ZIBELINE INTERNATIONAL™ PUBLISHING

ISSN: 2716-7046 (Online)
CODEN: TARCGA

Tropical Agrobiodiversity (TRAB)

DOI: http://doi.org/10.26480/trab.01.2022.16.20

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RESEARCH ARTICLE

GEOSPATIAL TREND ANALYSIS OF RAIN-FED AND IRRIGATION PRACTICES FOR CROPS YIELD IMPROVEMENT IN KURA AND MINJIBIR, KANO SATE, NIGERIA

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ARTICLE DETAILS

Article History:

Received 08 April 2022
Accepted 10 May 2022
Available online 12 May 2022

ABSTRACT

One of the advancements in Agriculture in recent time is the boost of crop yield to increase the number of output and feed the growing Nigerian population. The higher the output the less cost of food items and the more the food security. Kano State is one of the focal point not only on rain fed Agriculture alone but in irrigation farming. Irrigation was adopted coupled with soil fertility. most major crops such as Sorghum Bicolor, Maize, Millet, Beans and Groundnuts are typically grown during rainy season, while market garden crops such as Tomatoes, Pepper, Onion and Rice are now cultivated during the dry period in large hectares of land. This study focuses on different crops yield and its spatial distribution; to calculate the total crop yield per hectare and ascertain the duration of bumper harvest using trend analysis and normal probability. The result indicated more turn-out of farmers with double output of both rain fed and irrigation crops from 2019 and 2020 in two major local government area of Kano State Nigeria.

KEYWORDS

Trend Analysis, Crop yield, Geospatial, Agriculture, Geospatial

1. INTRODUCTION

About 850 million people, or about 15% of the world's population, are chronically undernourished. The nations of the planet have set a goal of halving that number by 2015, especially as the planet is currently producing enough to feed the world's population, so the long-term goal is Eliminating hunger altogether, but progress remains slow (Committee, 2013). One of the first problems is poverty in terms of both natural resources and money. Areas most suffering from hunger often do not have enough land and water resources to feed this growing population and are incapable of sourcing food from global markets, institutions, infrastructure and technology. It is a developing region with the highest growth rate. To increase their agricultural yields (Jaggard et al., 2010). For this reason, about 80% of the world's agriculture and 60% of agricultural production are covered by rainwater. Irrigated agriculture is arguably more productive, but much of the world's agriculture will be for decades to come, not only for the aforementioned water availability and economic reasons, but also for institutional reasons such as political reasons. It is safe to think of staying in the rainforest. Yamusa et al., 2015).

One of the key areas in these contexts is the semi-arid tropics, where poor small-scale farmers make a living from their land. It is mainly located in developing countries with rapid growth and severe land degradation problems and can also be considered connected. To areas that are most likely to increase rainwater agricultural production. For the purposes of this study, the semi-arid tropics are areas where the length of the season crop grown, the availability of soil moisture and the general temperature for 3-4 months for plant growth. The area is further divided into two zones. The dry semi-dry tropic with 2-3 months and the growing season is a wet semi-dry tropic with 3-4 months (Shiru et al., 2018). Satellite data occupies about 13% of the world's cultivated land and 14% of rainfed farmland. Currently, about 10% of the world's population lives within this framework, and diversity is expected to grow to 11-12% by 2025 (Fao, 2008).

In the semi-arid tropics, rainfed agriculture presents many challenges. Approximately 98% of agriculture in the arid region is rainwater and irrigation. climate is one of the most important factors that determine rainfall. The semi-arid tropics, as the name implies, are fairly dry, with an average annual rainfall of about 760 mm, 520 mm per year in dry semi-arid areas and 870 mm in moist semi-arid areas. On average, this may be sufficient to meet the water needs of crops grown in these areas. However, it is difficult to understand whether precipitation is sufficient, as precipitation fluctuates significantly over time.

Approximately one billion people worldwide are undernourished, and the world's population is projected to grow by 30% to about 9 billion by 2050, but food demand is expected to double. Competition for land and water resources from other sectors is intensifying, and competition for agricultural products for biofuel production is intensifying. The United Nations Millennium Development Goals to reduce the number of malnutrition to 420 million by 2015 is the question of how the current and future population can be nourished and where additional food demand is created. One of the regions of the world with great potential for improving agricultural production is the Semi-Arid Tropical Region (SAT), where agriculture is almost entirely rainwater and consists of poor smallholders. It is located in developing countries (Abel et al., 2021).

Because of the spread of natural factors including high climatic variability in time and space, poverty and poor education, poor policy and institutional support, and political instability, many areas within the SAT are aloof from reaching their potential agricultural production. Developing their full agricultural potential would help these areas feed their often rapidly growing populations further as reduce poverty, boost their economies and supply more food for world markets. AgroEcological Zones

Quick Response Code	Access this article online	
	Website: www.trab.org.my	**DOI:** 10.26480/trab.01.2022.16.20

(AEZ) methodology is applied to assess the agricultural potential of the semiarid tropics and compare it to currently reported yields (Okonya et al., 2013). Yield potentials are calculated for rainfed conditions under high inputs and advanced management to indicate what quantity yields will be improved. Furthermore, the AEZ methodology is adjusted to model the impacts on yield potentials of water management techniques like rainwater harvesting and soil moisture management.

The biophysical constraints on agriculture and thus the impacts of global climate change are analyzed with the AEZ (Oni et al., 2009). 1.1 Crop Yield Estimation Crop yield estimate from remote sensing is mainly based on NDVI because crop/crop yield and NDVI value are closely correlated. AVHRR's integrated seasonal NDVI value is widely touted as a valuable predictor for crop yield models that have developed a simple statistical regression model to estimate maize yield, wheat, cotton and rice at village scale in northern Greece (Bégué et al., 2010). The direct to mean regression model was developed as

Yield = a + b × NDVIsum.

1.1 Crop Yield Mapping

Crop yield mapping and forecasting is one of the survey conducted to ascertain the amount of food increase in a particular place. An application of GIS and Remote Sensing makes it easier to compute and analyse different crops yield. this has found the solution of increase demand in food supply to feed the growing population (Leng & Huang, 2017). Agricultural production is governed by a mixture of climate, soil conditions, farm management choices, technology, and genetic resources (Aliyu, 2004). While yields are steadily increasing, especially in areas with modern industrialized agriculture, interannual variability in weather is substantial and results in considerable yeartoyear variation in crop yields. as an example, variation in temperature and precipitation arising from ENSO events has been shown to be a key source of crop yield variability (Brown & Rosenberg, 1997) One amongst the foremost comprehensive studies of crop yield interactions was performed by (Chapman et al., 2020), who analyzed spacio-temporal relationships between USDA district corn yield data and weather over five Midwestern US states. More recently, trends in season temperature and precipitation are shown to be correlated with observed yield trends during the 20th century (Lobell et al., 2005) used countylevel USDA yield data and gridded climate data from 1982 to 1998 to point out that the maximum amount as 20% of observed increases in soybean and corn yields could also be associated with cooler season temperatures. However, other recent studies have shown that the effects of climate on crop yield are more complex and involve both physiological responses of crops and management decisions (Narisma et al., 2017).

1.2 Yield Gap

Crop yield potential is defined as the yield obtained when a crop is grown without water or nutrient restrictions and free of all pests, diseases and weeds. Thus, the yield potential of a crop can be a function of radiation, air temperature and crop genetics at a selected site (Kassie et al., 2015). In environments with a lot of rainwater (agricultural environments must depend on rainfall), the concept of yield potential is adjusted to yield potential that limits water because of crop growth and other factors. Other effects on yield potential are determined by site and ground characteristics (Asseng et al., 2015). The yield potential of the crop will be determined experimentally in a particular field or obtained from well-managed farmer fields. However, this is often expensive or difficult to achieve (Schlenker & Lobell, 2010). Crop modeling is used to estimate yield potential and water-constrained yield potential for specific fields, farms, and regions. In addition to quantifying possible yields, crop models are accustomed to understanding explanations for yield gaps, or the difference between actual and potential yields. for example, a researcher used crop modeling to attribute parts of the yield gap to disease, weeds, and the effects of water stress (Bouman, 1995; Tadesse et al., 2015). Low crop yields in sub-Saharan Africa are not only linked to poor soils in many countries but the shortage of rainfall (Guzmán et al., 2017), but also to limited use of essential inputs needed to raise crops to higher productivity. These inputs include the use of improved seeds, fertilizers, irrigation, and pesticides. It is assumed that the use of these inputs will increase crop yields.

The crop yield analysis is geographically known in some portions than elsewhere in the world, the continent had to import most of its food demand (Benneh et al., 1996). The requirements for agricultural rallying and productivity enhancement are not just related to limiting the country's foreign exchange import needs. This will ensure that people of many working ages entering the workforce on the sub-Saharan continent over the next 20 years will be in the workforce (Chapman et al., 2020).

2. Materials and Methods

The methods of mathematical calculation usually involve computing the output of some value of the input. These methods do not handle the distribution in the output but rather check the growth over time. Statistical techniques include performing a trend analysis using the inputs of a given distribution and assessing the effect of the yield of the inputs especially if more fertilizer is added to increase the output distribution (Walthall et al., 2013). These methods are applicable when comparing the yield over time to see the effects of interactions between multiple inputs that change at the same period. With computer-assisted aids Geographic Information System was used in visualizing the output over time, the parameters are automatically adjusted by the specified optimization search algorithm or automatically identified.

2.1 Trend Analysis

This is the kind of method used to show the time and duration of crop yield for a long period of time. At the same time, it denotes the crop yield estimated in a particular region or area.

2.1.1 Study Area

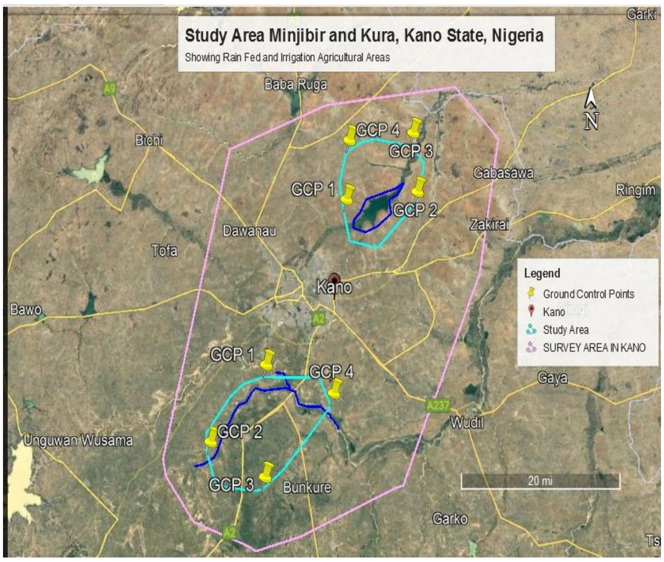

Figure 1: Study area Minjibir and Kura Local Government areas of Kano State Nigeria

2.1.2 Location of the Study Area

Table 1: Location of the Study Area (Minjibir and Kura, Kano State Nigeria)			
Ground Control Points (GCPs) Minjibir	**Latitude**	**Longitude**	**Altitude**
1	12° 7'9.67"N	8°36'33.33"E	19726m
2	12° 7'53.12"N	8°44'35.04"E	19718m
3	12°13'27.50"N	8°44'8.76"E	19723m
4	12°12'44.93"N	8°36'53.30"E	5593m
Ground Control Points (GCPs) Kura			
1	11°51'48.03"N	8°27'34.29"E	7734m
2	11°44'44.33"N	8°21'26.24"E	4865m
3	8°27'30.94"E	8°27'30.94"E	7918m
4	11°49'11.80"N	8°35'8.18"E	2395m

3. Result and Discussion

Most of the modern irrigation system nowadays are machine based (water pumping machine) with less cost of fuel consumption, the farmers found it easier to maintain them.

Figure 2: Water pumping Machine use at shallow water table 10-12m dept

The previous application of shadoop irrigation has been left out for almost 20 years. Now wash bore-holds were being constructed to irrigate up to 2-3 hectares of land per day.

Figure 3: Irrigated mixed Cropping (April, 2022) Project in Minjibir, Kano State

Table 2: Rice crop yield in Kura, Kano State, Nigeria

Year	Crop type cultivated in Hectares Rice (Oryza Sativa)	Crop Yield
2010	1	2850
2011	16	2400
2012	14	2100
2013	20	3000
2014	22	3300
2015	18	2700
2016	24	3600
2017	23	3450
2018	25	3750
2019	27	4050
2020	32	4800

There were greater increases in Rice yield from 2010 to 2020. In the last four years, there were reinforced from the Nigerian Government to boost the rice cultivation nationwide. The rest indicated increase in farm size as well as incentive provided to the farmers in Kano State. the subsidized loan scheme and the provision of improved seed varieties have enhanced large cultivation rice in the study area. Figure 4 are Mathematical model of trend analysis of rice production for 10 piloted studied years

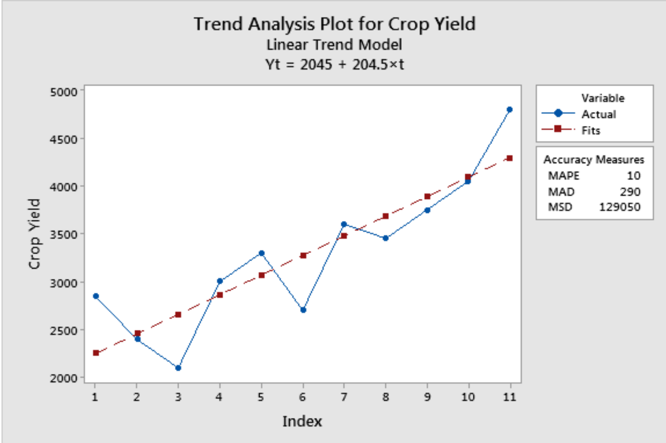

Figure 4: 10 years trend Analysis of Rice cultivation in Kura, Kano State, Nigeria

Based on the graphical model, Rice yield was fallen in 2012 and 2015 with 2100 and 2700 tonnes per annum. The highest rice yield was in 2019 and 2020 with 4050 and 4800 tonnes per annum. The mid-variance is 290 tonnes, which means that the output generally was high at that level.

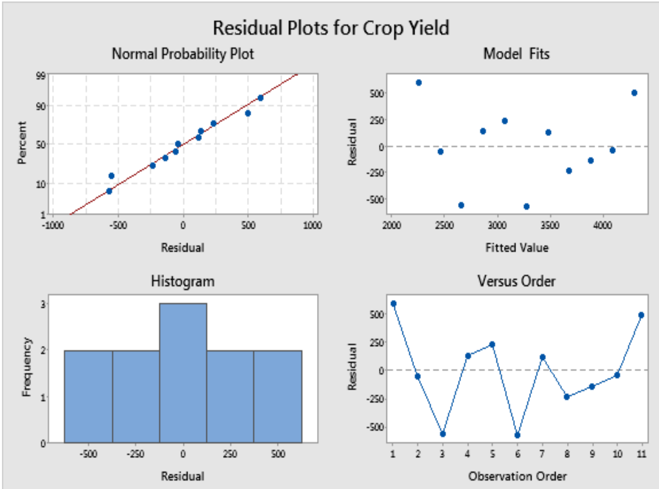

Figure 5: The combined Plot chart of Rice Crop Yield in Kura, Kano State Nigeria

There is significant relationship in the normal probability curve with the fitted value showing positive trend and the residue error remain 0. This has shown that if more input will be placed in rice cultivation in the stations, there will be more rice to ease the issue of food security in Kano State as well as other neighboring States in Nigeria.

Table 3: Guinea Corn (Sorghum Bicolor) crop Yield in Minjibir, Kano State,Nigeria

Year	Crop type cultivated in [Ha] Guinea Corn (Sorghum bicolor)	Crop Yield
2010	18	2160
2011	16	1920
2012	19	2280
2013	18	2160
2014	15	1800
2015	20	2400
2016	13	1560
2017	14	1680
2018	21	2520
2019	25	3000
2020	35	4200

Guinea corn or Sorghum Bicolor has being growing in tropical Africa. It is extensively cultivated in Kano State, Nigeria. There many varieties of S. Bicolor. The notable ones are the yellow and red varieties. Table 3 present the data collected for 10 years. The analyzed data compared the period of high and low crop yield in that region.

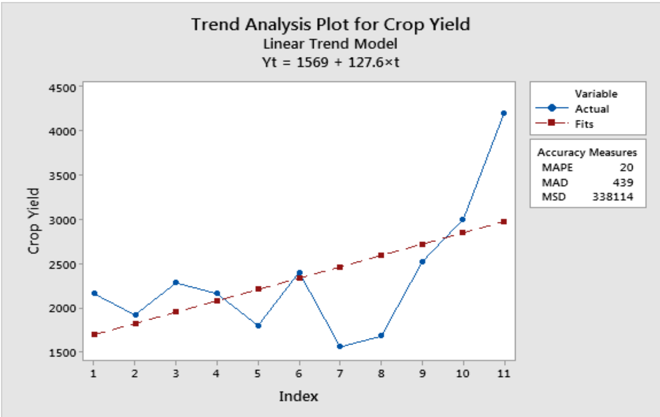

Figure 6: Linear Trend Analysis Model of Sorghum Bicolor crop yield in Kano State, Nigeria

The model plotted high crp yields and the reduction of the crop from 2014, 2016 and 2017 with low yield of 1800, 1580 and 1680 tonnes. While after 2 years of rising trend the Sorghum has being increasing in yield to 2020 with the highest yield of 3000 tonnes per annum.

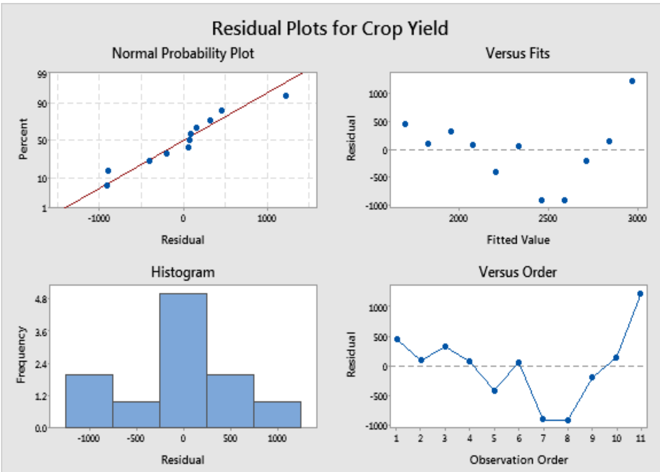

Figure 7: The combine Plot chart of Sorghum Bicolor Crop Yield in Kura, Kano State Nigeria

The combined plot analysis has indicated 0 % of residual average falls in Sorghum production. While the normal relationship is indicated good fit and the observed trend increase in recent years despite fall in the presiding years.

Table 4: Maize (Zea Maize) crop Yield in Kura, Kano State, Nigeria		
Year	**Crop type cultivated in [Ha] Maize (Zea Maize)**	**Crop Yield**
2010	**13**	**1690**
2011	**10**	**1300**
2012	**11**	**1600**
2013	**9**	**1170**
2014	**12**	**1560**
2015	**8**	**1040**
2016	**14**	**1820**
2017	**15**	**1950**
2018	**16**	**2080**
2019	**18**	**2380**
2020	**20**	**2600**

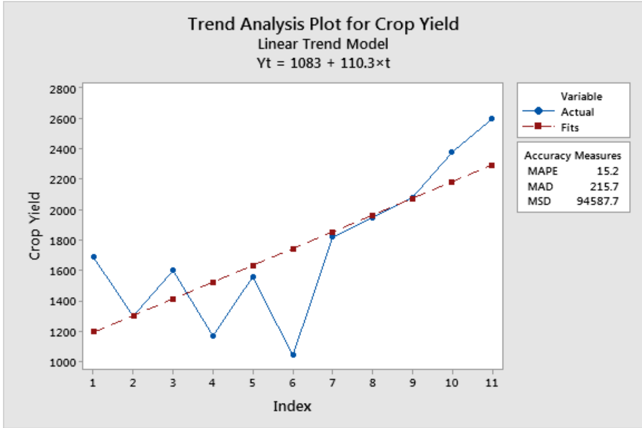

Figure 8: Linear Trend Analysis Model of Maize crop yield in Kano State, Nigeria

Maize is growing also everywhere in Nigeria. But in the case of the study, from the last 6 years till today more emphases were upon large production of the crop. However, based on the linear trend model in 2013 and 2015 only few hectares of land were cultivated. In recent times, maize has been growing in irrigated land. That is the more reason why there is double maxima production of maize and the yield has been tremendously increased.

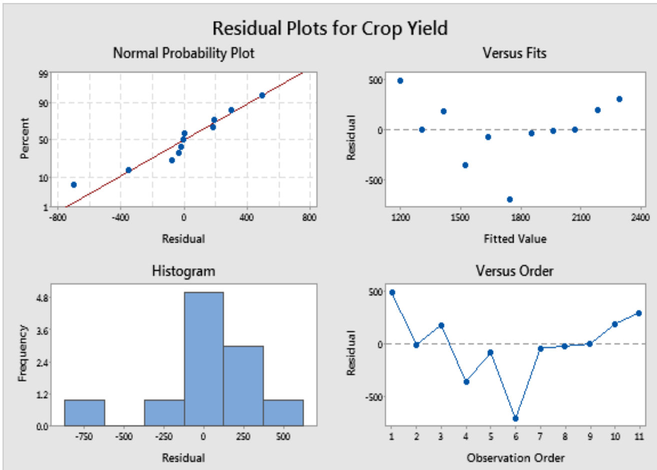

Figure 9: The combine Plot chart of Sorghum Bicolor Crop Yield in Kura, Kano State Nigeria

Maize crop has been popular in Northern Nigeria (Sufiyan et al., 2020). The Normal Probability model indicated fitted relationship with only one negative deviation. The residual model leveled 0% with more positive correlations. The observed trend analysis has shown progressive increase in crop yield.

4. Conclusion

The trend analysis of both crops including Rice, Guinea corn and Maize are shown positive trend in the boost of production. From the 2019 to 2020 there is increase in crop yield in Minijibir and Kura Local Government areas of Kano State. However, the reason behind the increase in the yield is the concerned efforts of the Nigerian government to boost food production in the 6 geo-political zones. The combined effort of human labours and farm size and capital incentives are also the factors contributed to the growth of Agricultural output in the study areas.

4.1 Recommendations

1. Attention must be given toward irrigation Agriculture in the other local government areas of Kano State.
2. Provision of capital investment from the federal government to local farmers.
3. Provision of large scale mechanization, to automated local farming systems.
4. Fertilizer subsidy must be provided in due course to all irrigation and red-fed farmers

5. Provision of low credit facilities through loan schemes.
6. Provision of pesticides and herbicides at lower cost to farmers.
7. Kano State Government should constitute strong board to those farmers for motivation, training or re-training of farmers on current Agricultural Systems.

The farmers should note that market is not the only the target but should control farm resources to those who can afford. Businessmen buy the farm produce and hoard it to increase price and create artificial scarcity in the country.

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