1984.

are aggregated for each of the sixteen Agricultural Districts, and are made available through the Agricultural Statistics Unit of the Ministry of Agriculture. The main indicators used in these reports, which are based on largely subjective estimates by extension staff, are: area ploughed, area planted by crop, estimated yields by crop, and food in store in the household expressed in the number of months supply available.

Similarly, subjective assessments are made of overall livestock condition, as well as grazing and water conditions for cattle, on the basis of a one of five index. These are then compiled monthly into national maps (see Fig. 3) and used to formulate a "livestock index," trends in which are also informative for monitoring and decision-making purposes.

Rainfall and agro-meteorology

Information collected by the Department of Meteorology forms the basic "input factor" to the EWS, and is also the most rapidly transmitted of the data sets used. Weekly rainfall collectives are given by radio for between 40 and 50 recording points, and are analyzed on a monthly basis in terms of percentage departure from the long-term mean (i.e. "normal" rainfall) both for the particular month and cumulatively for the season. In an important extension of the Department's capacity, an Agrometeorology section was established in 1983, and is now involved in drought monitoring through analysis of maximum achievable yields as a function of soil moisture availability for a given cropping region at a given point in the season, expressed as a water satisfaction index (see Fig. 4 and Table 2). The index is calculated for each of the five Agricultural Regions where

Table 2. Watersatisfaction situation and yield expected on *traditional* farms for maize and sorghum in the five major agricultural regions

	Southern	Gaborone	Central	Francistown	Maun	Five regions
Mean water-satisfaction index on 29th February 1984	61	72	77	67	86	71
Mean water-satisfaction index at the end of the seasons 1978/1979 — 1982/1983	79	78	70	77	82	76
Expected yield/*planted* hectare if no further waterstress occurs after 29th February 1983	5—55 kg	25—60 kg	65—135 kg	15—40 kg	35—60 kg	30—80 kg
Yield reduction as a result of waterstress, on 29th February (per planted area)	85—95 %	65—85 %	55—80 %	75—90 %	30—60 %	70—90 %
Possible yield/planted hectare if no water-stress occurs during graving period	375 kg	165 kg	305 kg	160 kg	85 kg	220 kg
Estimated total production if no further water-stress occurs after 29th February 1984 (tons)						2,400—13,000
Estimated total production if waterstress up till end of growing period (tons)						300—6,000

The mean *sorghum and maize* production over the past five years on traditional fields in Southern, Gaborone, Central, Francistown and Maun agricultural regions was 19,500 tons. During very good years, with a maximum of planted area, a total *maize and sorghum* production on traditional fields in those five regions of 50,000 tons must be possible.

Unexpected high yields (according to the stress that occurred during the season) are occasionally obtained on improved farms (fertilisers, etc.). A small number of such farms can represent sometimes a big percentage of harvested area, and then the total production is also unexpectedly high.

arable cultivation is practiced, which not only permits, as do the other reporting systems, a certain level of disaggregation in drought assessment, but also allows the possibility of harvest reductions or failures of the country's two main crops, sorghum and maize, to be predicted earlier than by the Agricultural Field Service data. This in effect buys time for the planning and mobilization of response efforts.

Food security

Given the reliable nature of cereal supplies for Botswana from private commercial importers, and the country's strong foreign exchange position over the last few years, the EWS is limiting its monitoring of food security to two main areas. Firstly, the stock levels of the national Strategic Grain Reserve held by the Botswana Agricultural Marketing Board are monitored and compared with the target level based on coverage of three months volume of commercial imports. Secondly, donor commitments for supplementary feeding programmes planned for the next 12 months are reviewed in relation to estimated requirements. Such needs are determined by beneficiary numbers and ration levels, which in turn may be based on assessment of the severity of drought and its effects on food supply at the household level, or, in non-drought periods, on the more limited institutional needs of schools and health facilities. Although attention is also paid to trends in cereal imports and changes in the commercial stocks of the Marketing Board as a major importer, the availability of food for the two "strategic" purposes noted above is taken as the main indicator of national food security at present.

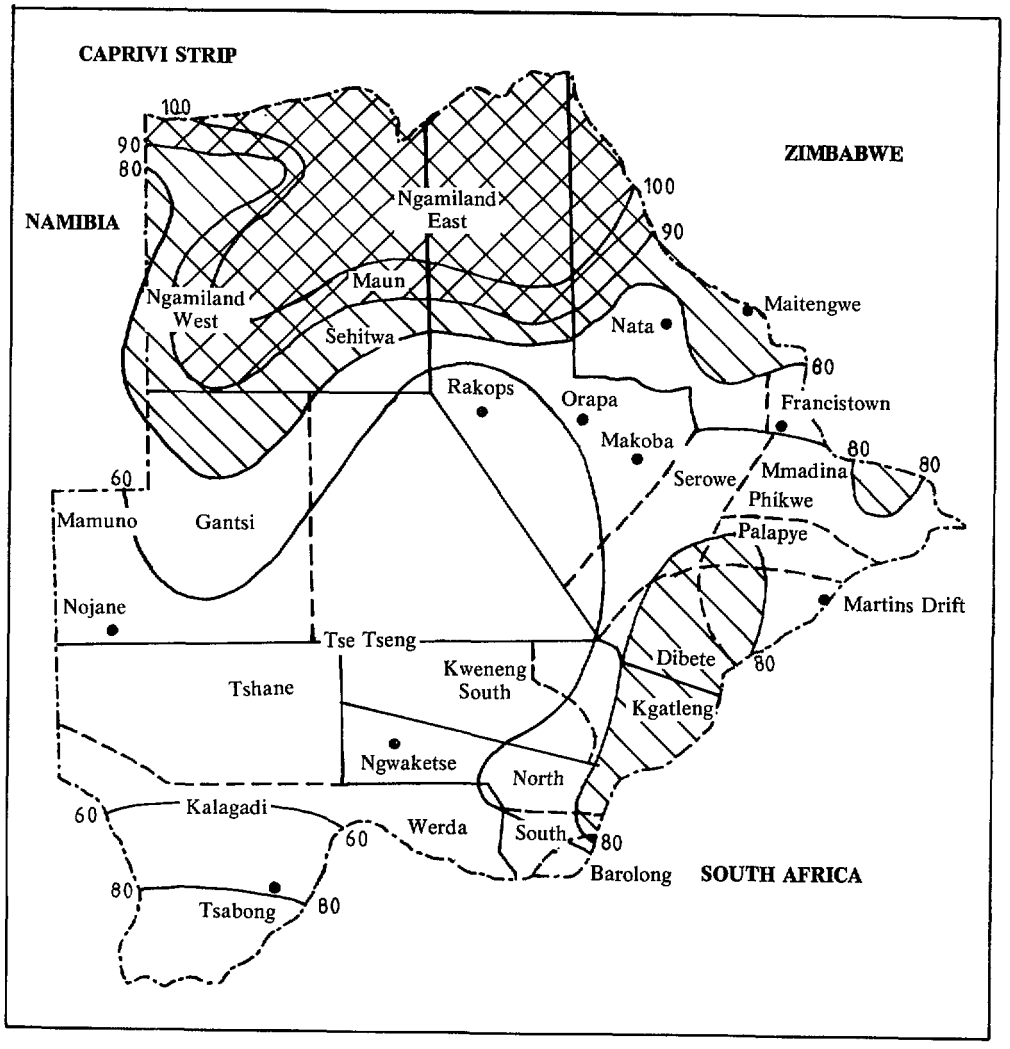

Fig. 4. FAO-water satisfaction indices for sorghum up to 29th February 1984. (**Warning:** This chart should not be used for spot-evaluations of the situation in a specific village, as rainfall can be highly variable from one village to another, and even from one field to another.)

District-level reports

A further subjective but valuable source of information for monitoring purposes is provided by District officials (including District Commissioners, Council staff and local politicians) at the District Drought Committees. Whilst no systematic reporting format has been introduced, it is possible for members of the national EWS both to corroborate their interpretations of the data streams described above and to gain information on areas and population groups not covered (mainly the remotest areas and semi-nomadic people) by using the records of District meetings or attending the meetings themselves. As one way of formalizing this relationship between the district and national-level information systems, a nationwide tour is made by members of the IMDC at the most crucial period in the year for drought assessment, in February (midway through the cropping season), to hold detailed discussions with the District Drought Committees. These meetings may yield important background information, for example on unusual population movements and on water shortages in villages, which otherwise is not regularly collected.

USE OF THE EARLY WARNING SYSTEM IN THE RESPONSE TO DROUGHT

Whilst these indicators of drought conditions are now reviewed on a monthly basis, a specific timetable is adhered to in terms of the use of data for determining national policy on drought relief measures. Given the rainfall and agricultural cycle, it should be possible to know fairly certainly by the end of February of each year whether Botswana is facing drought conditions. On the basis of the Early Warning Indicators, the Interministerial Drought Committee usually makes a presentation to both Cabinet and a Parliamentary Causus by the end of this month with a detailed assessment of conditions. When it is considered that relief measures are needed, recommendations are made on what they should be and where in the country and on what scale they should operate. Estimates of the call on financial resources are also made at this point. If necessary, a formal declaration of drought is made, and requests for assistance from the international community prepared. The aim of this planning is to initiate whatever relief efforts may be agreed upon in the June-July period, which is when the conse-

quences of reduced harvests or dwindling range resources would begin to be felt by human and animal populations. Similarly, the termination or scaling down of relief activities, based on improvements in EWS indicators, would normally take place in the middle of the calendar year.

There exists as yet no commonly agreed definition of exactly what constitutes a "drought" in terms of the indicators used in the EWS. Whilst this has the advantage of allowing flexibility in assessment, and for unstructured reports from District level to be weighed, it may cause difficulties at times or in areas where conditions appear to be "borderline," rather than as clearcut as they have been in recent seasons.

A further criticism of the present operation of the EWS is the tendency to rely on a limited number of indicators when assessing the situation, and in particular on Nutritional Surveillance alone (Tabor, 1983). The practice of basing assessments on a few reasonably reliable indicators with virtually national coverage is, however, closely related to the range of relief measures that are being used in Botswana during the present drought cycle. Nutritional data is the basis for setting ration levels, establishing beneficiary groups and target areas for supplementary and special direct feeding programmes, (run mainly through schools and health facilities). It also has potential applications to the planning and targetting of the other main component of the 'human' side of the relief programme, which is the creation of temporary jobs at a daily wage on village improvements schemes, such as road clearance, dam building, and the construction of storerooms. These projects, chosen by village committees themselves, are designed to supplement income to replace part of the drought-induced losses, and the scale at which they are run can be varied according to the assessment of the severity of conditions in particular localities. Much of the allocation of funds for such projects is done by the District Drought Committees, and in some instances those villages recording higher rates of malnutrition among their children have been allocated greater shares than their populations would otherwise entitle them to. Similarly, crop forecasts and livestock indices are used in the planning of a variety of agriculture-related relief measures, aimed at helping farmers to preserve and rebuild their assets: these include sales of stockfeed, seed distribution, arable land clearance grants, subsidies on the hire of draught power, and the purchase of weaker cattle for slaughter and use in the school feeding programme.

The most important point is that data collection is concentrated on those indicators which do not require expensive additional efforts to establish, and which are felt to be useful in terms of the possible relief measures identified (i.e. they are cost effective). Thus, for example, information on the availability of wild foods is collected on an *ad hoc* basis only; estimates of food in store at household level are generally thought to be insufficiently reliable; and price data for crops and consumer goods are not often used in the EWS, partly for similar reasons, and partly because they are largely determined by non-drought factors. Whilst village-level changes in supply and demand do cause fluctuations in crop prices, most grain produced is either consumed within the household or sold to the Agricultural Marketing Board, which provides a guaranteed floor price to producers. This is based on the landed cost of South African grain at Botswana's southern border plus transportation costs to location. Prices for traded food are also largely determined on the basis of import prices, rather than by conditions inside the country; only marketing margins are controlled for the widespread and highly competitive retail network operating in all but the remoter areas. Finally, the main factor affecting the prices attainable for cattle is the state of Botswana's main export markets in Europe and Southern Africa, whilst increases in sales in response to range conditions are constrained by limits on abbatoir capacity. However, an indicator of cattle condition which could be employed in future by the EWS is the average carcase weight and rate of condemnation of carcases at the country's one major export abbatoir: this indicator meets both criteria of being "cheap" (in terms of time) to acquire and relevant to possible relief interventions.

PROBLEMS AND POSSIBILITIES IN THE DEVELOPMENT OF THE EWS

Each of the main indicators and data flows on which the EWS is presently based has deficiencies which qualify their usefulness in short-term planning. In the case of the Nutritional Surveillance system, consideration has to be given to the uncontrolled and fluctuating composition of the sample, determined by those mothers who have managed to bring their children to health facilities on the days for child welfare clinics (often with the main objective of collecting relief rations); to errors in setting scales and recording in over 500 recording points scattered throughout the country; and to the irregularity of receipts of reports from some health facilities, often the more remote ones. A further drawback is that the central processing of monthly reports at the government Computer Bureau leads to data being produced roughly two months after the time of weighing. Nonetheless, as indicated earlier, use of trends over several months, coupled with the large size of the overall sample in recent years, allow fairly confident interpretations to be made of these data.

Whilst, in contrast, rainfall statistics and their Agrometeorological interpretation can be made available with a time lag of only a few days, the usually very localized incidence of rainfall in Botswana creates a need for a higher density of reporting stations than has been achieved by present resources. This is especially the case for the network of synoptic stations, of which only ten are presently established compared with a minimum number of twenty-five advised by the World Meteorological Organization. The establishment of long-term mean rainfall for many locations, including some of the larger settlements, is inhibited by the lack of historical records stretching back sufficiently far. These are deficiencies that will be reduced only gradually.

The agricultural situation reports are reduced in value both by their subjective nature — although the skills of extension staff in describing the conditions within their assigned areas are probably considerable and can be enhanced both through training and consultation with the

local community — and by the slowness of transmission from the field. This produces a time lag in data availability comparable with the nutritional system. Consideration is being given to the acquisition of satellite imagery which should improve the range monitoring capability of the EWS as well as being adaptable to other uses.

Cornell University Nutritional Surveillance Programme in conjunction with the Ministry of Health in Botswana has recently carried out an analysis of the historical relation between some of the agricultural indicators used in the EWS and the prevalences of malnutrition recorded in the Nutritional Surveillance system (Cornell Nutritional Surveillance Programme, 1984). This work, which is continuing, is expected to be extremely useful in guiding members of the EWS in the use of available indicators to predict possible outcomes of trends in nutritional status. Two of the strongest relationships derived by this analysis of data over three to four seasons were between excess malnutrition in the period June to December and both the water satisfaction index for maize, and an adjusted livestock index of cattle condition, at earlier times of the year. In the case of the latter, it is likely that loss of milk production during drought periods leads to lower intake among children in rural areas, which then is reflected in the Nutritional Surveillance results. Extension of this work both in scope (for example through examination of the historical relationship between rainfall and nutritional status) and in terms of refinement through an expanded time series over future years, holds promise for increasing the predictive capacity of the effects of drought from an early point within any season. A major problem still to be resolved, however, is how to separate out the effects on prevalence of a further factor: the large increases in the amount of supplementary food distributed as both the numbers of eligible people and the monthly ration levels are increased in response to drought.

FUTURE FRAMEWORK FOR BOTSWANA'S DROUGHT EARLY WARNING SYSTEM

The further development of the EWS in Botswana may best be reviewed at three levels: national, district and regional. An effort is presently underway to elaborate a comprehensive National Food Strategy (NFS) which will cover the medium term, represented by the new Six-Year Plan due to begin in 1985. The NFS will provide a co-ordinated framework for projects aimed at increasing food production, for measures taken to improve nutritional status, and for efforts to achieve a greater level of food security for the nation and for individual households. Prominent among the programmes encompassed by the NFS will be the institutionalization of mechanisms for drought monitoring and contingency planning, particularly in terms of agency responsibilities.

It is therefore envisaged that the present arrangements for the operation of the EWS will be continued, and that the framework for the application of EWS data will be extended by a number of new sources of information. These include the projection of food consumption requirements and food availability within a national Food Accounting Matrix, annual agricultural survey results, data from household surveys on health status in 1984 and on income and expenditure in 1986, as well as the continuation of collaborative work with Cornell University assisted by UNICEF.

At District level, greater efforts will be needed to encourage, partly through training, those planners involved in District Drought Committees to make greater use of data sent to and transmitted from the EWS. There is good potential for this because of the relatively decentralized nature of decision-making over the allocation of resources earmarked for relief purposes. It is hoped that, as familiarity with EWS data grows, it will permit better targetting of resources to the more needy areas and populations within administrative Districts. Similar considerations apply to the use of other related sources of information, such as the national population census results.

Finally, the future development of Botswana's EWS will be related to the establishment of a Regional Early Warning System for the nine countries of the Southern African Development Co-ordinating Conference (SADCC). This is envisaged as part of the series of initiatives planned under the Food Security Programme, and will involve a central unit, based in Zimbabwe, which will be a point of collection and analysis for the reports issued by the member countries. This will offer considerable potential benefits to the Early Warning Systems already operating in the region, many of which are in their early stages. Harmonization of data collection and reporting methods, general exchanges of experience and the long term improvement of drought monitoring and food security planning will benefit the whole region.

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