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Boosting self-sufficiency in maize crop production in Osisioma Ngwa Local Government with internet of things (IOT)-climate messaging: A model

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The cultivation of maize round the year is a great challenge to both subsistence and mechanized farmers in Abia State owing to the changes in climatic conditions especially precipitation, relative humidity, and temperature during the two traditional seasons, which affect the growth and yield of the cereal crop. This paper is the first of a two-part study aimed to evolving an internet-based remote monitoring and messaging system for farmers in the Umueze-Umuchi communities and other connected areas in Osisioma Ngwa Local Government of Abia State to enable monitoring of vital climatic conditions that are much likely to affect their maize farms during the dry season. This study is descriptive and presents succinct information on maize cultivation in the communities with recourse to topography, relief and drainage, climate, soil and vegetation of the area. Data were collected through observation and interview of selected farmers. The vital atmospheric conditions required for maize farming such as temperature, vapour pressure, and relative humidity were noted to vary during the seasons: rainy and dry seasons, respectively. Data from farmers showed that maize cultivation begins in early march following early rainfall and actively ends around June when the volume of precipitation is at its peak. No maize cultivation is done during the dry season beginning from early November owing to low precipitation regardless of the presence of the Aba River across these communities. Consequent upon the findings, the authors are led to examining the option of all year-round maize cultivation aided by an internet of things (IoT)-enabled climate monitoring system in order to boost maize production in the aforementioned communities. It is submitted that the use of the monitoring device will enable the farmer know when to complement the adverse climatic conditions during the dry season thereby enhancing maize cultivation round the year.

Key words: Osisioma Ngwa, Abia State, maize farming, internet of things (IoT), food production, climate monitoring system.

INTRODUCTION

Research has shown that Africa faces great challenges in the production of cereal crops of which Maize is the largest (Macauley and Ramadjita, 2015). This is against the backdrop that maize forms the highest percentage of calorie intake in the national diet of 22 countries of the world, sixteen of which are domiciled in Africa (Blein, 2013). According to a United Nations report, Maize accounts for almost 50% of the calories and protein

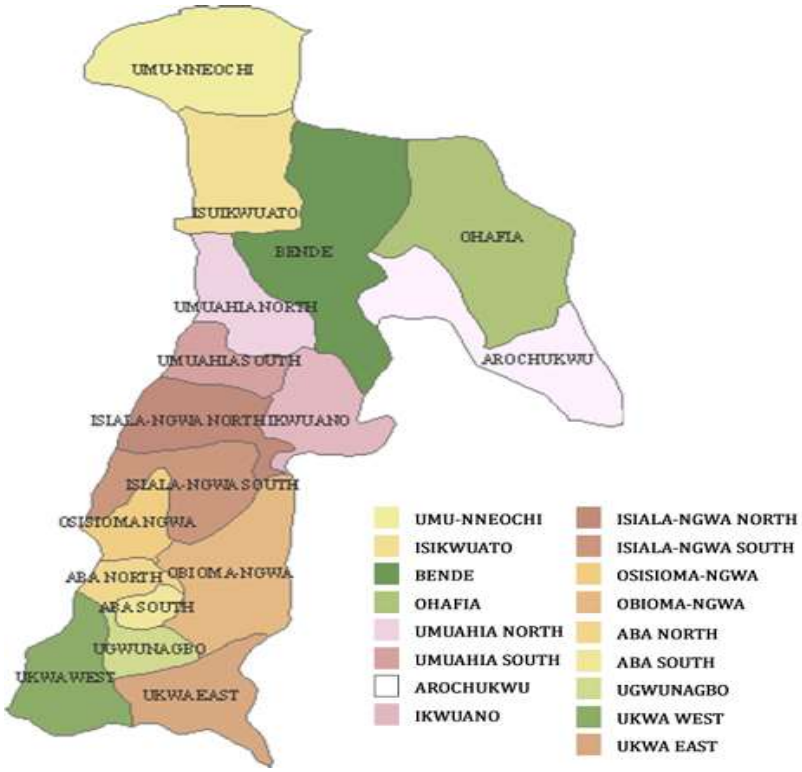

Figure 1. Map of Abia State.

consumed in Eastern and Southern Africa, and 20% of the calories and protein consumed in West Africa. It is estimated that about 208 million people in sub-Saharan Africa depend on maize for food security and economic wellbeing. Maize is adjudged the most important cereal crop (Badmus and Ariyo, 2011) in the world after wheat and rice with regard to cultivation areas and total production (Osagie and Eka, 1998; Purseglove, 1972). Maize occupies more than 33 million hectares of sub-Saharan Africa's estimated 200 million hectares of cultivated land. Considering the low average maize grain yields that are still pervasive in farmers' fields, meeting the projected increase demand for maize grain in Africa presents a challenge. In Nigeria, maize cultivation is predominant across the North-Central, South-East, South-West, and South-South states. It is estimated that 48.3% of all households in Nigeria (NBS, 2016) cultivate maize crop.

Concise geography of Abia State

Abia State is one of the prominent South-Eastern States in Nigeria. The state whose capital is Umuahia, was carved out from Imo State in 1991. It is geographically located on approximately latitude 5°25′N and longitude 7°30′E. Abia "God's own State" as it is fondly called, is popular for Commerce, Industry and Agriculture. The state, which has 17 local council areas (Figure 1), occupies a land area of 5,834 km^2 (ABSG, 2015). The state is bounded on the West by Imo State, on the North by Enugu and Anambra States, respectively, on north-east by Ebonyi State, on the East by Cross River State, on the south-east by Akwa Ibom State, and on the South by Rivers State (Figure 2). Its commercial nerve centre is Aba located south of the state. Aba is prominent for its strategic location as well as its industrial and commercial potentials with notable industries involved in textile manufacturing, footwear and leather production, pharmaceuticals, soap, plastics, cement, and cosmetics (Hoiberg, 2010). Aba is also the largest town in the state and situated on a plain with Aba River Valley lying on its eastern side. Aba is about 60 km south of Umuahia, the state capital, and is generally accessible to all the south-eastern states by road. Notwithstanding the industrial potentials of the state, the manufacturing sector accounts

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Figure 2. Abia State and its boundaries.

for 2% of the gross domestic product (GDP). Agriculture is the most prominent sector in the state and accounts for about 70% of the state's economic activity.

Overview of maize cultivation in Osisioma Ngwa Area of Abia State

Like in other parts of Abia State, maize is the predominant cereal crop cultivated in Osisioma Ngwa area. The reason behind this is not farfetched. Maize is enjoyed by majority of the local population in various flavours such as: roasted maize, boiled maize, maize cake, pap (known in the local parlance as akamu), maize flour, etc. During the middle of the year, maize in combination with the local African pear provides a wonderful meal for majority of the local dwellers. In addition, maize seeds are used as raw materials for the production of starch and other compounds by chemical and pharmaceutical industries within Aba and beyond. Maize cultivation commences in early march at the onset of the rainy season. Planting of maize by farmers continues until mid-June and stops around early July when the volume of rainfall is at its peak. Thus, the plant is not really favoured by continuous heavy precipitation.

General conditions for maize cultivation

Relative humidity, temperature, and precipitation are basic climatic elements that are important to crop cultivation in the tropics in addition to good arable soil. Consequent upon the foregoing, crop production and yield may be largely affected by any or all of these factors especially when the required amount for plant growth is either not met or exceeded. The climatic conditions for maize cultivation are well documented (Agbossou et al., 2012; Bert et al., 2006; Fakorede and Opeke, 1985; Oluwaranti et al., 2015; van Eijnatten, 1965). The maturity period of the maize crop ranges from 3 to 4 months. Sub-optimal atmospheric conditions beginning from late June affect maize productivity. The general conditions necessary for maize cultivation are briefly discussed herein.

Maize grows well at temperatures between 18 and 27°C during the day and around 14°C during the night. The most important factor in the growth of maize seedlings is the frost-free days usually 140 days during its growth cycle. The growing maize plant is very susceptible to frost hence its commonplace in temperate climates. There is a relationship between temperature and relative humidity. Relative humidity (RH) is expressed as a ratio of the actual water vapour content to the saturated water vapour content at a given temperature and pressure. RH is often given in percentage. RH is known to increase at low temperatures hence the mean maximum RH is usually recorded in the early morning whereas mean low values are recorded during the early noon hours. As in other crops, RH influences the growth of leaves, pollination, photosynthesis, etc. The growth of maize is seriously affected by very high and very low humidity. At low RH,

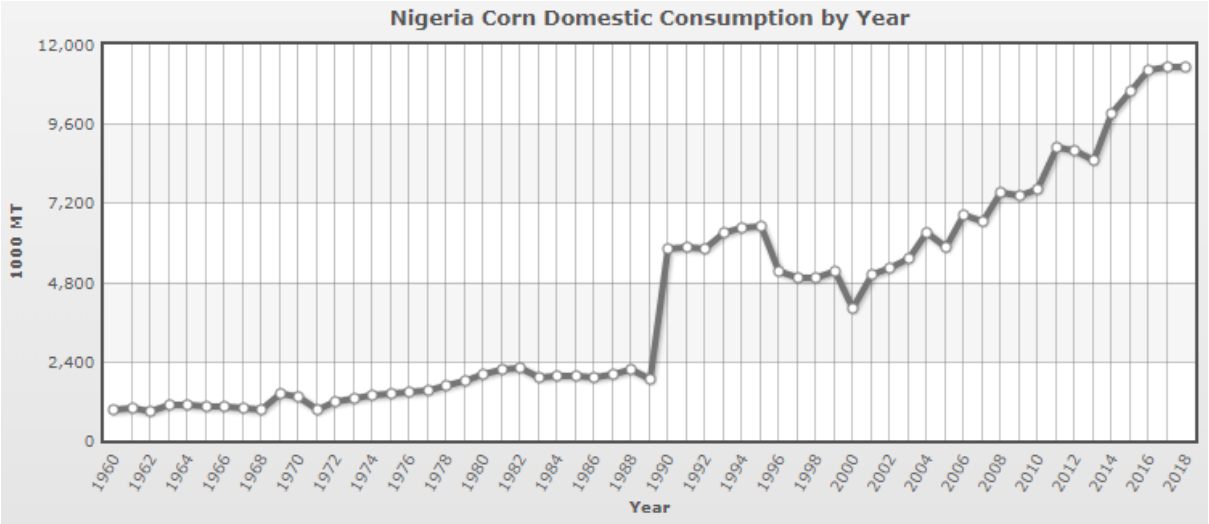


Figure 3. Domestic maize/corn consumption rate in Nigeria.
Source: indexmundi.com, 2018.

transpiration increases which results in water deficits and consequently the stomatal pores close up preventing the admittance of carbon IV oxide necessary for photosynthesis. A high RH on the other hand reduces evapotranspiration, increases heat load of plants, activates closure of stomatal pores, decreases Carbon IV oxide uptake, etc. Thus, for optimal maize growth, a moderately high RH of about 60 to 70% is required.

The maize plant thrives well under climates with annual precipitation ranging between 600 and 1100 mm, as well as in warm climates with precipitation of about 400 mm. Precipitation decreases the water stress levels. As numerous researchers have shown, water stress is an important factor to be considered prior to cultivation having regard to irrigation and the particular soil as well as on different species and the different origins of the species, and ultimately has been found to be of great importance while identifying the species that are most resistant to drought (Cetin, 2013; Sevik and Cetin, 2015; Yigit et al., 2016a, 2016b; Cetin, 2017; Guney et al., 2016a; Guney et al., 2016b; Sevik et al., 2017; Guney et al., 2017).

Like precipitation, humidity is a very important factor the growth of plants as it determines the rate of transpiration or water loss through the stomatal aperture. In other words, humidity regulates the rate at which photosynthesis takes place, tissue temperatures, water potentials, and concentrations of calcium in certain tissues, tissue osmosis, and vapour uptake (Tibbitts, 1979).

With respect to soil, maize grows in a wide range of soils, ranging from podzolic soils in temperate climates to rich loamy soils of the tropics. The deep, rich black soils with abundant nitrogen is often adjudged the most suitable soil for maize cultivation. The plain regions are most suitable for maize cultivation. Cultivation is best on fertile loamy soils located on relatively flat well-drained surfaces. Maize is also cultivated on undulating lands as well as on lower slopes of the hills.

Unlike other food crops, maize cultivation does not require huge capital as it does not require much mechanization. The most important economic factor to maize production is well-drained arable land. Labour requirements are not significant save in medium to large scale production. Labour may also be reduced by the use of appropriate machinery.

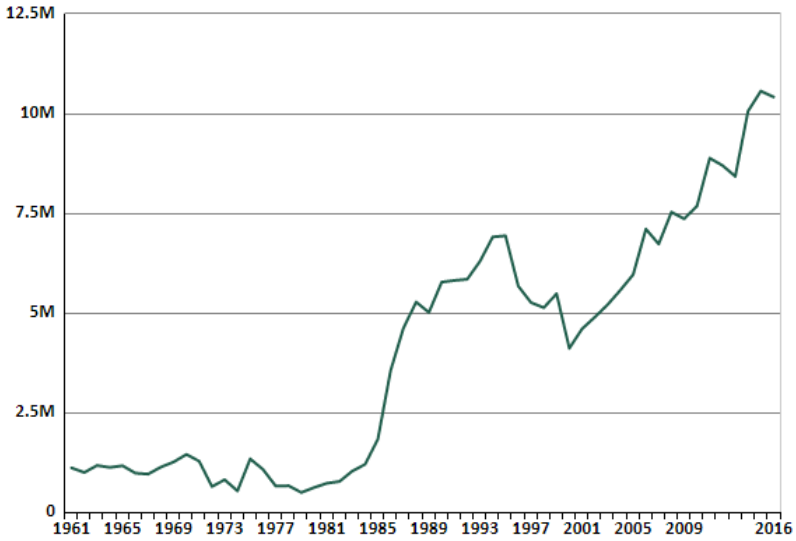
Trends in maize production and consumption in Nigeria

Research has shown that consumption rate of maize is higher that production rate in Nigeria (Indexmundi, 2018; Knoema, 2018). In 2016, maize production for Nigeria was 10.4 million tonnes (Indexmundi, 2018) whereas in the same year 11.2 million metric tonnes were reported consumed (Knoema, 2018).

Figures 3 to 4 show the consumption and production rate of maize in Nigeria. It is evident that as the population grows, the rate of consumption increases.

Statement of the problem

Maize like any other plant cultivated in the tropical and temperate climates is affected by climatic conditions. In addition to good soil, atmospheric conditions such as precipitation, relative humidity, temperature, sunlight are important to the growth of the maize plant. Due to the existence of two different seasons in a year in Abia State, maize is termed a seasonal crop which cultivation is considered feasible during the beginning of the rainy



Date	Value	Change, %
2016	10,414,012	-1.40 %
2015	10,562,050	5.00 %
2014	10,058,968	19.43 %
2013	8,422,670	-3.13 %
2012	8,694,900	-2.07 %
2011	8,878,456	15.65 %
2010	7,676,850	4.33 %
2009	7,358,260	-2.22 %
2008	7,525,000	11.91 %
2007	6,724,000	-5.30 %
2006	7,100,000	19.19 %
2005	5,957,000	

Figure 4. Domestic maize production from 2005 to 2016.
Source: Knoema (2018).

season. The seasonal maize farming may be connected to the shortfall in the production of the food crop as reported by Knoema (2018) wherein it is stated notwithstanding the continuous rise in maize production in Nigeria from 1967 to date, there is still a shortfall in the production of the maize vis-a-vis the consumption rate. To this end, it is submitted that the continued cultivation of the maize in both dry and rainy seasons may help remedy the shortfall thus improving food availability and ultimately help combat hunger. A workaround to the seasonal problem may require continuous measurement and monitoring of the basic atmospheric conditions especially in the dry season to enable farmers know when and what kind of human intervention to adopt as it affects the protection of their maize farms. Intervention in this context may imply the use of artificial means to remedy the natural climatic conditions. A typical example is irrigation of a maize farm to improve relative humidity and soil water. It is widely reported that soil water increases the relative humidity (Doerr et al., 2002; Leelamanie, 2010).

Aim and objectives of the study

The aim of this paper is to propel the idea of all year-round maize production in Abia State having regard to its importance as a staple food for over 90% of the local population as well as for livestock production. The objectives of this paper are:

(1) To briefly review the factors necessary for maize growth and yield in the local communities in the Osisioma Ngwa Local Government Areas of Abia State with emphasis on those communities that are in proximity to natural water bodies.
(2) To review the effects of relative humidity, precipitation, and temperature on the all year round cultivation of maize in Umueze and Umuchichi communities in Abia State.
(3) To examine the scientific relationships between Relative humidity and Temperature as they affect maize farms during rainy and dry seasons in these communities.
(4) To discuss the usefulness of IoT-based community-wide climate messaging system among farmers as it affects the all year-round cultivation of maize in the local communities.
(5) To propose a model that when implemented will enable many farmers within the communities share a single messaging system that would enable them engage in maize cultivation regardless of the traditional cultivation season.

METHODOLOGY

Location of study

This study is conducted around the Umueze and Umuchichi communities, respectively in the Osisioma Ngwa Local Government Area (Figure 5) located in the Southern district of Abia State. These two congruous communities are strategically located in that they are less than 7 km from Aba the commercial nerve centre of Abia State. The communities are accessible through Aba-Owerri road and Okpu-Umuobo road (an exit point from Aba-Owerri road around the Umungasi axis) respectively. In addition to sharing common boundaries, they also share common Relief, Drainage, Climate, and Vegetation. Of significant importance to these two communities is the Aba River, which flows through both communities with its

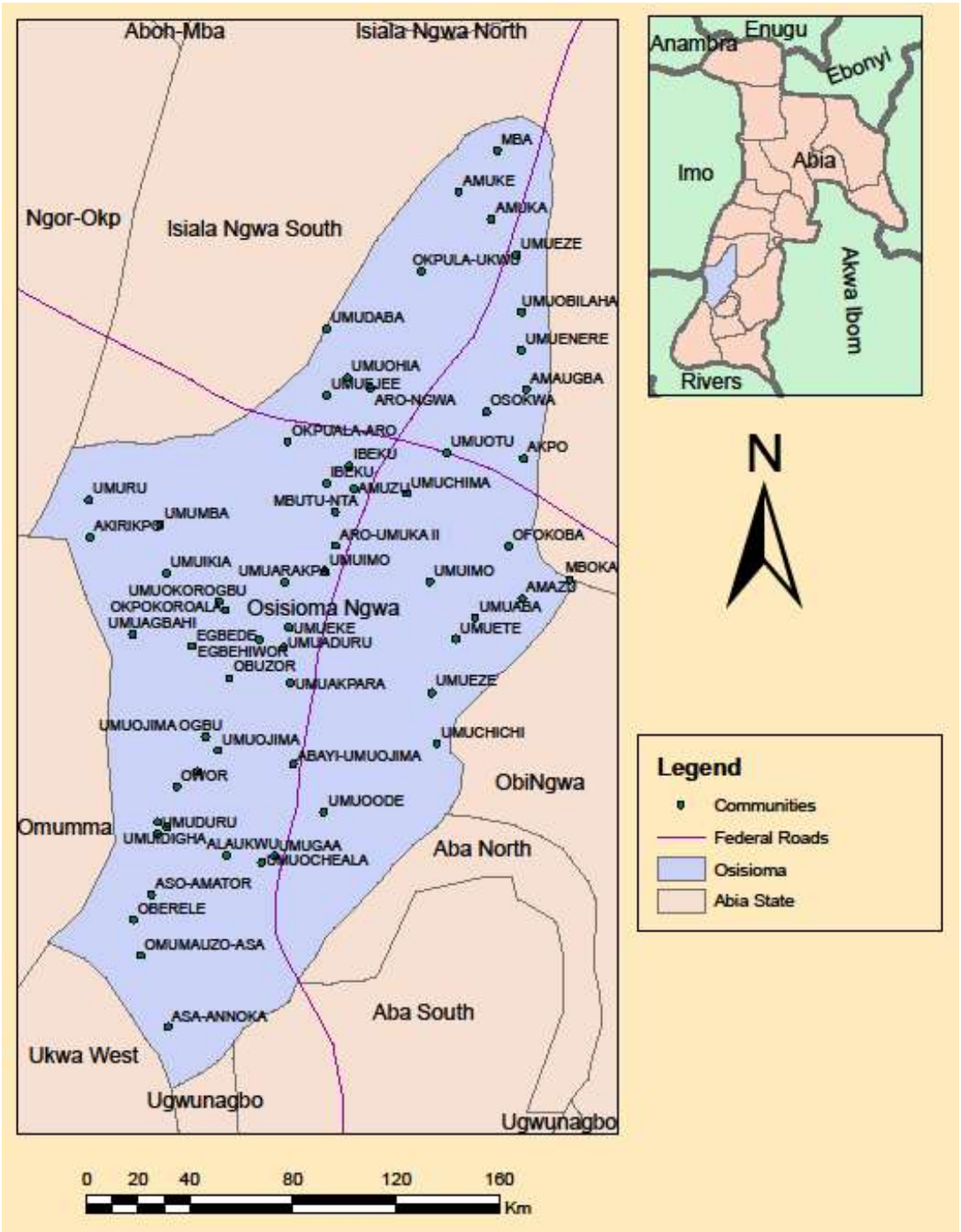


Figure 5. Map of Osisioma Ngwa Local Area of Abia State.
Source: Nwagbara and Okwuonu (2016).

headwaters at Urata in Okpu-umuobo a neighbouring community lying northwest to both communities.

Study population

The population sample is drawn from farmers in the two communities. The sample consists of 100 maize farmers who have actively participated in maize farming from 2014 to 2018.

Materials

The materials used include: Handheld GPS device (HN-5000A), Tecno 10-inch 4G Smart Tablet running Android 7.0 with GPS coordinate, and My elevation apps installed; HP ProBook 6470b

Figure 6. Extech 445580 Compact Digital Hygro-Thermometer pen.

Notebook running Grass GIS 7.4 and Google Earth, Interview Schedules, Extech 445580 Compact Digital Hygro-Thermometer pen for humidity and temperature measuring equipment (Figure 6).

Method of data collection

The methods of data collection employed were observation and interview. A series of observations were made in the month of March on 25 cleared and cultivated farmlands located around Umueze and Umuchichi spanning through an area of 20 km^2 during the beginning of the early rains. The second survey was conducted in the month of June during the time of harvest of ripe maize grains, and the third set of surveys were made during the month of August on uncultivated farmlands spanning an area of 10 km^2 in the same communities. The essence of the first set of observations was to document physical setting of the communities and the maize growing patterns during the onset of the early rains. The second series of surveys were meant to ascertain the usual time of harvest of maize in the said communities whereas the third survey was aimed at establishing the rate of maize cultivation at the end of the first maize harvest. Data on actual geographical locations, vegetation, temperature, and relative humidity were also collected during the survey on the farmlands. To complement data gathered through the survey, interview was used to document the farming history especially as it affects the cultivation of maize in the communities. Other information collected include: seasonal preferences, soil fertility and labour requirements, climatic conditions, logistics, harvest, economies of scale, sale of harvested crops, consumption and preservation.

RESULTS AND DISCUSSION

Relief and drainage of the area

Osisioma Ngwa Local Area is located between latitudes and 5°19’32”N and longitudes 7°15’49” and 7°25’23”E and has a land area of about 198 km^2 and an estimated population of 250,000 inhabitants. Umueze also called Ayaba Umueze is located around latitude 5°8’52”N and longitude 7° 21’32.3”E. Umuchichi is located on latitude 5°8’48.3”N and longitude 7°21’33.468”E.

The two communities are characterized by a variety of landforms though flat and tablelands are more prominent though Umuchichi has marked lowlands and gentle slopes especially at the areas around the Aba River (Figure 7). The major road traversing Umuchichi is Okpu-umuobo road which has its entry point from Aba-Owerri road around the Umungasi axis. Its elevation varies from 39 to 50 m above sea level as against Umueze which enjoys a relative table land with elevation varying between 68 and 74 m above sea level. Both communities receive inflows from the Aba River, which flows through the principal commercial city of Aba.

Climate

Generally, the climatic condition in the communities like every other area in Abia State round the year is classified in terms of seasons. There are two seasons in one year, namely: the rainy (wet) season and the dry season. The rainy season starts in early March and often terminates around late October. About a week of rain-free period is often experienced around the month of August and popularly called the ‘August break’. The onset of the rainy season is marked by heavy thunderstorms. There is also a slight decrease in the total rainfall from 2200 to 2000 mm across the two communities from March towards late October. The relative humidity is relatively high throughout the year, reaching its peak during the rainy

Figure 7. Section of Umuchichi village and Aba River.

season with mean values above 90%. At the commencement of the early rains in March, there is the usual notion of liveliness among potential farmers. The foregoing often heralds the clearing of farmlands and commencement of farming. Traditionally, farmlands are not cultivated continually but left to fallow after harvest for at least 12 months before the next cultivation.

With adequate rainfall during the rainy season and the fertile arable land, the farmlands in the communities flourish with notable food crops such as yams, maize, cassava, rice, plantains, potatoes, *etc*., as well as cash crops especially the oil palm. Also notable is the constant temperature round the year with an annual minimum temperature of 21.2°C and an annual mean maximum temperature of 31.9°C.

The dry season begins in middle to late November each year and ends by early March of the following year. The average period of the dry season is 4 months. The hottest dry period is between January and March with a mean temperature of at least 27°C.

Soil and vegetation

The common soils in the communities are the ferralitic and alluvial soils. The ferralitic soils are less predominant whereas the alluvial soils are predominant along the low terrace of the areas supplied by the streams from Aba River in both communities. Due to heavy annual precipitation, the soils are prone to leaching. The communities are somewhat exposed to ecological problems of sheet and gully erosion. Like other areas in southern Nigeria, the tropical rainforest vegetation is predominant. Numerous species are prevalent in the rainforest vegetation of both communities but the most predominant trees are the oil palm, which is also the most prominent cash crop in the state.

Maize farming culture in the communities

Mono-cropping is not traditional practice in the communities hence maize is often cultivated with other crops like Melon, Cassava, Yam, etc., on loamy soils. The planting period is usually during the onset of the early rains in March. Cultivation is preceded by bush clearing and burning. Artificial fertilizers are commonplace as majority of the soils are prone to leaching hence a significant reduction in the soil nutrients required for crops to thrive.

Figures 8 to 9 show a cross-section of maize farms in both communities in early May. It is interesting to note that the growth of maize on both environments is very similar owing to similar climatic conditions.

Harvest of mature maize grains starts around early June and ends around July. Late planting of maize is seldom practiced in the communities for want of rainfall regardless of the available water sources in the communities. In other words, at the end of the first maize (Corn) harvest, the supply of fresh corn dwindles greatly and ends by late July. Thus there is a gap of about 9 months before the commencement of another season of maize cultivation.

Individual involvement in maize farming

The survey conducted shows that the farmers in both communities are distributed among the young and the old. Out of the 100 farmers surveyed, 50 had the primary school certificate (First School Leaving Certificate), 30 persons attended secondary school whereas 5 have

Figure 8. Maize farm in early May at Umuchichi community.

Figure 9. Maize farm in early May at Umueze community.

advanced qualifications, while 15 have vocational training in areas other than agriculture. Though the highest numbers of farmers involved in maize farming are those whose education is at primary level having accounted for 50% of the entire sample population, however, all the participants agreed that Education and Technology are important vehicles for modernizing agricultural practices in the communities. Table 1 shows the statistical distribution of the interviewees having regard to their educational backgrounds. The age distribution of the farmers is shown in Table 2. Maize farmers between the age of 50 and 59 are most prominent having accounted for 26% of Maize farmers in both communities. As regards the gender, maize cultivation is predominant among the female folks especially the married ones in both communities (Table 3). There is also what appears to be somewhat among the farmers in the communities generally, that is, maize farming is perceived as a peculiar farming practice of women whereas men farmers are more interested in tuber crops especially yam. Table 4 shows the distribution of farmers with respect to seasonal maize cultivation. All the farmers cultivate maize during the rainy season. No farmer carries any maize farming during the dry season.

Relevance of climatic conditions to maize cultivation in the communities

All the farmers agree that maize farming is actually regulated naturally by such elements as precipitation, sunshine, temperature, *etc.* It is widely believed by the locals that maize can only thrive during the early rains. The belief appears to be the ground underlying the traditional practice of not cultivating maize during the dry season. Sunshine is almost regarded as a constant climatic element in the communities hence is not considered as a challenge to maize farming. However, it

Table 1. Educational distribution of maize farmers in both communities.

Level of education	Population by community		Total
	Umuchichi	Umueze	
Tertiary/Advanced	2	3	5
Vocational	5	10	15
Secondary School	14	16	30
Primary	28	22	50
None	0	0	0
Total			100

Table 2. Age distribution of maize farmers in both communities.

Age	Population by community		Total
	Umuchichi	Umueze	
70-79	2	3	5
60-69	7	15	22
50-59	9	17	26
40-49	14	6	20
30-39	4	11	15
18-29	5	7	12
Total			100

Table 3. Gender distribution of maize farmers in both communities.

Age	Population by community		Total
	Umuchichi	Umueze	
Male	20	15	35
Female	40	25	65
Total			26

Table 4. Maize cultivation pattern in both communities.

Season	Population by community		Total
	Umuchichi	Umueze	
Rainy	50	50	100
Dry	0	0	0
Total			100

is important to note that such an assumption is rebuttable, as there exists a connection between the amount of radiation and temperature. High temperatures during the dry season often cause an increase in evaporation of water from the soil surface leading to loss of soil water as well as soil nutrients. Consequently, plant growth is affected by soil temperature especially as it concerns water and nutrient uptake and root growth. A reduction in temperature often results to a decrease in water and nutrient uptake at a constant moisture content. Transport of minerals and nutrients from the root to the shoot and vice versa is reduced at low temperatures. The relevance of relative humidity to growth of maize has been discussed previously.

Maize cultivation during the dry season in the communities

Notwithstanding the presence of the Aba River and its

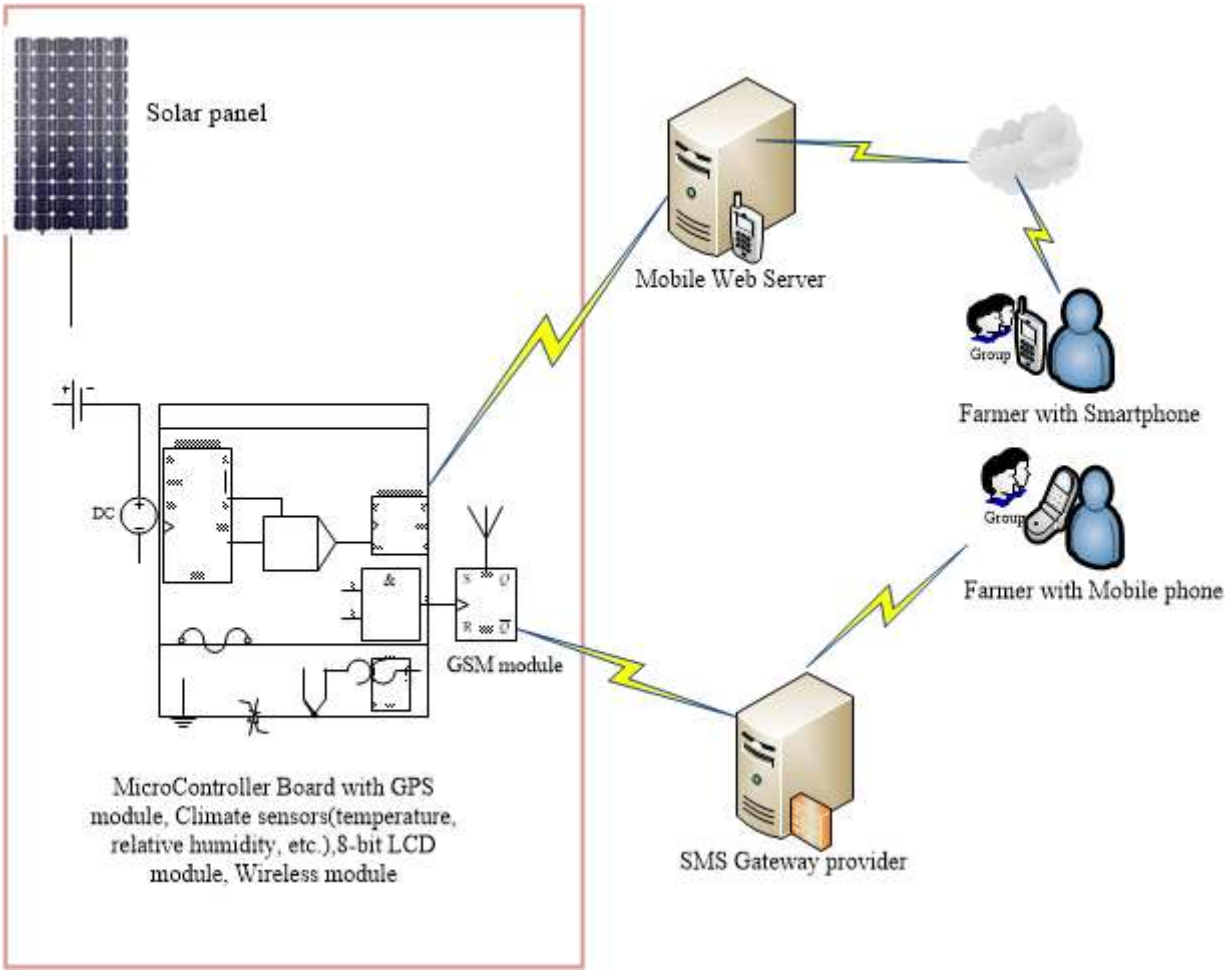


Figure 10. Schematic model of the proposed system.

tributaries within the communities, the cultivation of maize during the dry season is not a practice in the communities owing to the general conception that labour and seedlings expended on such activities will be a waste.

Proposing a remote monitoring and messaging system for maize farmers

All farmers drawn in the sample understood the importance of humidity and temperature among other climatic conditions in the cultivation and growth of maize. The farmers agreed that cost-effective control and messaging systems would be helpful in monitoring the status of their farms not only during the rainy season but also during other times. They also agreed that such a technology should be able to notify farmers through short messaging service regarding the status of the climatic conditions especially when the conditions are tending towards the extreme.

Having regard to the understanding of the farmers, we proposed a group internet-based remote messaging system option. The model of the proposed system is as shown in Figure 10. The function of the remote messaging system is to automatically measure the temperature and relative humidity within an area spanning across interconnected maize maize farmlands over a short period, compare it with reference values and alert the concerned farmers who are registered on the system, through a short messaging service over the internet. Farmers with smartphones can also monitor on real-time the status of the climatic conditions. Penultimate, the essence of the messaging to the farmer when extreme limits of temperature and humidity is recorded is to afford the farmers to take action as to the application of measures to ensure that the growth of the crops are not hampered. Another importance of such an arrangement is to reduce the wastage of resources whereby farmers visit their farms on a daily basis for physical assessment of the situation. In addition, with such notifications, a farmer who is far away from the locality can engage a second party to carry out some

tasks such as sprinkler irrigation where such is necessary.

Assumptions on the proposed system

In proposing an internet-based group remote messaging system for farmers, basic assumptions have been made based on the field measurements and data collected from the farmers. The assumptions were:

(1) The spread of sunshine across the concerned communities is constant over the year and that there is no significant difference in the distribution from one community to another.
(2) The precipitation levels across the communities are similar
(3) The average temperatures across the communities over a year is the same
(4) A single microcontroller-based IOT device deployed in a given location within the referenced communities can effectively and efficiently serve many farmers who have farmlands within the communities.
(5) 95% of the sampled farmers own at least a mobile phone

With regard to the aforementioned assumptions, it would take less effort to enrol many farmers into one multi-user device thus reducing the cost of implementation of the system. And as the number of users increase the expenditure per farmer as to the cost of acquisition and maintenance of the messaging device falls.

Conclusion

The centerpiece of this paper is to design an automated solution that can help boost maize production in the local communities in *Osisioma Ngwa* Area of Abia State. From the data gathered through field measurements and farmers' submissions, this study discovered farmers value a system that can provide real-time information on the climatic conditions of their farmlands having regard that maize cultivation is affected by a good number of climatic factors such as temperature, relative humidity, precipitation amongst others. It was noted that due to the farmers' familiarity with the traditional farming period notably at the commencement of the early rains, no attempt is made carrying out cultivation during the dry season regardless of the surrounding streams. The study unveiled the gap which is traced to the deficit in the knowledge of the farmers. Consequently, this study concludes that:

(1) Vital information regarding the state of climatic conditions are necessary for the participation of local farmers in all round the year maize farming;
(2) Any cost-effective system that could provide farmers with necessary information as to improving their farming practice would be beneficial
(3) Since mobile phones are ubiquitous across the local communities, a microcontroller-controlled IoT-based system with mobile messaging capability can assist farmers within a given geographical area with same climatic conditions such as temperature, relative humidity, sunshine, *etc.*
(4) With one such device that can serve numerous farmers in a community, the cost of deployment will fall and farmers will benefit more as the number of farmers' subscription into the system increases.
(5) Every potential maize farmer within the communities can be motivated to engage in all round the year maize farming is he is assured of being duly informed on what to do to his farm even during the dry season.
(6) The resultant effect of such a novel invention is that many farmers would participate in maize farming thus boosting the production of sufficient maize cereal for local consumption as well as for sale or even exports thus curtailing the menace of hunger and food scarcity across Abia State in particular and Nigeria at large.

FUTURE WORK

This study has laid appropriate foundation for the construction of a multi-user IoT-based climate messaging system. It is our firm understanding that the groundwork was concluded in this paper leaving out the actual implementation of the proposed system. In our next paper, we shall address the design and implementation of this proposed novel technology to enable farmers have access to real time information to boost their farming culture. The necessary factors such as cost-effectiveness, ease of use, service quality, location coverage, and choice of technology for implementation of the system.

CONFLICT OF INTERESTS

The authors have not declared a conflict of interests.

ABBREVIATIONS

ABSG, Abia State Government; **GDP,** gross domestic product; **IoT,** internet of things; **NBS,** National Bureau of Statistics; **RH,** relative humidity; **UN,** united nations.

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