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Analysis of Rainfall Variability on Potato Production in Kenya: A Case of Oljoro-orok Division

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ABSTRACT--- ***The paper analyses the trend of rainfall and its effects on potato yields in Oljoro-orok Division, Nyandarua County. The objective of the study was, to analyse seasonal and annual rainfall characteristics and correlate them with potato yields in Oljoro-orok division. Secondary data on rainfall and potato yields was collected from Nyahururu Meteorological Station and District Agriculture Office respectively for the period of eleven years. The data collected was analyzed using descriptive statistics namely frequencies, percentages and means with the aid of Statistical Package for Social Science (SPSS) version 17.0. The results were presented using line and bar graphs, tables and circles. The findings were that annual rainfall and potato yield shows an increasing trend between 1999 and 2009. Rainfall has shown a decreasing trend during the long rain season and an increasing trend during short rain season. Rainfall variability is significant in both seasonal and annual trends ranging from +464.97 in 2007 to -239.63 in 2009 on the annual trend, +624 in 2007 to -360 in 2008 during the long rain season and +152 in 2006 to -171.6 in 2007 during the short rain season. From the findings, the researchers recommend that Soil and water management practices should be enhanced to reduce loss of moisture from the soil and increase soil water retention capacity during dry spell in the upper sides of the division. Sustainable management practices such as mulching, digging of trenches and earth dams and use of irrigation during the dry spell as an adaptation measure should be applied to cope with rainfall variation.***

Keyword--- rainfall variability, rainfall characteristics and potato production

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1. INTRODUCTION

Agricultural sector faces many challenges stemming from weather variability, growing global populations, land degradation and loss of cropland to urbanization. Although food production has been able to keep pace with population growth on the global scale, there are serious regional deficits and poverty related nutritional deficiencies affecting close to a billion people globally in this century. Weather variability is affecting food production and availability in many parts of the world, particularly those most prone to drought and famine (Rosenzweig *et al.*, 2002)

Weather variability has affected Irish potatoes (*Solanum tuberosum*) world's fourth largest food crop following rice, wheat and maize. Weather variability scenario studies performed using crop models show increases in potato yields in northern Europe and decreases or no change in the rest of Europe (Wolf, 2000). Temperature, incoming solar radiation, water and nutrient availability are the main factors that generally determine potato yields. Biological systems are based primarily on photosynthesis and thus dependant on incoming radiation. Irregular rainfall patterns results in high risk of drought and intra-seasonal dry spell, leading to low crop yields and sometimes total crop failure (Kinoti *et al.*, 2010).

During the past decades, weather variability has had a marked influence on European agriculture (Orlandini *et al.*, 2008, and Reidsma *et al.*, 2009). The impacts of the 2003 heat wave in Europe, with temperatures up to 6°C above long-term means and precipitation deficits up to 300 mm, resulted in an estimated loss of 13 billion Euros for the European agricultural sector (Ciais *et al.*, 2005). Global climate model result shows that future heat wave in Europe will become more intense, more frequent and long lasting in the 21st century (Meehl and Tebaldi, 2004). Potatoes often respond nonlinearly to changes in their growing conditions and have threshold responses; this greatly increases the importance of weather variability and frequency of extreme events for yield, yield stability and quality (Porter and Semenov, 2005).

In Africa agriculture constitutes a large share of her economies, with a mixture of subsistence and commercial production. African agriculture is sensitive to present weather variations. The effects of weather variability are uncertain, but adverse impacts are likely in many regions. The future of African agriculture and food security depends on the outcome of weather variability, indigenous responses to global change, development efforts in the next few decades and global patterns of commodity production and demand (IPCC, 2007).

The Africa regions have distinct characteristics. North Africa and the Indian Ocean islands rely on irrigated agriculture. In West Africa, the gradient of climates from the Sahara to the humid coast determines the potential for agriculture. Subsistence agriculture and pastoralism dominate the Sudan and Sahelian regions; plantation agriculture is found along the Guinea coast. The highlands of East Africa are well known for potato production that takes advantage of the two rainy seasons. The lowlands, however, are subject to erratic rainfall and poor soils. The humid and sub-humid zones of Central Africa, where drought is problem, are conducive to roots and tubers (Maharjan, 2011). The effects of rainfall variability on potato yields are already being felt in Africa and beyond. The average potato yields in Sub Sahara Africa have remained stable at between 5-10 tons per hectare while those in Western Europe are over 30 tons per hectare (Kaguongo *et al.*, 2007). It is against this background that the study investigated the effect of rainfall variability on potato yields in Oljoro-orok division

2. MATERIAL AND METHODOLOGY

The study area was Oljoro-orok division, Nyandarua County situated in the central part of Kenya. The division lies between Latitude 0^o 8´ north and 0° 40' south and between 35^o 13´ east and 36° 22’ east between the Rift Valley and Aberdare Ranges (Nyandarua District Strategic Plan, 2010). Secondary data on rainfall and potato yields was collected from Nyahururu Meteorological Station and District Agricultural office respectively. Potato yield data collected was for both long rain season and short rain season between 1999 and 2009. The long rain season yields were added to the short rain season yield to get the annual yields in each year. The data collected was from the seasonal data recording sheets found at the division agriculture office. The recording sheet captures the number of hectares planted in a growing season, expected yields and the actual yields realised at the end of the season. Monthly rainfall data was collected between 1999 to 2009, Rainfall data collected had the following rainfall characteristics; rainfall amounts, number of rainy days and onset and cessations. The rainfall data was collected from the rainfall recorded at Nyahururu Meteorological Station where daily, monthly and annual rainfall is captured.

Trend and variability test were carried out on seasonal and annual rainfall and potato yield data between 1999 and 2009 in Oljoro-orok division. Simple line graphs on seasonal and annual rainfall and potato yield were computed and the trend line drawn to determine the significance of the trend. Trend analysis was done to determine the relationship of rainfall and potato yield data in Oljoro-orok division. Both annual and seasonal trends of rainfall and potato yield data were analysed. Seasonal and annual variability indices of both rainfall and potato yield were computer using the following formula to determine their relative variability.

Formula for calculation of relative variability

$$RV = \frac{X - \overline{X}}{\overline{X}} \times 100 \qquad (1)$$

Where;
RV is relative variability,
X is the data element and
$\overline{X}$ is the mean of the data.

3. RESULTS AND DISCUSSION

Trend of annual rainfall

The results in Figure 1, shows that annual rainfall amount has increased between 1999 and 2009 in Oljoro-orok division as shown by the trend line. Peaks are noticed in 2001 and 2007 while dips are noticed in 2000 and 2009. The peak in 2001 is as a result of favourable rainfall during the long rain season in that year as shown by Figure 2. The peak in 2007 was as a result of favourable rainfall especially during the long rain season in that year as shown by Figure 2. The dips in 2000 and 2009 are as a result of unfavourable rainfall during the long rain season in the same period as shown by Figure 2. The short rain season data contributes a lot to the increasing trend on the annual rainfall since as shown on Figure 2, rainfall trend shows a decreasing during the long rain season. R^2=0.075 shows that strength of the line is weak. The findings supports the argument that, ‘Year to year and season to season rainfall variability is persistent in East Africa, a phenomenal that continue to present a challenge to agriculture production (Shisanya, 1996; Seleshi and Zanke, 2004).

Figure 1: Annual Rainfall data trend for years 1999 – 2009

Trend of seasonal rainfall during the Long rain season

The result in the Figure 2 shows a decreasing trend of rainfall between 1999 and 2009 during the long rain season. Peaks are noticed in the year 2001, 2003 and 2007 while dips are noticed in 2000, 2002, 2008 and 2009. The peaks were as a result of favourable rainfall in the season while the dips were as a result of unfavourable rainfall in the season. The variation of rainfall in Oljoro-orok as the study found is supported by IPCC (2007) argument that rainfall variation in East Africa is as a result of the El Niño phenomena. This argument is also supported by Boer (2004) that variability of rainfall at Bandung district is significantly correlated with global climate forces, SOI (Southern Oscillation Index) and IOD (Indian Ocean Dipole). The El Niño, SOI and IOD are global phenomena that have large scale climatic effects.

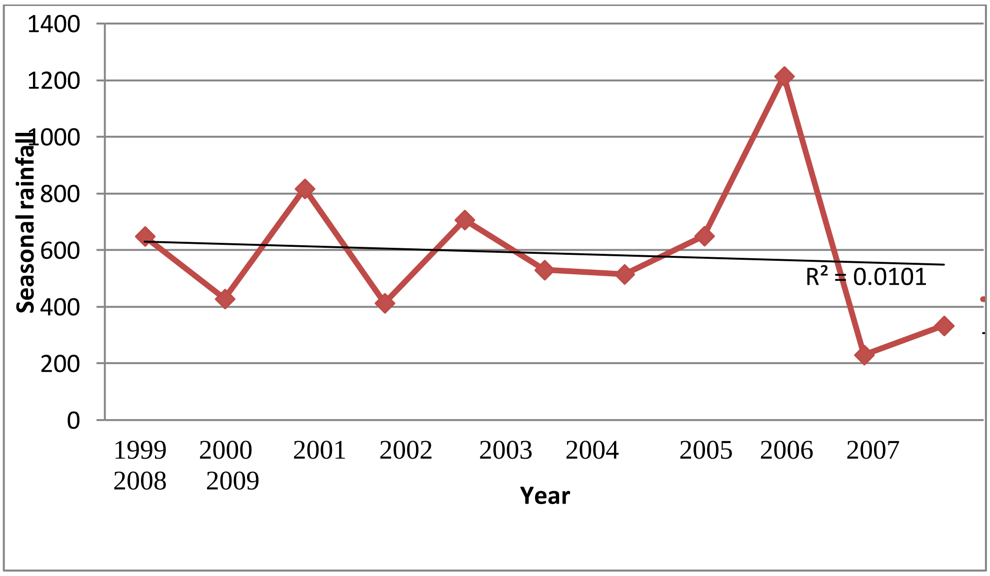

Figure 2: Trend of Rainfall (mm) data: 1999-2009 – Long rain season

Trend of seasonal rainfall during the Short rain season

The trend line in the Figure 3 shows that rainfall during the short rain season increased between 1999 and 2009 in Oljoro-orok division. Peaks are noticed in 2002, 2006 and 2009 while dips are noticed in 1999, 2003, 2005, and 2007. The peaks are as a result of high rainfall in the season while the dips are as a result of low rainfall in the season. R^2=0.1443 shows that the strength of the line is weak.

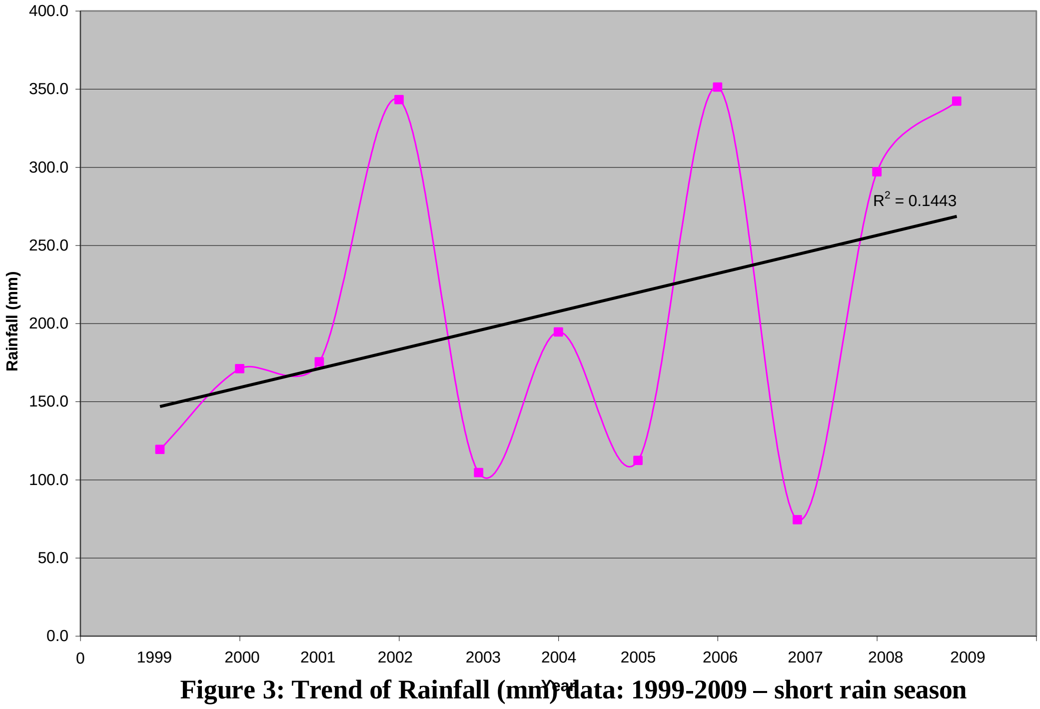

Figure 3: Trend of Rainfall (mm) data: 1999-2009 – short rain season

Rainfall Variability

Rainfall variability was computed using rainfall variability index. Annual rainfall variability ranges from +48.9891 in 2007 to -25.2473 in 2009 as shown in Table 1. Rainfall variability is significant in the long rain season trend and ranges from +105.7627 in 2007 to -61.01695 in 2008 as shown in Table 1 Rainfall variability is also significant in the short rain season trend and ranges from +61.7886 in 2006 to -69.7561 in 2007 as shown in Table 1.

Table 1: Seasonal and annual rainfall variability index

Year	Annual rainfall amount	Annual rainfall variations mean=949.13	Seasonal rainfall amount -long rain	Seasonal rainfall variation-long rain mean=590	Seasonal rainfall amount -short rain	Seasonal rainfall variation-short rain mean=246
1999	786.6	-17.1241	649	10	11.4	-51.6260
2000	617.9	-34.898	428	-27.4576	311.9	26.8293
2001	1187.3	+25.0935	817	38.4746	246.4	0.1626
2002	961.5	+1.3033	413	-30	343.2	39.4309
2003	905.9	-4.5547	707	19.83o5	104	-57.7236
2004	907.2	-4.4177	530	-10.1695	195	-20.7317
2005	890.7	-8.8649	515	-12.7119	174.3	-29.1463
2006	1058.5	+11.5232	650	10.1695	398	61.7886
2007	1414.1	+48.9891	1214	105.7627	74.4	-69.7561
2008	1001.2	+5.4861	230	-61.0169	392	59.3496
2009	709.5	-25.2473	333	-43.5593	343	39.4309

Trend of potato production

Trend of annual potato yields in tonnes

The study as shown on Figure 4 found that Potato yields have increased between 1999 and 2009 in Oljoro-orok division as shown by the trend line. The increasing annual trend is noticed but the yields have varied over the years. R^2=0.124 shows that the strength of the line is weak. Peaks are noticed in 2001, 2003, 2004 and 2007 while dips are noticed in 2000 and 2009. The peaks in 2001 and 2007 are due to favourable rainfall as shown on Figure 1 on the annual rainfall trend. The dips in 2000 and 2009 are as a result of the unfavourable rainfall as shown by the dips on Figure 1

Figure 4: Trend of annual Potato yields in tons for the years 1999-2009

Trend of seasonal potato yields in tonnes during the long rain season

From the findings shown in the Figure 5, R^2=0.0461 shows that the strength of the line is weak. Potato yields have increased in Oljoro-orok between 1999 and 2009 during the long rain season. Peaks are noticed in 2003, 2004 and 2007 while dips are noticed in 2001, 2006 and 2009. The peaks in 2003 and 2007 are as a result of favourable rainfall as shown by the peaks on the Figure 2 on seasonal rainfall trend. The dips in 2000 and 2009 are as a result of unfavourable rainfall as shown by the dips on the Figure 2 on seasonal rainfall trend. The dip in 2006 was as a result of a dry spell on the upper side of the division as rain was not uniform in the season, it rained more on the lower side than the upper side.

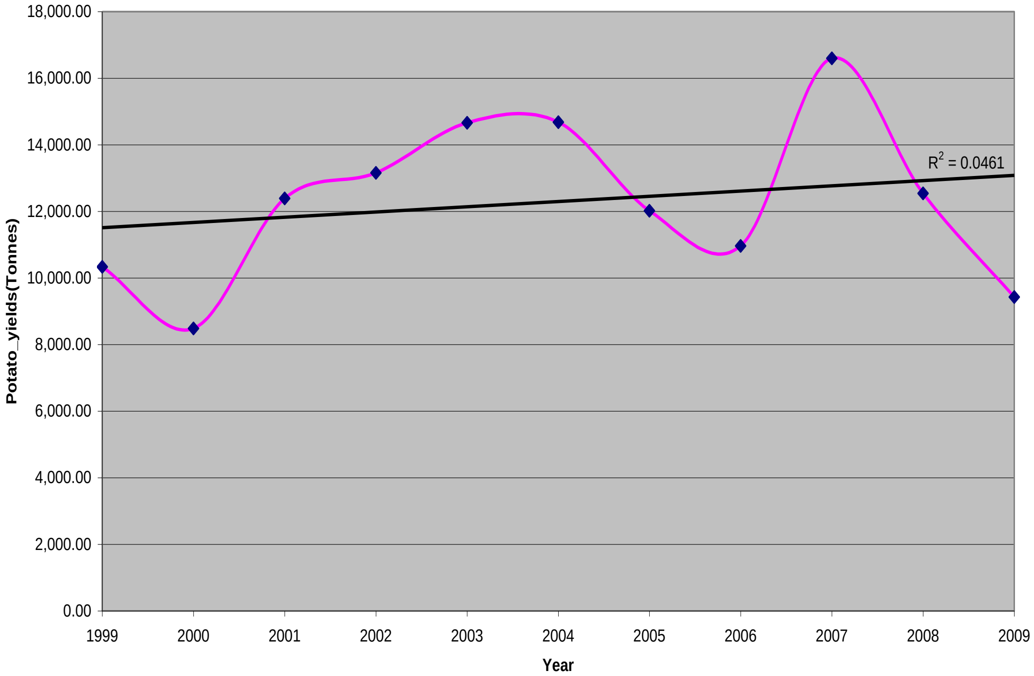

Figure 5: Trend of potato yields in tons between 1999 and 2009- Long rain Season

Trend of seasonal potato production in tonnes during the Short rain season

The finding in Figure 6 shows that potato yield during the short rain season increased between 1999 and 2009. A peak is noticed in 2007 was as a result of high potato prices towards the end of the short rain season in 2006. More land (3,112 ha) was put under potato in the 2007 long rain period leading to high yield as shown by the peak in Figure 6. In 2007 there was delayed cessation of rainfall during the long rain season which resulted to a portion of the long rain season potato yields mixed with the short rain season yields. The short rain season had low rainfall in that year and even though the yields in the upper zone declined due to the dry spell, the yields in the lower zone increased because of the soil water retention capacity.

Figure 6: Trend of potato yields in tons between 1999-2009- Short rain Season

Potato Production Variability

Potato production variability was computed using potato variability index. The land under potatoes was not uniform between 1999 and 2009 but ranges between 1400 hectares in 1999 to 3112 hectares in 2007. Annual potato production variability is evident by variations ranging from -33.1369 in 2000 to +60.8892 in 2007 as shown on Table 2. Long rain potato production variations ranges from -30.9963 in 2000 to +34.9898 in 2007 as shown on Table 2. Short rain potato production variations ranges from -45.2353 in 2000 to +144.0588 in 2007 as shown on Table 2.

Table 2: Seasonal and annual potato production variability index

Year	Annual potato yield in tons	Annual yield variation mean=15474	Seasonal potato yield in tons-long rain season	Seasonal yield variation-long rain season mean=12295	Seasonal potato yield in tons-short rain season	Seasonal yield variation-short rain season mean=3400
1999	12600	-18.5731	10332	-15.9658	2268	-33.2941
2000	10346	-33.1369	8484.048	-30.9963	1862.35	-45.2353
2001	15110	-2.3556	12389.79	-0.7645	2719.71	-20.02941
2002	13590	-12.1753	13157.31	7.01098	2888.19	-15.0588
2003	17875	+15.5164	14657.5	19.211	3217.5	-5.3824
2004	17905	+15.7102	14682.1	19.4144	3222.9	-5.2351
2005	14654	-5.3008	12016	-2.2692	2637.675	-22.4412
2006	16443	+6.2621	10962	-1.08174	5481	61.2059
2007	24896	+60.8892	16597.34	34.9898	8298.65	144.0588
2008	15295	-1.1568	12541.9	2.008	2753.1	-19.0294
2009	11500	-25.6818	9430	-23.3022	2070	-39.1177

Comparative trend Analysis

Annual rainfall and potato yields data.

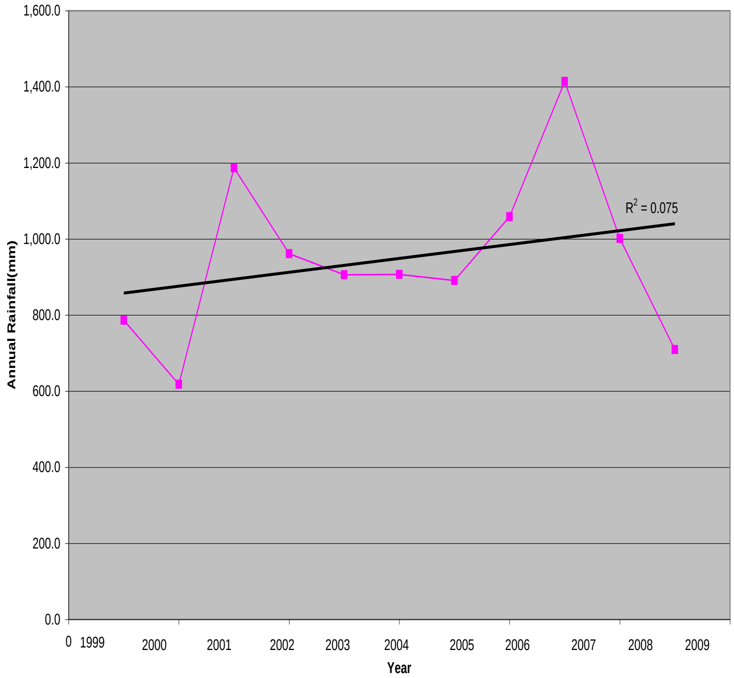

Figure 7(a); Annual rainfall data trend for years 1999 – 2009

Figure 7(b); Trend of annual Potato yields in tons for the years 1999-2009

The results in Figure 7(a) and 7(b) shows that variation of rainfall causes variations in potato yields in Oljoro-orok division. As shown by Figure 7(a) and 7(b) potato yield and rainfall both increased in Oljoro-orok between 1999 and 2009. The variation on potato yields with variation of rainfall in Oljoro-orok as the study found supports the arguments by KARI (2005) that rainfall determines the type of crop to be grown in different environment as well as the type of agricultural system to be practiced in different parts of the country. The study found that variation and increased Irish potato yields has been caused by variations and increased rainfall in Oljoro-orok division. These findings supports the earlier work by Olaoye (1999) that regular occurrence of drought as a result of erratic rainfall distribution and/or cessation of rain during the growing season reduce Nigeria's capability for increased crop production.

Seasonal rainfall and potato yields data during the long rain season.

The results in Figure 8(a) show a decreasing rainfall trend and an increasing potato trend in Figure 8(b) between 1999 and 2009. The potato yield dynamics in the division is as a result of variation of rainfall, different types of soils in both lower and upper zone of the division as well as the potato prices in the previous season. When rainfall is high the lower zone are affected by water logging. When rainfall are low the upper zone of the division namely, Nyairoko and upper Oraimutia location records low yield since the black cotton soils in the area drains very fast. The lower zone potato yields increase during such a time because the soils there retains water. These argument is supported by Ogola *et al.* (2011) that there are many factors that affect potato yields, such as lack of clean seed, lack of water and nutrients in the soil, damage from pest and diseases. The peak in the rainfall and potato yields in 2001 and 2007 on Figure 8(a) and 8(b) shows that potato yields increases with increase in rainfall during the long rain season. The dips in 2000 and 2009 in both figures show how potato yields are correlated with rainfall in a growing season.

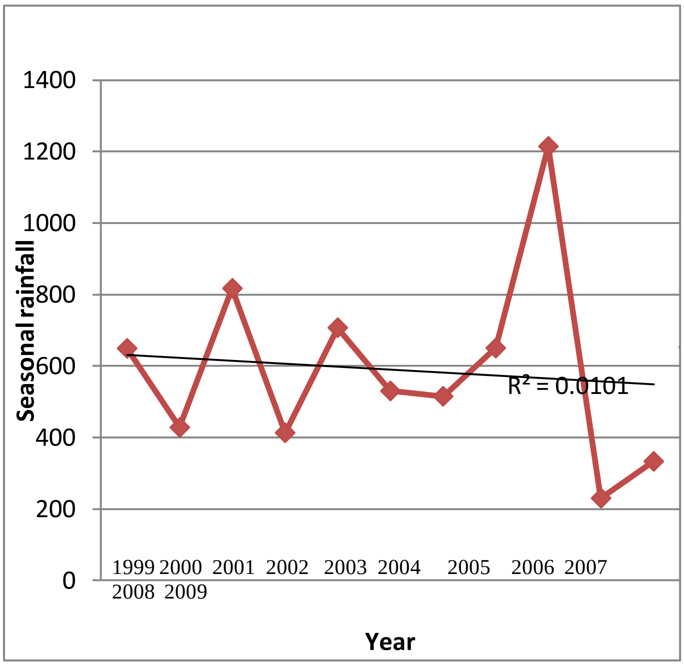

Figure 8(b); Trend of Potato yields in tons for the years 1999-2009: Long rain season

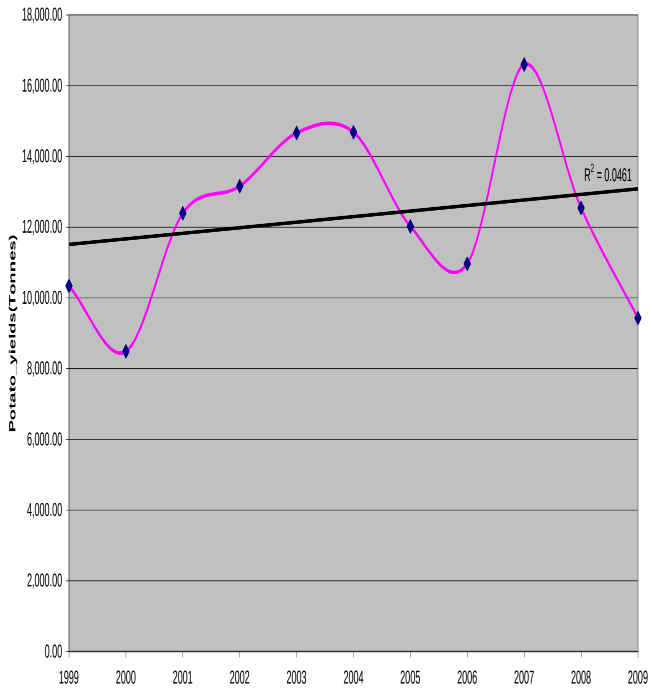

Figure 8(a); Trend of Rainfall (mm) 1999-2009: Long rain season

The main objective of the study was to analyse the effect of rainfall variability on Irish potato production in Oljoro-orok Division. The study found that rainfall amounts have increased over the years between 1999 and 2009 in Oljoro-orok Division. The study also found that there is significant relationship between rainfall characteristics and potato yields in Oljoro-orok division. Rainfall characteristics and potato yields have varied over the years between 1999 and 2009. Variability of rainfall leads to variation of potato yield, as rainfall is the main source of water for potato growth. The upper zone of the division has a well drained soil while the lower zone has soils with high water retention capacity hence able to retain water during the dry spell. There has been a shift on the onset and cessation of rainfall. The onset alternates from March to May during the long rain season and September and November during the short rain season. The cessation alternates from June to August during the long rain season and November and January during the short rain season.

5. RECOMMENDATIONS

The study recommends for sustainable land management practices such as;
Soil and water management practices should be enhanced to reduce loss of moisture from the soil and increase soil water retention capacity during dry spell in the upper sides of the division. In the lower side of the division more trenches should be dug to reduce cases of water logging during heavy rain seasons. This water should be drained into earth dams hence more earth dams should be dug so that they can store water which together with the existing dams such as Gichaka, Jacob and Ngara should be utilised for irrigation on the upper side of the division during the unfavourable rainfall seasons in Oljoro-orok division.

6. REFERENCES

Boer R., Wahab I., perdinan and Meinke H. (2004). The Use of Global Climate Forcing for Rainfall and Yield Prediction in Indonesia: Case Study at Bandung Distr Bogor Agricultural University. Australia

Ciais P.(2005). Europe-wide reduction in primary productivity caused by the heat and drought in 2003. *Nature journal 437, 529–533.*

IPCC (2007). Climate change 2007: the physical science basis, Contribution of Working Group to the fourth Assessment report of the intergovernmental panel on climate change. Solomon, S., Qin, D., manning, M Chen, Z., Margiquis, M., Averyt, K.B., Tignor, M., and Miller, H.L (eds) Cambridge University Press Cambridge, UK and New York, NY, USA, 996pp

Kaguongo, W., Gildemacher, p., Demo, p., Wagoire, W. Kinyua, P., Andrade, J., Forbes, G., Thiele, G., and fugile, K. (2007). Farmers practices and adoption of improved potato varieties in Kenya and Uganda. Maastridit School of management.

KARI, (2005). Status of potato industry in Kenya. Potato development and transfer of technology report Nairobi.

Kinoti, j., Zhongbo, S., Woldai. Kiteme, B. (2010). Integrating socioeconomic aspects in spatial multi-criteria evaluation process for selecting Rainwater harvesting sites as a mitigation measure to climate change in Sub Sahara Africa. Centre for Training and integrated Research in ASAL Development (CETRAD) Nanyuki, Kenya.

Maharjan, Keshav L., Piya , Joshi, Niraj P., Luni. (2011*).* Effect of climate variables on yield of major food-crops in Nepal -A time-series analysis Published in: *Journal of Contemporary India Studies: Space and Society , Vol. 1, (March 2011): pp. 19-26.*

Meehl G.A., Tebaldi C. (2004). More intense, more frequent, and longer lasting heat waves in the 21st century. *Science 305:994–997*

Ogola, O., Milton, W., Ayieko, A., Orawa, O., Kimani, W. (2011). Analysis of fertiliser use in potato production in Nakuru district, Kenya. *Africa journal of Agriculture vol.6* (16):3672-3677

Olaoye O (1999). Developing drought tolerant varieties for the Savanna agro-ecologies of Nigeria in 25th year Commemoratives Publications of Genesis Society of Nigeria. *pp.173-182*

Orlandini S, Nejedlik P, Eitzinger J, Alexandrov V.(2008); Impacts of climate change and variability on euro-pean agriculture results of inventory analysis in cost countries. *Clim Res 1146:338–353*

Porter J.R., Semenov M.A. (2005). Crop responses to climatic variation. Philos Trans R Soc B *360:2021–2035*

Reidsma P., Ewert F., Lansink A.O., Leemans R. (2009); Vulnerability and adaptation of European farmers: a multi-level analysis of yield and income responses to climate variability. *Reg Environ Change 9:25–40*

Rosenzweig, C. Philips, j., Goldberg, R., Carroll, J. and Hodges, T. (2002).Potential impacts of climate change on citrus and potato production in the US. *American Journal of Potato Research*. 20: 259-270

Shisanya, C.A. (1996).Chances and risks of maize and beans growing in semi-arid areas of SE Kenya during the expected deficient, normal and above normal rainfall of the short rainy season, PHD Thesis (published) Trier Germany.

Seleshi, Y. and Zanke, U. (2004). Recent changes in rainfall and rainy days in Ethiopia. *International journal of climatology*, 24: 973-983.

Wolf, J., Harrison, P.A., Butterfield R.E and Lonsdale, K. G. (2000b). 'modelling climate change impacts at the site scale on potato', in downing, Climate change, climate variability and agriculture in Europe: An integrated Assessment, research, report, environmental change unit, university of oxford, *PP 239 – 261*.