Government of Malawi

DEPARTMENT OF CLIMATE CHANGE
&
METEOROLOGICAL SERVICES

AGROMETEOROLOGICAL UPDATE

FOR FIRST ROUND 2010/11 AGRICULTURALPRODUCTION ESTIMATES

Released 28th January 2010

2010/11 Growing Season Preparedness

The Department of Climate Change and Meteorological Services issued the 2010/11 Seasonal Rainfall Forecast on 1st September 2010. At that time, moderate to strong La Nina conditions, which are the cooling of Sea Surface Temperatures over the eastern equatorial Pacific Ocean, had established and were predicted to persist into the first quarter of 2011.

La Nina conditions are usually associated with average to above average rainfall over a greater part of Southern Africa and below average rainfall over Eastern Africa region. As such Malawi lies in the transition zone between Eastern African and Southern African climate regions. The effects of La Nina are therefore mixed depending on strengths but generally the southern half experiences better rainfall performance than the northern half where some areas experience poor rainfall performance.

The forecast suggested that during 2010/2011 rainfall season, a greater part of Malawi would experience normal to above normal total rainfall amounts that could result in floods especially in prone areas.

The Start and Progress of 2010/2011 Rainfall Season

In terms of timeliness, the main rains started a bit late compared to last season. The main rains generally started between mid of November and early to mid-December which represented average to late onset when compared to the climatological start of rains in Malawi. A few areas received first effective rains in December and these included Karonga district in the north and some parts of Dedza and Mchinji districts in the Centre. The spatial and temporal distribution of rainfall in most areas has been good with no major breaks except in the north where some areas had experienced erratic onset of rains due to dry spells especially at the beginning of the season.

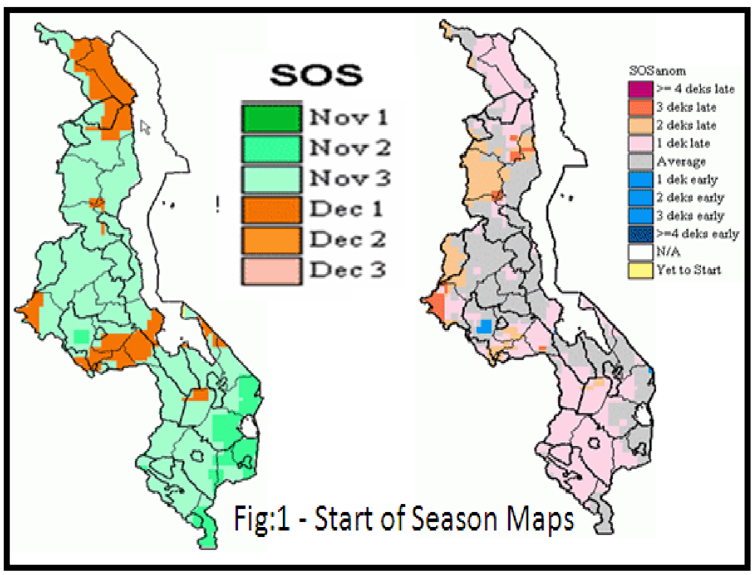
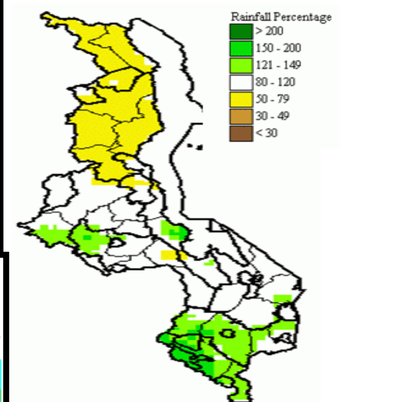


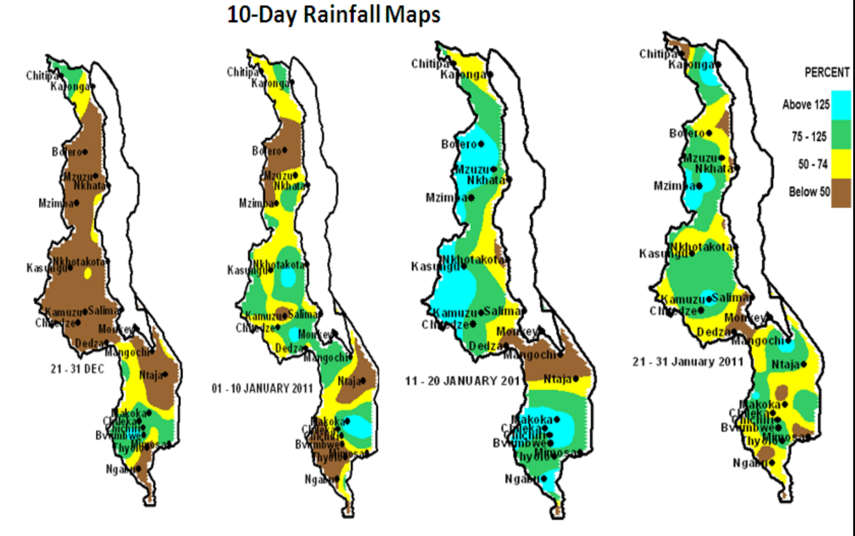
Fig:1 - Start of Season Maps

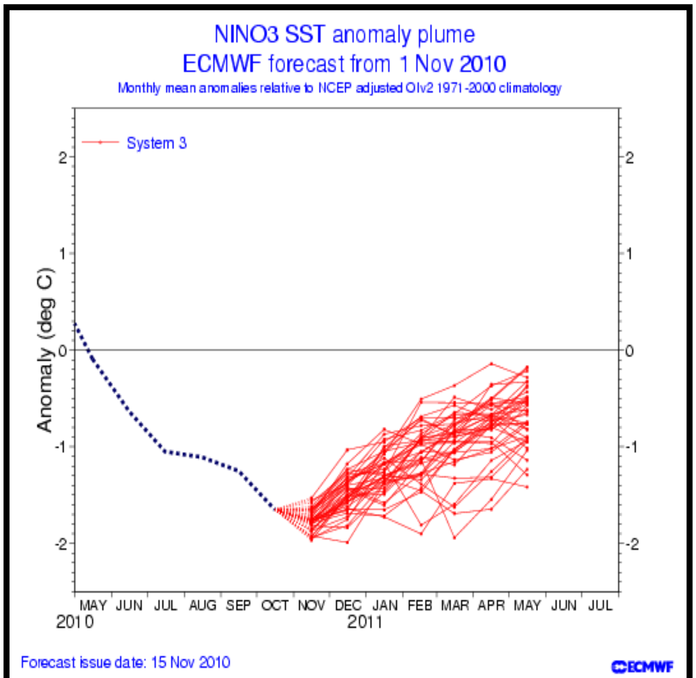
At the end of December 2010, which is the end of the first half of the season, the Agricultural Development Divisions (ADDs) in the north had registered below average cumulative rainfa1l performance while average to above average total rainfall amounts were received in the other ADDs in the south and centre. By 20th January the cumulative rainfall situation had improved slightly, but still most of the north was still under below average cumulative rainfall situation.

Fig:2. Cumulative Rainfall Map



10-Day Rainfall Maps





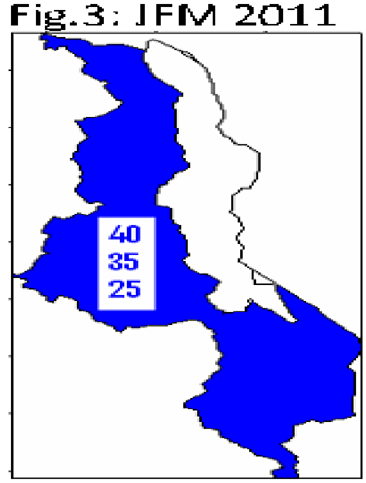
La Nina Update

Most Climate models project persistence of moderate to strong La Nina conditions into the first quarter of 2011

Rainfall Forecast for January to March 2011

The models continue to suggest that the greater part of Malawi should expect above average to average rainfall amounts from January to March 2011. Details of rainfall probabilities are on Fig.3.

Fig.3: JFM 2011



The expected above average to average rainfall over Malawi will most likely support water resources, maturity, growth and development of most crops including root and tubers.

2010/11 First Round Maize Production Estimates from the Model

Definition of Crop Yield Assessment model

A crop yield assessment model is defined as a system represented by a mathematical or statistical expression of crop response to its environment. The mathematical expression helps to define the factors which affect the response. If the factors were perfectly defined one could forecast the outcome accurately.

In a typical biological environment perfect conditions do not exist. In any case our limited knowledge of the interactions of the environment with the cropping system and inadequate measurements make it extremely difficult to forecast the outcome accurately. A further problem is the space variability inherent in a biological system. Another problem is how to collect and analyze the data needed to represent the crop response system in a dynamic way for early warning. Given the aforementioned, it is no wonder that modelers try to short circuit the system with simple models.

USES OF CROP ASSESSMENT AND FORECASTS

Crop assessments are useful measurements for early warning for food security

- Used for prediction of food security status
- Indicative tool to policy makers to make preparatory mitigation measures
- Imperative to have reliable production measures for crop production

CROP PRODUCTION FORECASTS

Crop production forecasts are used for assessment of crop production **before** harvest. These can be prepared before the crop season starts on the basis of seasonal forecast, planting intentions, inputs availability, economic and marketing factors that affect crop production.
Early estimates are made when crops are still in the field and they are not reliable.

Why?

The crops are subject to adverse effects before harvesting for instance water-logging of the crop, excessive rains, floods, attack by pests, damage by livestock, theft etc.

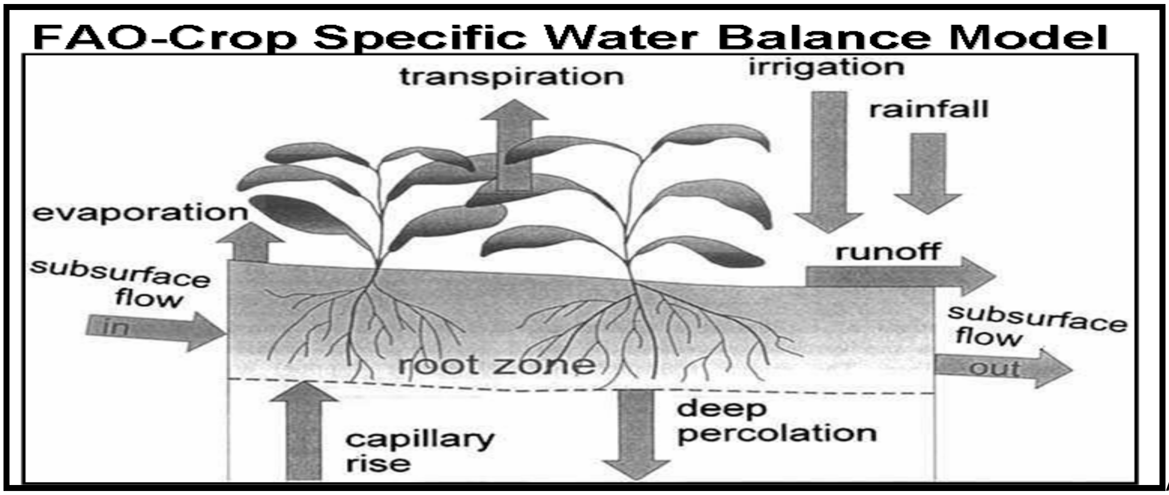
MAIZE YIELD ASSESSMENT USING FAO CROP SPECIFIC WATER BALANCE MODEL

- **Basic Principles of FAO Water Balance Model**

FAO has developed a procedure of computing cumulative water balance over the growing season of a crop and uses the outcome (WSI) to assess crop performance and yields. SADC Regional Early Warning System for food security adopted this procedure for crop monitoring and yield assessment. The method is applicable only where water supply to the crop in terms of amount and distribution is the main constraint.

- **Calculation of the Water Balance**

The Water Balance is the difference between rainfall received by the crop and the water lost by the crop and the soil. It is a calculation technique which compares available water and water requirements of a given crop for each dekad (10-day period) of the growing season.



A shortfall or large excess of water in any dekad will result in a reduction of the "crop index", which the model generates as means of monitoring crop conditions and forecasting yields.

According to Frere and Popov (1986), "the originality of the model lies in simultaneous use of actual observed rainfall data and climatological and agronomic information for the water requirements of the crops". By relying on a minimum of actual observed data, "real time", monitoring is made possible. Many variables included in the model, such as soil water retention capacity, and potential evapotranspiration are calculated prior to the actual operation of the model during the growing season.

Model Data Requirements

The following data sets are required to calculate Water Balance:

1. Soil Water Holding Capacity (WHC)

Is the amount of water a soil type can hold. The order of magnitude depends on soil texture, composition and compaction. It is higher for clay soils and low in sand soils.

2. Crop Cycle (LGS)

Length of the Growing Season is the time from sowing to maturity in dekads. Data for common varieties of Maize can be obtained from Ministry of Agriculture and Food Security.
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3. Dekadal Normal rainfall from climatology

4. Dekadal Actual rainfall received

5. Dekadal Effective rainfall for each station

On a flat land it is often assumed that all rainfall infiltrates into the soil. On slopping field a good part of rainfall, depending on intensity, soil characteristics, etc may be lost as surface runoff. In this case not all the water is beneficial to the crop. An empirical ratio may be introduced to account for the non-beneficial rainfall eg the runoff.

Effective Precipitation = (Actual pcpn*Effective pcpn Ratio)

6. Dekadal Normal Potential EvapoTranspiration (PET)
7. Dekadal Actual Potential EvapoTranspiration (PET)
8. Crop Coefficient (Kcr)

Crop coefficient depends on the crop and the growing stage. It indicates the water requirement as compared to Evapotranspiration. According to Doorenbos and Prate (1977), maize had a KC of 0.3 in the first dekad of the cycle, as the young plants cover on a fraction of the soil and water requirements are much lower than that of a dense grass cover. In the later crop stages, KC increases gradually to reach 1.2, during flowering. Later, near maturity, the coefficient declines.

9. Water Requirement (WR)

Water requirements of crops are obtained by multiplying the potential evapotranspiration for a given dekad and the crop coefficient for the same dekad. The total water requirement for the season can be calculated from the beginning by summing up successive water requirements dekad by dekad.

- **Water reserves in the soil**

Is the available water in the soil at the end of each dekad. Available water has a maximum value depending upon the soil type and depth, and on the profile of the roots of a given crop at a specific growth stage. The soil moisture at the first dekad after planting is carried forward as the opening soil moisture of each successive dekad. If available water is negative, the soil moisture is indicated as zero.

- **Surpluses and deficits of water**

Excess values occur when available water is higher than water holding capacity of the soil. If the water holding capacity of the soil is 100 mm and available water is more than 100 mm, it is counted as excess or surplus. A deficit occurs when due to insufficient rainfall in consecutive dekads, the calculation of soil moisture reaches a negative value.

- **Crop Water Satisfaction Index**

Is the extent (in percent) to which the total crop water requirements for a growing season have been satisfied in a cumulative way at any growth stage. When the water requirement is met throughout the growing season, one can expect optimum crop response. The index starts with a value of 100 at the beginning of the season. Water deficits and excesses above the water retention capacity decrease the value. The higher the index at the end of the season, the lower the water stress and the likely it is for higher yield.

Crop yield indices have been calculated for past years for various locations in Malawi. Using simple linear regression analysis, the data was analysed against historical crop yields data for each location.

The relationship between the index and yields is tentatively as follows:

Index	**Comments**	**Expected Yields**
100	Excellent	100% or more
97 – 99	Good	90 – 99%
80 – 96	Average	50 – 89%
60 – 79	Mediocre	20 – 49%
50 – 59	Poor	10 – 19%
<50	Complete failure	<10%

It is important to note that the model must have reliable historic yield data in order to forecast yields. In other words, the model is not a substitute for a well-functioning system that gives statistically sound estimates of crop yields as well as area and production. However, the model can be used in conjunction with such a system, particularly to serve as a check.

Why use Crop Water Satisfaction Index

With knowledge of **area planted and potential yield** values, Crop Water Satisfaction Index values can be translated into production estimates.

- Production (tons) = f (Yield)
- Yield (tons/ha) = f (WRSI)

A simple linear regression model is of the form:

Y = a + b*WRSI

Where Y = estimated yield (dependent variable)
a = constant
b = coefficient of variable
WRSI = Water Requirement Satisfaction Index

ASSUMPTIONS OF CROP WEATHER MODEL

- When running the model at any particular time, rainfall is assumed to be normal to the end of the season
- The model output leans towards minimum reported district yield in a bad season and towards maximum reported district yield in a good season
- Fertilizer uptake is reflected in the historical reported yield data
- Year to year variability of yield is due to weather variables
- Soil types and Water Holding Capacities are based on FAO classifications
- The area planted reported by the Ministry of Agriculture and Food Security is assumed correct
- In the absence of actual hectarage data previous season's data is used (assumed not to have changed)
- The effects of pests and diseases, and other environmental, political, socially-economic ally induced factors are not taken into account

STRENGTHS OF THE MODEL

- It can be run on a ten day interval and at district level
- The model is a very useful early warning tool since it can provide reliable yield estimates well ahead of the final production figures (as early as February)
- Model results compare very well with agricultural production estimates survey (APES) output by MoAFS
- Model outputs gives room for planning for both the best and worst case scenarios
- The model is scientific and therefore objective
- The model can be adapted for any crop provided historical yield data is available
- The model can be run on a simple desktop/ laptop computer
- Use of the model is cost-effective compared to other methodologies

LIMITATIONS OF THE MODEL

The Crop Water balance model has some inherent limitations which affect the usefulness of the index obtained.

- Assumption of one soil layer and no account of root growth
- No objective accounting of excess soil moisture
  - ✓ e.g if surplus = 100mm, then WSI decreases by 3%
  - ✓ other if Surplus = WHC, WSI reduced by 2%
  - ✓ effect of excess water differ with growth stage
- WSI can only decrease with time
  - ✓ WSI starts at 100 and can progressively decrease
  - ✓ Model considers cumulative effects throughout the season
  - ✓ Negative effects assumed additive & crop makes no recovery (some crops may recover to some extent if in early vegetative stages)
- Assumed constant rate of development

- ✓ If crop LGS is 10 dekads, then maturity is is assumed at the end of period irrespective of other factors eg temperature
- Use of FAO crop coefficients other than for varieties **grown in Malawi**

FACTORS AFFECTING THE MODEL

- Low density of station network negatively affects the performance of the model
- Poor communication of data from rainfall stations. Some stations stopped reporting
- Unavailability of fortnightly data
  - ✓ Actual planting dates
  - ✓ Area planted
  - ✓ Crop conditions, etc
- Poor quality of data from other stations due to limited recording skills

Meanwhile, efforts are underway to improve the water balance based models by incorporating crop productivity models. One of the potential candidates for this is the FAO AquaCrop Model.

TABLE 1: 2010/11 LOCAL & COMPOSITE MAIZE PRODUCTION ESTIMATES

LOCAL MAIZE - SEASON 2010-2011

ADD	Area Pl.	WRSI	a	b	S.E.	t stud.
SHIRE VALLEY	28688	94	-65.01	1.679	14.289	1.761
BLANTYRE	134895	96	-68.00	1.663	13.821	1.714
MACHINGA	208344	95	-86.13	1.978	15.190	1.714
SALIMA	31713	96	-128.30	2.444	13.652	1.721
LILONGWE	217681	97	-114.41	2.275	10.452	1.692
KASUNGU	208119	98	-80.44	1.909	11.668	1.693
MZUZU	86242	97	-85.82	1.980	10.945	1.717
KARONGA	20891	98	-140.85	2.583	13.004	1.812
NATIONAL	936573	96	-86.17	1.954	12.980	1.645

RDP	EST. YIELD (% Max.)	EST. YIELD (kg/ha)	EST. PROD. (Tonnes)	YIELD LOW	YIELD HIGH	PRODUCTION LOW	PRODUCTION HIGH
Balaka	101	1727	70141	1283	2171	52098	88184
Blantyre	92	2832	67662	2104	3560	50274	85050
Chikwawa	92	1285	28952	934	1637	21040	36863
Chiradzulu	92	2281	36401	1695	2867	27047	45755
Chitipa	112	3172	31603	2505	3838	24964	38243
Dedza	106	2069	123658	1725	2413	103103	144214
Dowa	106	2585	149541	2103	3067	121670	177412
Karonga	112	2628	28714	2076	3180	22681	34747
Kasungu	106	2497	159644	2032	2963	129890	189399
Likoma	106	1841	11	1515	2166	9	13
Lilongwe	106	2198	212390	1833	2563	177084	247695
Machinga	101	1865	72130	1385	2345	53576	90685
Mangochi	101	2248	182096	1670	2826	135254	228939
Mchinji	106	2541	153907	2067	3014	125222	182591
Mulanje	92	2527	73849	1877	3176	54871	92827
Mwanza	92	1804	16343	1340	2268	12143	20542
Mzimba	106	2293	165211	1888	2699	135997	194425
Neno	92	1916	29271	1424	2409	21749	36792
NkhataBay	106	2692	18559	2216	3168	15277	21840
Nkhotakota	105	2592	29453	2013	3171	22877	36028
Nsanje	92	1294	7977	940	1647	5797	10157
Ntcheu	106	1751	107324	1460	2042	89484	125165
Ntchisi	106	2707	69728	2202	3211	56733	82724
Phalombe	92	2558	62793	1901	3215	46657	78930
Rumphi	106	3187	23286	2624	3751	19168	27404
Salima	105	2504	50948	1945	3063	39573	62322
Thyolo	92	2793	47302	2075	3511	35146	59458
Zomba	101	1846	88698	1371	2321	65881	111514

CROP YIELD ASSESSMENT BASED ON THE WATER SATISFACTION INDEX (WRSI)

YIELD: kg/ha WRSI: % AREA: Hectares PRODUCTION: Tonnes

90% CONFIDENCE INTERVAL: Y(est)+/-t(0,10)*Std. Err. of Y(est)

AREA BASED ON FIRST ROUND 2010/11 CROP ESTIMATES FIGURES

	10/11	10/11	YIELD	YIELD	10/11	10/11	PROD	PROD
ADD	WRSI	YIELD	LOW	HIGH	AREA	PROD	LOW	HIGH
SHIRE VALLEY	94	1287	935	1639	28688	36929	26838	47020
BLANTYRE	96	2473	1838	3109	134895	333620	247887	419354
MACHINGA	95	1983	1473	2493	208344	413065	306808	519322
SALIMA	96	2535	1969	3101	31713	80400	62450	98350
LILONGWE	97	2037	1698	2375	217681	443373	369670	517075
KASUNGU	98	2560	2083	3037	208119	532821	433515	632126
MZUZU	97	2401	1976	2826	86242	207067	170452	243682
KARONGA	98	2887	2281	3494	20891	60317	47645	72990
NATIONAL	**96**	**2250**	**1778**	**2723**	**936573**	**2107592**	**1665264**	**2549919**

TABLE 2: 2010/11 HYBRID MAIZE PRODUCTION ESTIMATES

HYBRID MAIZE - SEASON 2010-2011

ADD	Area Pl.	WRSI	a	b	S.E.	t stud.
SHIRE VALLEY	14580	92	-108.484	1.991	12.513	1.734
BLANTYRE	120900	97	-108.072	1.982	10.000	1.740
MACHINGA	81215	94	-72.913	1.448	7.893	1.833
SALIMA	28316	93	-57.574	1.334	18.938	1.729
LILONGWE	130186	95	-52.891	1.350	6.276	1.833
KASUNGU	152188	96	-31.645	1.063	11.382	1.729
MZUZU	60736	95	-24.802	0.853	13.925	1.782
KARONGA	19604	97	-194.014	2.779	18.037	1.771
NATIONAL	607725	95	-76.262	1.763	14.768	1.645

RDP	EST. YIELD (% Max.)	EST. YIELD (kg/ha)	EST. PROD. (Tonnes)	YIELD LOW	YIELD HIGH	PRODUCTION LOW	PRODUCTION HIGH
Balaka	63	2071	37494	1592	2550	28819	46168
Blantyre	84	3221	64358	2555	3887	51042	77674
Chikwawa	74	1779	16663	1260	2298	11805	21520
Chiradzulu	84	3045	40575	2415	3675	32179	48970
Chitipa	77	3006	19950	1752	4261	11626	28274
Dedza	76	2476	71518	2099	2853	60634	82402
Dowa	70	2506	77984	1801	3211	56038	99931
Karonga	77	2604	33765	1517	3690	19677	47852
Kasungu	70	2435	140940	1750	3120	101276	180605
Likoma	56	1964	291	1095	2832	162	419
Lilongwe	76	3244	235245	2750	3738	199444	271045
Machinga	63	2913	23066	2239	3587	17729	28402
Mangochi	63	1886	40257	1450	2323	30943	49571
Mchinji	70	2464	113722	1770	3157	81718	145726
Mulanje	84	3239	91053	2569	3909	72214	109893
Mwanza	84	2478	17428	1965	2990	13822	21034
Mzimba	56	2089	96752	1165	3013	53951	139553
Neno	84	2559	19967	2030	3089	15836	24099
NkhataBay	56	1964	14701	1095	2832	8198	21204
Nkhotakota	67	2161	22746	1099	3223	11568	33925
Nsanje	74	1698	8853	1203	2193	6272	11434
Ntcheu	76	2419	69641	2051	2787	59043	80239
Ntchisi	70	2679	45618	1925	3432	32780	58455
Phalombe	84	3070	45568	2434	3705	36140	54997
Rumphi	56	2438	16526	1360	3517	9215	23836
Salima	67	2517	44786	1280	3755	22777	66795
Thyolo	84	3166	94352	2511	3821	74830	113875
Zomba	63	2489	84247	1913	3065	64755	103739

CROP YIELD ASSESSMENT BASED ON THE WATER SATISFACTION INDEX (WRSI)

YIELD: kg/ha WRSI: % AREA: Hectares PRODUCTION: Tonnes
90% CONFIDENCE INTERVAL: Y(est)+/-t(0,10)*Std. Err. of Y(est)

AREA BASED ON FIRST ROUND 2010/11 CROP ESTIMATES FIGURES

	10/11	10/11	YIELD	YIELD	10/11	10/11	PROD	PROD
ADD	**WRSI**	**YIELD**	**LOW**	**HIGH**	**AREA**	**PROD**	**LOW**	**HIGH**
SHIRE VALLEY	92	1750	1240	2260	14580	25516	18078	32953
BLANTYRE	97	3088	2449	3727	120900	373302	296063	450541
MACHINGA	94	2279	1751	2806	81215	185063	142246	227880
SALIMA	93	2385	1213	3557	28316	67532	34345	100719
LILONGWE	95	2891	2451	3331	130186	376404	319121	433687
KASUNGU	96	2486	1786	3185	152188	378264	271811	484717
MZUZU	95	2112	1178	3046	60736	128269	71525	185013
KARONGA	97	2740	1597	3883	19604	53715	31303	76126
NATIONAL	**95**	**2613**	**1949**	**3277**	**607725**	**1588065**	**1184493**	**1991637**

In summary to come up with results in Tables 1 and 2 the following assumptions have been made:

1. The rainfall performance from February up to end of the season would be normal,
2. The remaining part of the 2010/11 season would not be affected by external factors like floods and outbreaks of pests and diseases

Therefore the national level production of Local, Hybrid and Composite maize varieties for 2010/11 season using FAO Crop Specific Water Balance Model is estimated at **3,695,657 Metric Tons**. Please note that the official source of agriculture production estimates in Malawi is the Ministry of Agriculture and Food Security.