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Trend and Linkages between Climate Elements, Pest Activities and Pesticide Usage in Urban Farms Communities in Lagos

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Abstract

This paper provides an assessment of the relationships between climate elements, pest activities and pesticide usage in urban farms in Lagos. The connections were analyzed with the view to ascertaining the extent and how well climate elements (rainfall and temperature) are related to pest activities and pesticide usage. Available rainfall and temperature data between 1971 and 2006 were collected and collated to estimate the linear and decadal trend as well as their variability in order to detecting temporal pattern in the period covered. The service of insectology was further employed to identify common pests on the farms and their seasonal characteristics. Proxy and available data on sales of pesticide from selected pesticide vendors and farmers were used together with literature to determine the seasonal pesticide use in the urban agricultural communities in Lagos. The results suggest that both rainfall and temperature have been increasing over the period covered. Estimations revealed that rainfall increased in order of 42 mm/per year/per decade while temperature increased in order of 0.270C per year/ per decade. Maximum temperature recorded for the months of February and August were 32.6oC and 28.2oC respectively. The result further revealed that pest activities are widespread during the dry season when temperature is high. This stimulates increase pest attack on crops and increase in pesticide usage. There is thus an indication of increases pest activities and pesticide usage as the trend in the climate elements was found to be linked with pesticides sales/usage with 30,000 liters to 15,000 liters of pesticides usage estimated for the months of February and August respectively.

Keywords: pattern, linkages, climate elements, pest activities, pesticide usage, urban farming

1. Background

The connection between climate elements and pest activities and pesticide usage is increasingly becoming a challenge to urban agricultural practices as the urban demand for food and employment continues to increase (Palikhe, 2007). Almost all urban farmers use pesticides to control insect pests and diseases of food and fiber crops in order to improve the quantity and quality of yield. Despite the important role that pesticide application plays in sustaining agricultural practices and human society, less information is available on its seasonal relationship with the trend and pattern of rainfall, and temperature and pest activities within the urban agricultural practices (Mansour, 2008). With the current observed changes in climate elements, Yet, the observed changes in these climate elements have been associated with the dynamic, growth and spread of some insects, mites, weeds, nematodes, disease-causing organisms, and vertebrates and seen as competitors that could lower the quality and yield of food with its consequential increase in pesticide usage far above maximum acceptable limit (Pimentel, 2005). These trends and patterns and their effects on pest infestation and pesticide usage have raised concern on the quality of urban farm products as various studies have revealed positive relationship between high pesticide applications, food contamination and poisoning resulting to several human health problems such as asthma, cancer, attention-deficit (hyperactivity) disorder, nervous system disorders and weaken immune systems (Owen, et al, 2010).

In most parts of the world, pest and pesticide management is highly regulated and very transparent to scientists, stakeholders and the public. In addition, all aspects of variability in climate elements as it's related to all aspect of human livelihood particularly agriculture is often communicated to practitioners, and its related policies are often synchronized among all related sectors. Nigeria As a signatory to international conventions and protocols to address increasing concerns over the management, disposal and transboundary movements of severely hazardous pesticides (Basal, 1989 Rotterdam, 2001 Stockholm), Nigeria is committed to the promotion of environmentally sound use of hazardous chemicals by facilitating information exchange about pesticide characteristics among other things. There are several policy documents and programmes including the New Nigerian Agricultural Policy, Drug and Related Products (Registration, Etc) Decree of 1993 And 1999, National Environmental Policy, the Draft Occupational Safety and Health Bill, National Environmental Standards and Regulations Enforcement Agency (NESREA), Pesticide Legislation for Nigeria and National Policy on Chemical Management for creating awareness on variation in climate elements related to effective pesticide management (Stacie 2013). Yet Inspite of all these, there is only little if any data and information to increase farmers' awareness on the appropriate methods of handing pest problems and pesticide applications,while current efforts at reducing the impact of climate on human development have also not adequately considered pest activities and pesticide usage as a critical component of minimizing the effects of climate change on human environment.

Realizing the synergy between trend and pattern of temperature and rainfall, pest activities and pesticide usage, Nigeria particularly Lagos is highly at risk in the area of food security, poverty reduction, and healthy and sustainable environmental development. The task ahead is therefore to increase the adaptive capacity of vulnerable and potentially vulnerable poor communities in order to minimize the present urban food insecurity problems by gaining a deeper understanding of the synergy among these variables and reducing the challenges faced in urban communities and emerging cities. This paper therefore attempts to examine trend and seasonal pattern of observed change in climate elements and their relationship with pest activities and pesticide usage in two urban agricultural communities in Lagos.

2. Study Area

Lagos lies in the humid tropics within the tropical forest zone of southwest Nigeria, experiencing high rainfall and temperature for most parts of the year. The mean annual rainfall is about 1600mm and could reach over 2000mm, in very wet years while the mean monthly rainfall is about 135mm. Lagos typically experiences the bimodal rainfall pattern with first rainfall peak occurring in June-July and the second occurring in September. Rainfall onset (with rainfall >50mm) is around March to April with cessation occurring between late October and November. December to February (DJF) are typically dry and hot months with very little or no rainfall. The month of August represents the "little dry season" characterized by decreased rainfall and moist cold wind. Alapere Farm is located at the north eastern part of the Lagos metropolis and at the extreme end of the Third Mainland bridge, opposite Estate Bus Stop and has an area of about 66.45hectares (Anosike, 2007). Barracks Farm located at the South western part of the metropolis covers about 1296 hectares. The land belongs to the Nigeria Army as the site is part of the Army Barracks (see Figure 1.1).

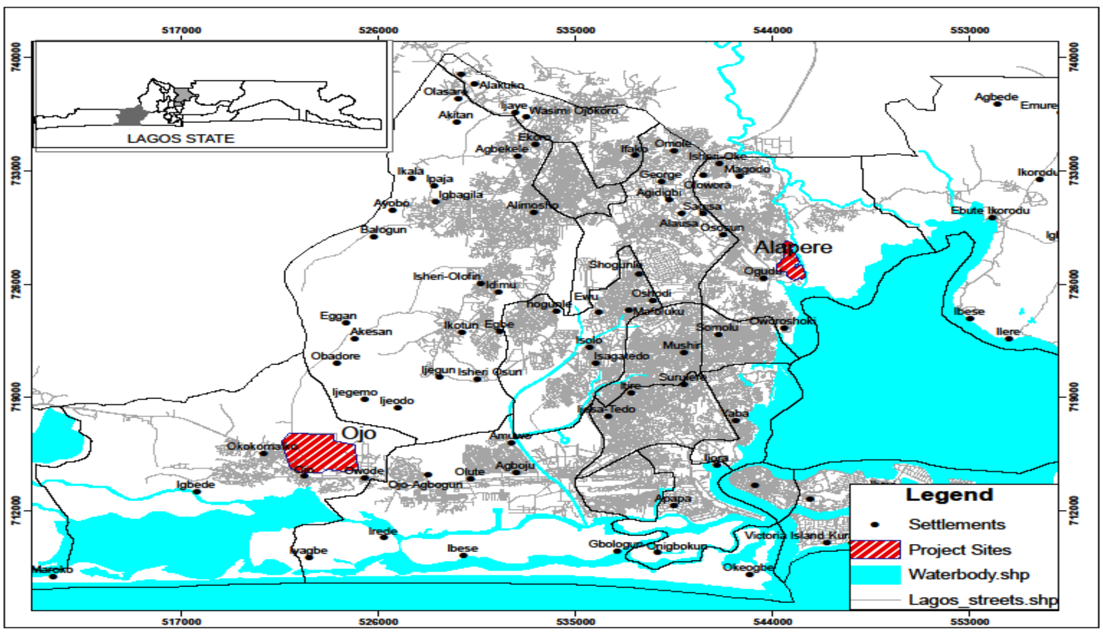

Figure 1. Map of metropolitan Lagos showing the study locations

3. Methods

A multidisciplinary approach was adopted in the collection, collation and analysis of data and information for this research. The first was the use of historical and downscaled climate data used in our analysis. Historical daily rainfall and maximum temperature data for two climatic stations (Ikeja and Island) in Lagos was sourced from the archive of the Nigerian Meteorological Agency (NIMET) and was statistically processed to derive the average for Lagos. The use of rainfall and maximum temperature is justified by the fact that they are the limiting factors for vegetable growth and to some extent, the propagation of vegetable diseases that necessitated the use of pesticides. The downscaled climate data for the same stations (Ikeja and Island) was obtained from the Climate System Analysis Group (CSAG) of the University of Cape Town.

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Climate data downscaling represents the cross-scale relationships between the larger scale circulation (from the GCMs) and local climate responses. It is based on the premise that the local-scale climate is in some measure a response to the larger, synoptic-scale forcing (Wilby *et al*. 2004). Observational data are were further used to derive a relationship between the synoptic-scale and local climates, and that relationship can then be used with comparable resolution fields of a GCM to generate information on the local climate consistent with the GCM forcing (Hewitson & Crane, 2006, Wilby *et al.* 2004). Empirical downscaling is important for generating regional and local scale scenarios of future climate to make climate change information available for impacts and vulnerability assessments, policy formulation, and climate change adaptation at regional and local scales. It has the advantage to downscale to point scales – a scale that matches the observational data characteristics that the impacts community is commonly used to. Downscaled projections of climate data also provide regional detail that is consistent with the actual spatial gradients over the region.

The downscaling process was forced by SRES A2 emissions scenario (Hewitson and Crane, 2006). The A2 emission scenario storyline family assumes a very heterogeneous world with continuously increasing global population and regionally oriented economic growth that is more fragmented and slower than in other storylines (Nakicenovic et al., 2000). The driving GCMs were adopted from the Coupled Model Intercomparison Project Phase Three (CMIP3) archive (http://www.pcmdi.llnl.gov/projects/cmip/Table.php) which makes statistical downscaling possible for the non-seamless periods 2046-2065 (near future) and 2081-2100 (far future) scenarios.

The downscaling process, apart from reproducing the observation data, yields present and both near-future (2046-2065) and far-future (2081-2100) climate projections for 10 different GCMs which are NCEP/NCAR Reanalysis; CCMA CGCM3.1; MPI _ECHAM5; MRI CGCM 2.3.2; GISS Model E-R; CNRM_CM3; CSIRO_MK3.0; CSIRO_MK3.5; IPSL_CM4 ; and GFDL_CM2.0. Model output comparison studies often use statistical approach and sometimes combine integrations from different models to form large ensemble sets. Cook and Vizy (2006) have evaluated 18 coupled GCM outputs (including the 10 GCM downscaling model output from CSAG) at the process level to diagnose only those models that are best suited for capturing the West African monsoon climate and its variability. The MRI CGCM 2.3.2 (developed by the Meteorological Research Institute, Japan) was found to provide the most reliable simulation of the twenty-first century climate over West Africa (see Cook & Vizy, 2006 for more details on the performamnce of the 18 GCMsover West Africa). The MRI CGCM 2.3.2 has a pressure at the top of the atmospheric model of 0.4hpa, and the horizontal and vertical resolution at top is T42 (~2.8°x2.8^{0}), L30 (Muller, 2009, Cook & Vizy, 2006). The broad variety of climate projections, considering all models and driving scenarios, cannot possibly be considered in its full breadth in smaller impact research projects (Muller 2009). And since inter-comparability of models output is secondary to this study, the MRI CGCM 2.3.2 was adopted for describing the future climate of Lagos.

The second method was a social survey which includes the gathering and use of available proxy data on sales of pesticide from literature, selected pesticide vendors, key stakeholders, extension Agents and farmers to determine seasonal pesticide use by interview. The service of an insectology was employed to identify common pests and their seasonal characteristics on the farms. In addition, About 200 questionnaires (100 questionnaires in each location) were administered using random sampling method to determine farmers' views on pest activities and their characteristics and pesticide uses and applications. In addition, Focused Group Discussions were conducted with executive members of each farm community and pesticide vendors. Both descriptive and regression analytical techniques were adopted within the framework of Statistical package for Social Sciences (SPSS) to assess the relationship among rainfall , pest activities and pesticide usage on one hand, and temperature, pest activities and pesticide usage on another hand. While descriptive statistics was used to describe the details of the data set regression was employed to determine the partial and net relationship among the variables. The results were presented in simple percentages, graphs and tables and figures.

4. Results and Discussions

Inconsistencies in climate element as rainfall and temperature are predicted to impact negatively on the diversity and abundance of pests (IPCC, 2007: Babasaheb et al 2012), and ultimately influence pesticide application. Over past hundred years, the global temperature for instance has increased by 0.80C and is expected to reach 1.1-5.4 0C by the end of next century. Paying attention to the observed changes in climate elements as it affects pest infestation on crops is therefore important for better pesticide usage and application. The presentation of the results and the discussions is considered under the following subheadings:

4.1 Trend in Temperature and Rainfall in Lagos

The study shows a linear rainfall trend in Lagos for the period 1977 to 2006. This suggests that rainfall has been increasing in the order of 42mm/ per year/per decade (Figure 2), suggesting that under present climate condition, Lagos may continue to receive increased total rainfall and the seasonal and monthly distribution of rainfall may change drastically.

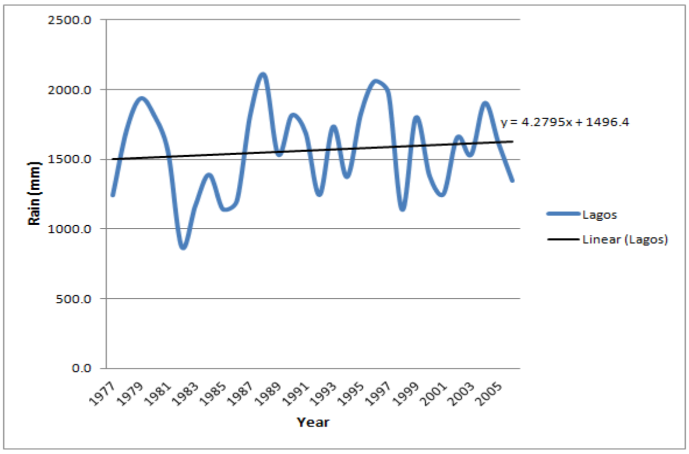

Figure 2. Rainfall Trend over Lagos (1977-2006)

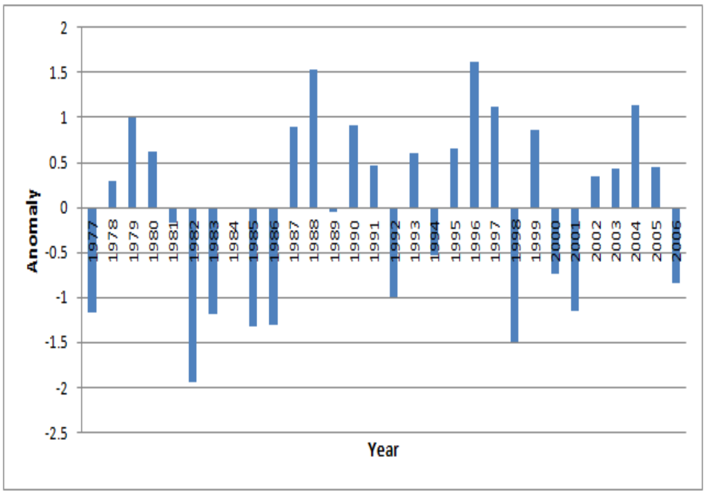

Figure 3. Rainfall anomalies over Lagos (1977-2006)

A near decadal oscillation is also observable on the rainfall pattern of Lagos (Figure 3). The decadal oscillation suggests that years of very high rainfall has always been followed by some rainfall reduction. For example, the peak oscillation was observed around 1978, 1988 and 1996 with mean annual rainfall approaching or surpassing 2000mm. In addition, the standardized rainfall anomalies on Figure 3, depicts the year 1981 to 1986, 1992, 1998, 2000 and 2001 as dry years since the received rainfall is below normal. Meanwhile, 1982 and 1998 annual rainfall is less than 1.5 standard deviation normal rainfall, an indication of severe drought.

For temperature, the mean monthly maximum temperature anomalies over Lagos suggest that maximum temperature has been increasing in the order of 0.27^0C per year/per decade (Figure 4). This suggests a direct relationship between rainfall and temperature. The consequential increase in rainfall and temperature at the same time is an indication of high sensible heat in the atmosphere which increases pest activities. Figure 5 shows the standardized maximum temperature anomalies over the Lagos environment. The years 1994 to 2006 show consistent warming. This is also consistent with the global observation on climate change and global warming in the late 20th century as reported by the Intergovernmental Panel on Climate Change (IPCC) in its fourth assessment report released in 2007.

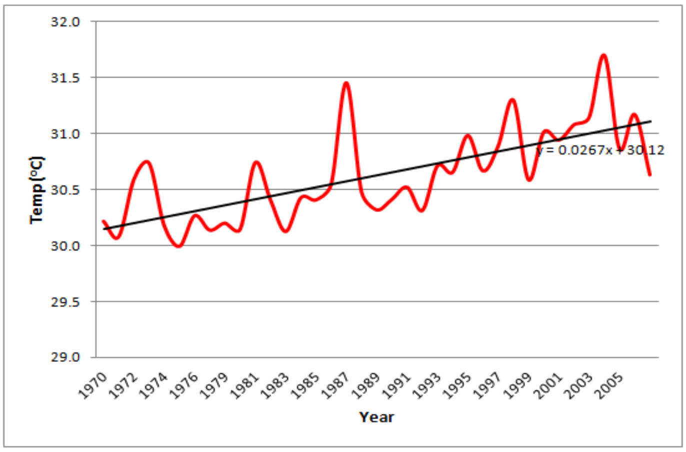

Figure 4. Mean monthly maximum temperature over Lagos (1970-2006)

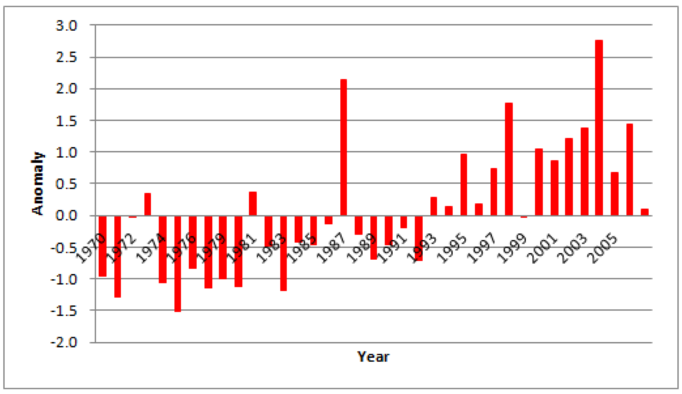

Figure 5. Standardize maximum temperature anomalies over Lagos (1970-2006)

4.2 Pest Activities in Lagos

Field analyses revealed over 87% loss in vegetable production caused by insect pest. Field observations and identifications further revealed prevalent insect pest in Alapere and Barracks as depicted on Table 1. In Alapere, the population of insect caterpillars ranked first, followed by Garden Snails, leaf warms, beetles, aphids, with the least rank being white flies. Meanwhile, in Barrack farm, beetle and caterpillars are the most common and problematic insect pests. As observed, insect pest in the study locations cause plant root rot, leaf yellowing, holes and other pathogenic infections (see Plate 1 and 2). The insect pests identified in the study locations have developed resistance to common and available pesticide. Farmers result to consistence and continue use of pesticide. Identified pest and the vegetable they infest is as presented in Table 2.

Table 1. Ranking of Pest infestations in Alapere and Barracks Farms

Pest	**Scientific Name**	**Ranking**	
		Alapere	Barracks
Caterpillars	Psara bipunctalis	1st	2nd
Garden Snails	Cornu asperum	2nd	6th
Cabbage worm	Acraea terpsichore	3rd	3th
Beetles	Podagriecbrea sp	4th	1st
Aphids	Brevicoryne brassicae	5th	5th
White flies	Bemesia tabaci	6th	4th

Source: Field Survey, 2011.

Plate 1: Garden Snail infestation on lettuce in Alapere

Plate 2 3.8: Aphid infestation on spinach in Barracks

Table 2. Pest Types and Vegetable infestations

Vegetable Crop	**Scientific Name**	**Pest**
Bitter Leaves	Verona Amygdalins	Caterpillar, beetles
Ewedu	Cachous Litarius	Caterpillar, worms
Spring Onions	Allium Fistolosum	worms
Lettuce	Lactuca Sativa	Garden Snail and cabbage worms
Ugu leaves	Spinacia Oleracea	Aphid and worms
Spinach (Efo tete)	African Spinach	Aphid and Caterpillar

Source: Field Survey, 2011.

4.3 Pesticide Usage and Management

Although there is no sufficient data to support the increasing trend in pesticide use in the study locations, the sampled farmers and pesticide dealers revealed that vegetables are treated with pesticides three to five times (3-5) times throughout their gestation periods. It was furthers revealed that different pesticides types based on their efficacy are applied on a single crop production until the desired outcome is achieved. In Alapere agricultural community for instance, pesticides are applied by farmers without adherence to instructions as a guiding rule for users. In the study locations also confirmed indiscriminate use of pesticide, poor transportation, packaging and disposal of pesticide containers as earlier reported by Neptal (2010) and World Researches (1991).

Table 3. Pesticide Usage and their Active ingredients

Name of Pesticides	Active ingredients
Karate SEC	Lambola-Cyhalothin, Metalaxy 1-M
Ridomil GOLD M2	Lambola-Cyhalothin, Metalaxy 1-M
Olythrin KA315 EC	Lambola-Cyhalothin, Metalaxy 1-M
Best	Cypermethrin
Trical	Chloropyriphos
Gerage	Imidacloprid
Best Action	Dimothoabe, Cyper Methrin
Lamola	Lambola Cyphalothrin
Milzeb	Mancozeb

Source: Fieldwork, 2011.

Pre-Harvested Interval (PHI) is rarely adhered to except in some few cases, over 75% of farmers use non-standardized sprayers with poor maintenance and cleaning culture. Safety precautions are lacking as those who dispense pesticides do not use Personal Protective Equipment (head cover, water proof apron, poor, respirator (mask), Gloves and eye protector (visor). Preference for pesticide types is usually not clear and is based on the prescription by hawkers and informal traders. The various types of pesticides identified in the study area are as presented on Table 3.

4.4 Relation between Change in Temperature, Rainfall, Pest Activities and Pesticide Usage

Discussions with farmers suggest that pest activities are more devastating and widespread during the dry season when temperature is high. As depicted in Figure 6 to less pest attack is often experienced during peak rainfall season when the atmosphere is saturated and temperature is low.

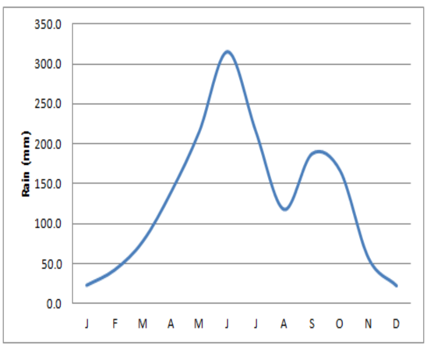

Figure 6a.

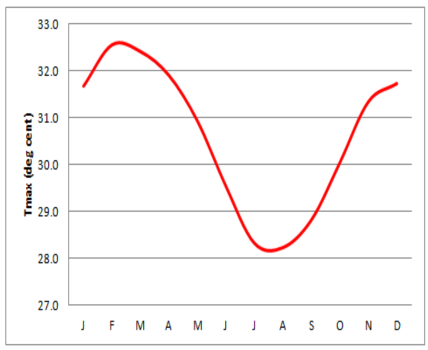

Figure 6b.

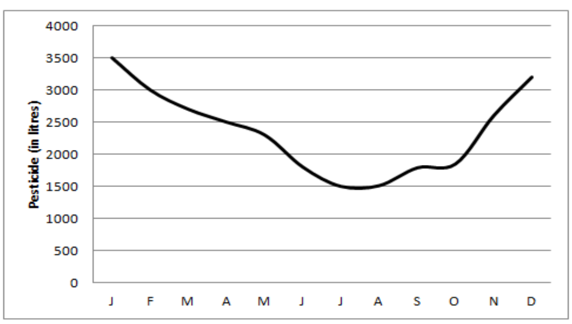

Figure 6c.

Figure a, b & c. Relationship between Seasonal Pattern of Rainfall, Temperature and pesticide usage in Lagos

As depicted in Figure 6, the annual mean maximum for Lagos is about 30.6^{0}C, although micro-climatic studies reveal variation from point to point and from one ecological zone to another. The highest maximum temperature which is normally recorded in the month of February could reach 32.6^{0}C. July and August are the coolest months with maximum temperature of about 28.2^{0}C. On monthly basis, the quantity of assorted pesticides sold seems to drop from about 3500 litres in January and February to about 1500 litres in July and August and then rises again in October, reaching over 3000 litres in December. This pattern positively correlated with the pattern of seasonal temperature but negatively correlates with the season rainfall pattern. Thus the climate-pesticide nexus can be summarized as period of higher temperature and lower rainfall indicates an increased pest activities and increased pesticide use, while lower temperature with higher rainfall means less pest activities and less pesticide use. The study further revealed that the identified pests are cold blooded and as such multiply sporadically in warm weather conditions within the temperature threshold of between 10^o C and 45^o C. Within this threshold, the movement, flight, reproduction and feeding activities of pests get to the peak, while below and above this threshold pest growth and activities are restricted. The identified pests are also prone to high and sporadic rainfall and experience high mortality, diseases and slow growth at peak wet seasons. However, moderate humidity thus plays a critical role in their incidences and activities.

The empirical regression results using R^2 revealed that rainfall account for 82.3% for the pest infestation and pesticide usage while temperature account for 99.2%. At 0.05 significance level, the result suggests that there is a relationship between temperature, pest infestation and pesticide usage and rainfall, pest infestation and pesticide usage as the values are less ($P < 0.05$).

According to some recent climate downscaling and future climate projection carried out by the Climate Systems Analysis Group of the University of Cape Town. Future climate projections for the Lagos area suggest that rainfall may reduce substantially, in the order of about 56mm/year/decade between 2046 and 2065. The bimodal rainfall pattern may also collapse, giving way to a mono peak that will occur around May to June. In the same way, the present seasonal temperature pattern is projected to continue, but at increased level (Figure 7.). The implications of this projection could suggest possible increase in pest activities and pesticide usage with its consequent negative impacts on the quality of vegetables produce, pesticide residue in the environment and its impact on human health.

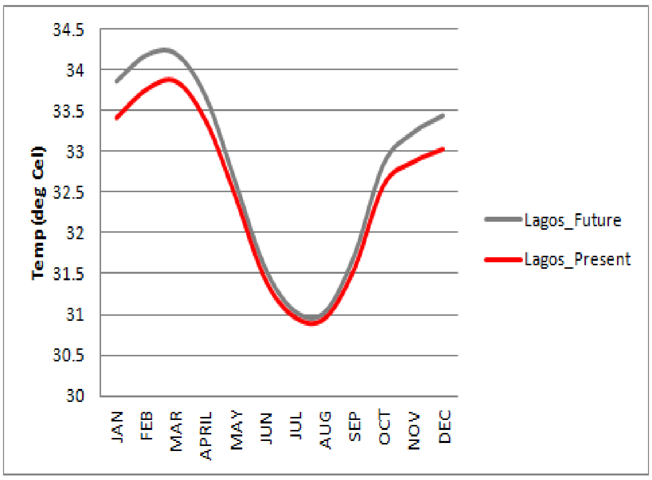

Figure 7. Present and projected future seasonal maximum temperature pattern over Lagos (2046-2065)

4. Conclusion

This paper has discussed the connection between pest activities and pesticide usage due to the influence of change in climate variables. It revealed that a reduction in rainy season and increase in temperature possibly increase in pest activities and consequently pesticide usage in urban agricultural practices. This could mean that an increase in climate variables as temperature in the future could possibly increase pest activities and pesticide usage even beyond the present levels. A continuous use of pesticides to reduce the negative impact of pest in urban and peri-urban agricultural farms activities appears critical and has a multidimensional effect on the human -environment. An approach to minimize pesticide use in response to pest therefore should be looked into in order to reduce the possible effects of pesticides on urban agricultural products, human health and on the environment. This is pertinent because various studies have showed the link between several health and environmental problems and long term excessive pesticide usage. This scenario further suggests the need for public enlightenment, farmers sensitization and advocacy for municipal regulations and bye-laws in support of, and practice of organic farming health.

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