THE INTERNATIONAL JOURNAL OF HUMANITIES & SOCIAL STUDIES

Methods of Adaptation of Irish Potato Farmers to the Effects of Climate Variability in Santa, Cameroon

Karba Nji Julliet
Doctorate Student, Department of Geography, University of Yaounde I, Cameroon
Nkwemoh Clement Anguh
Associate Professor, Department of Geography, University of Yaounde I, Cameroon
Chop Leonard Nkimih
Doctorate Student, Department of Geography, University of Yaounde I, Cameroon
Nkiene Valentine Antu
Doctorate Student, Department of Geography, University of Yaounde I, Cameroon
Ngwateze Mariam
Doctorat Student, Department of Geography, University of Yaounde I, Cameroon

Abstract:
Climate change has greatly impacted global agriculture. This situation has aggravated the present burning issue of world food crisis. Santa Sub-Division epitomizes areas over the globe that are facing this problem. This study, therefore, stood out to research the specific adaptation strategies of Irish ptatao farmers.
The Methodology that has been adopted entailed Classical and Impirrical approaches. This required the collection of data from secondary sources through the consultation of books, reports, thesis and dissertations, Journals from libraries, and topographic maps of the area. The collection of data from primary sources stemmed from fieldwork, including the administration of questionnaires, interviews, and focus group discussions. Data analyses were done with the assistance of SPSS Software and Microsoft EXCEL. The results were then presented in the form of figures, tables, graphs, and pictures.
Findings reveal that adaptation strategies that have been adopted by Irish potato farmers were viewed at different levels. They include farm-level, plant-level, and farmer-level adaptation strategies. Improving soil fertility (21%) and ameliorating irrigational methods (39.7%) are the main adapting strategies used at the farm level. Meanwhile, the use of resistant (CYPIRAL), less resistant (SPUNTA), and the use of short cycle species (MONDIAL) are technics observed at the plant level. At the farmer's level, the common practices include:

- *Varying planting dates (50%),*
- *Varying and ameliorating planting and conservation technics (46%), and*
- *Associating different species (4%)*

We ended up with some barriers to adaptation, of which we made some recommendations regarding the reinforcement of extension workers, improvement of small credit schemes, farm-to-market roads, rehabilitation of Meteorological Centers, and the promotion of agro-forestry.

Keywords: *Adaptation, Climate variability, Irish potato production, Santa sub-division*

1. Introduction

Climate change is one of humanity's greatest challenges, affecting both current and future generations. Without urgent and concerted action, it will damage fragile ecosystems, obstruct development efforts, frustrate poverty alleviation programs, and force large-scale migration from food-scarce regions leading to serious social and economic implementations (Ricardo et al., 2009). According to IPCC (2007), climatic variability refers to the climatic parameter of a region varying from its long-term mean, with some years having low average rainfall and temperature and others having average or above average rainfall and temperature. Present variability, which is manifested by frequent extreme rainfall events and increases in temperature (Nkwemoh & Karba, 2017; Nkienne et al., 2016), has now rendered the farmers' adaptation strategies put in place incapable of enhancing continuous high production (Karba, 2017). Therefore, some of these strategies need to be revised to continuously enhance high production by increasing the coping range of the plant, thereby decreasing vulnerability. A clear understanding of adaptation strategies as indicated by farmers, means of diffusion of innovation strategies, adoption of adaptation strategies, and limitations to adaptation strategies is an important aspect to consider in boosting Irish potato cultivation productivity.

An array of studies have been overviewed on farming technics and systems like digging canals for water evacuation in times of floods, irrigating or watering farms in times of droughts as adaptation measures to the effects of climate variations on agriculture by Molua (2009), Eldin, (1989), Gleave and White (1969), Nkiene (2014) and Hounkponou, (2015). Others like Ayuk and Kabore (2013) looked at the different ecological zones and the elimination of

undesirable species. Meanwhile, Aiyelaaga (1992), Kang (1985), Pardel (1986), Weeraratna and Ashgha (1992), Rosecrance et al. (1992), Nkwemoh (1991) observed agro-forestry as an adaptation method for the improvement of productivity. The main focus of this study centers on Irish potato farmers' adaptation to the observed effects of climate variability in Santa sub-division. Hence, the following objectives guided the process of the research:

- Assess the observed effects of climatic variability on Irish potato production
- Identify the various methods of farmers' adaptation
- Identify barriers to effective adaptation

2. Physical Background

Santa sub-division is situated between longitude 09°58 and 10°18 east of the Greenwich meridian and latitude 05°42 and 05°53 North of the equator. According to the geographical coordinates, it is found within the tropical climate zone. It is one of the sub-divisions of the Mezam division in the North West region of Cameroon. Santa is boarded to the North by Bamenda Central sub-division, to the West by Bali and Batibo sub-division, to the South by Lebialem and Bamboutou division, and to the East by the Ngoketundja sub-division (figure 1). Santa covers a surface area of about 532.67km^2, and harbours a population of about 99, 852 inhabitants (BUCREP 2010).

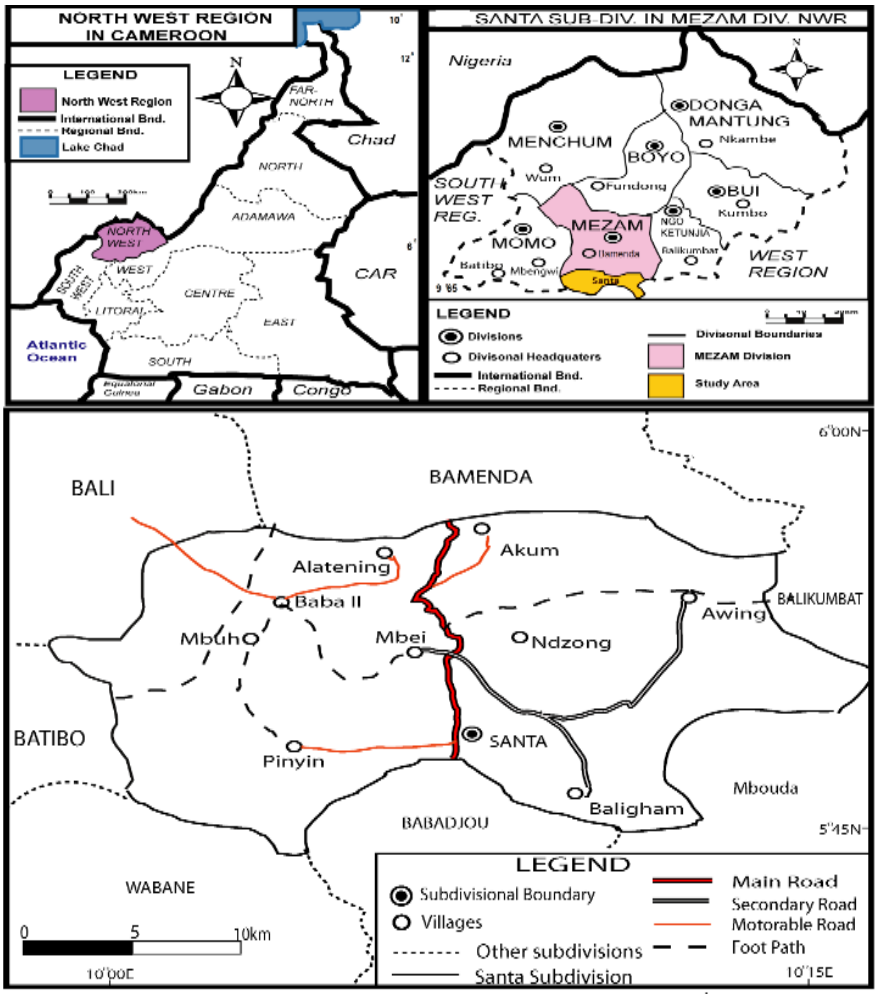

Figure 1: Location Map of Santa Sub-Division
Source: Adapted from Nkwemoh and Karba 2017

Her population density is about 108 persons per square km, with an annual growth rate of about 2.8%. The Santa area is considered a melting point of ethnic groups that make up different villages. These ethnic groups include: the Moghamos (Mbe, Mbuh, and Baba II) and the Ngembas (Alatening, Akum, Awing, Ndzong, and Pinyin) originated from Widikum around the 18th Century, and the Chambas (Baligham) from Ndobo and mount Atlantica around the 19th Century.

The morphology of the Santa area is very complex. The topology of Santa is constituted of a very high elevation ranging from about 1200-2400m; the relief is generally diversified with entrenched valleys adjoining interfluves or hilly chains and steep slopes Nkwemoh and Karba (2017). The area is confined within 3 river basins:

- The cross river,
- Atlantic, and
- Katsina river basin

Its upland areas bear mostly streams in torrential stage coming down from mountains, while the mid-altitude area is dissected by streams (Nkwemoh, 1992). Santa falls within the tropical latitude, and it is classified under the Guinean climate indicating that The area is humid with great ecological variations at the local scale marked by two seasonal rhythms. They include a short dry season (December to March) and a long rainy season (April to November). This heterogeneous topography also portrays a diversified soil in the area. The main soils are classified under:

- Volcanic,
- Granitic, and
- Depositional soils

The altitudinal range shows two main climax communities of vegetation: the bamboo forest (2200m^{+}) and the mountainous forest (1600 to 2200m) and a sub-climax community -the savanna woodland (1200-1600m) Karba (2017).

Introduced in Cameroon during the colonial (around 1940) by the British, Irish potato is one of the principal crops that are cultivated in Santa, Karba (2017). It is a starchy tuber crop from the herbaceous perennial plant of the Solanaceae family, botanically called *solanum tuberosum.* Irish potato is a plant that grows to 60cm high (depending on the variety) and is grown for its tubers, Wasito et al. (2006). The physical condition it requires for its growth entails, amongst others, regular rainfall/water (900-1400mm), temperature ranging between 12-30°C and coarsed textured light loamy soil conditions (deep, well-drained, and light to medium texture) (FAO, 2012). Even though there are more than 100 varieties, the 4 basic categories of Irish potatoes are:

- Long white,
- Round white,
- Russet, and
- Round red (FAO, 2012)

Most of the varieties cultivated in Santa are the new varieties grown from seed and are propagated vegetatively by tuber planting. The seed multiplication is assured by the state of existing firms in the region. The species are both imported (Mondial, Caeser, Dosa, Sponta – Netherlands and Chalenger and Panamera -Peru) and local (Cipira-Cameroonian type). The farmers follow a well-defined and regulated agricultural calendar following the seasonal cycle (figure 2).

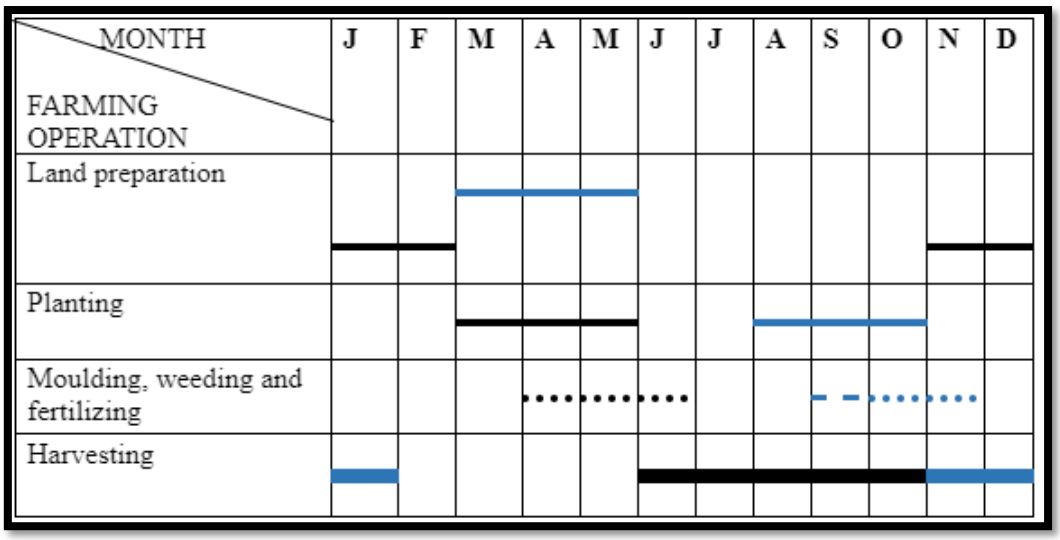

Figure 2: Farming Calendar for Irish Potatoes
Sources: Fieldwork 2019

Potato farming in the Santa sub-division is done in two periods. It can be observed from the figure above that the first cycle (planting to harvest) goes from March to October, while the second cycle runs from August to January.

3. Matériel and Method

Data collected as secondary sources were from the main libraries of the university of yaounde 1 and the Ministries of agriculture and rural development. Numerical data on the number of Irish potato farmers, the surface area, and annual production of the area in tons from the Sub-divisional delegation of agriculture and rural development. Topographic sheets of Bafoussam 3c (Foumban Dchang) at the scale 1: 50,000, 1:20,000; aerial photographs and LANDSAT images of 2010 have been utilised for location and mapping. Primary sources were investigated for quantitative and qualitative data collection. Questionnaires were directed to farmers and guided interviews to resource persons; 214 Irish potato farmers actually responded to questionnaires. These questionnaires were made up of 60 questions, both open and close, in order to assess farmers' perceptions. The number of respondents varied from one village to the other regarding its size and accessibility. Field observation was carried out on 3 different farms, and focus group discussions were organised to assess farmers' perceptions.

Inductive and deductive methods have been used to demonstrate the importance of developing adequate adaptation strategies to reduce the effects of climatic variability on Irish potato production. Data were analysed using

descriptive statistics in the Statistical Package for Social Science (SPSS) and Microsoft Excel to generate results. These results have been presented in the form of tables and graphs. The cartographic aspect of this study is done through the use of computer-assisted drawing and GIS programs such as Adobe illustrator, QGIS 2.0, and ArcGIS 10.0.

4. Results and Discussions

4.1. Observed Effects of Rainfall and Temperature Variations on Irish Potato Production

Regional climatic conditions are a primary determinant of agricultural productivity as plants' metabolic processes are regulated by variables such as temperature, solar radiation, and water availability, amongst others (Chaves et al., 2003). The variability observed in rainfall and temperature patterns in Santa disclose that Irish potato production is highly threatened because it is greatly vulnerable to variations observed in these variables Nkwemoh and Karba (2017). Some negative effects that have been exposed are summarized in table 1.

Climatic Variable	Observed Effects
Water deficit	• Delayed and uneven emergence limits the number of tubers initiated • Restricts plant development and response to fertilization, and tubers dehydrate • Alternating deficits result in tuber disorders (brown spots, hollow heart, growth cracks, malformations, and secondary growth)
Excess water	• Damages the development of a well-developed root system • Promotes luxurious foliage growth that can be conducive to the development of diseases such as early and late blight and increases leaching of nitrogen • Leads to enlarged lenticels (a pore in the outer layer of a plant stem, through which gases pass from inside the stem to the atmosphere), which will cause poor tuber appearance and provide access to soft rot bacteria, and promotes seed piece decay and thus lower plant density
High Temperatures	• Prevents the healing of cut seed piece surfaces which leads to decay • Delayed and uneven emergence • Less haulm per plant. Thereby causing the plant to grow under stress; hence fewer yields are obtained • Induces the development of plants with thin stems, small leaves, long stolons
Low Temperature	• Proliferation of blight infection • The stimulation of seed production prematurely • Loose germination ability and reduction in tuberization.

Table 1: Effects of Rainfall and Temperature Variations on Irish Potatoes
Source: Adapted from Karba (2017)

Climatic variations and their effects on Irish potato cultivation prompt a number of changes in farming operations in SSD. A majority (73%) of farmers testify of changes in their farming operations, while only a few others (27%) attest to the fact that there has been no change in their farming operations. Given this great majority, it is realised that adaptation strategies carried by farmers are an important aspect to consider in cultivating Irish potatoes in the area. This section has been divided into 3 parts:

- The first part analyses adaptation strategies as indicated by farmers,
- The second shows the means of diffusion of adapting actions, and
- The third shows the rate of adoption of adapting methods

4.2. Adaptation Strategies as Indicated by Farmers

Adaptation refers to the technics, means, and coherent decisions and measures put in place by Irish potato farmers to responsibly adjust to climatic variability and benefit from the opportunities offered in turn, Karba (2017). Stakeholders in potato farming in SSD have often developed strategies to adapt to the effects of climatic variations. These strategies could only enable the coping of potato production with past variations. Strategies of adaptation carried out by farmers are observed following 3 levels:

- Adaptation at the level of the farm,
- Adaptation at the level of the plant, and
- Adaptation at the level of the farmers

These are reactive methods of adaptation.

4.2.1. Farm-Level Adaptation

At the farm level of adaptation, besides the farmers, the government, too, is involved through ACPs who train the farmers on new farming methods. The farmers carry out a number of actions which are summarised in table 2.

Operations	Frequency	Percentage (%)
Increase water conservation technics (increase storing capacity)	16	7.5
Canalize water into the farms	43	20.1
Use of surface water	14	6.5
Increase irrigational methods and facilities	42	19.6
Increase land size cultivated	12	5.6
Improving soil fertility (use of inputs and organic matter)	45	21⁂
Move to different sites	21	9.8
Others	21	9.8
Total	214	100

Table 2: Farmers' Knowledge of Adaptation at the Farm Level
Indicates Common Adapting Methods Practiced by Farmers
Source: Field Work 2019

According to the results, common actions include:

- Improving soil fertility,
- Canalising water into farms, and
- Increasing irrigational facilities

4.2.1.1. Improving in Soil Fertility

Soil fertility improvement involves replenishing basic soil nutrients needed by plants. These nutrients include:

- Nitrogen for vegetative growth,
- Phosphorus for strength and rigidity, and
- Potassium for the root system

They are abbreviated as NPK, which are very important elements.

This is observed through an increase in phytosanitary treatment carried through the application of manure, chemicals, and fertilisers. Manure used in the area is fowl and pig droppings applied in a trough open on a ridge or along the line mixed with soil. Compound fertilizer used by farmers is the NPK applied at different stages of growth. The first application is at planting, where NPK 11-11-22 is advised because the dominant component is Potassium. The second week after shooting, the second fertiliser application is made using Urea; a universal fertiliser composed of NPK 20-10-10, implying that Nitrogen is favoured and molding is done during this application. A month later, Urea is still applied, and a second molding too.

To fight against fungus (blight), the farmers use the contact and systemic fungicides. Contact fungicide like Manusa and Pennozep assures the external protection of plants, and it is applied 6-7 days after planting, 7-10 weeks after planting, and before harvest. This is because it stays for a short period on the plant. Systemic fungicide such as Banko Plus, Plantop, and Balya is used to assure the internal protection of the plant. It is applied at germination, that is, 2 weeks after planting, so that at harvest, chemical residues are avoided given that it last longer. Also, contact and systemic herbicides are used in farms. Systemic herbicides are used for weeds, while the contact is used for vine killing (10-11 weeks after the shoot). Vine killing is aimed at destroying the greenish part of the stems and leaves to enable the tubers to drain faster and promote dehaulming (hardening the tubers back), e.g., Gramaxone. Insecticides and pesticides are effective in fighting against insects applied 5-7 days after shooting. They are sprayed early in the morning or in the evening when temperatures are mild.

4.2.1.2. Irrigational Methods

Whenever Irish potato plant is subjected to small moisture deficiency, the growth rate is reduced and will affect both the quality and the number or sizes of tubers. In SSD, because of the seasonal extension of crop cultivation to the dry season and climatic variation, farmers have developed irrigational technics, which are:

- The channeling of water from rivers and or streams to farms, and
- The construction of artificial dams for water storage

Farmers, with the use of pipes, can bring water to their farms from rivers and streams that flow through the village. This pipe, once in the farms, is attached to sprinklers which are spotted in the farm for watering.

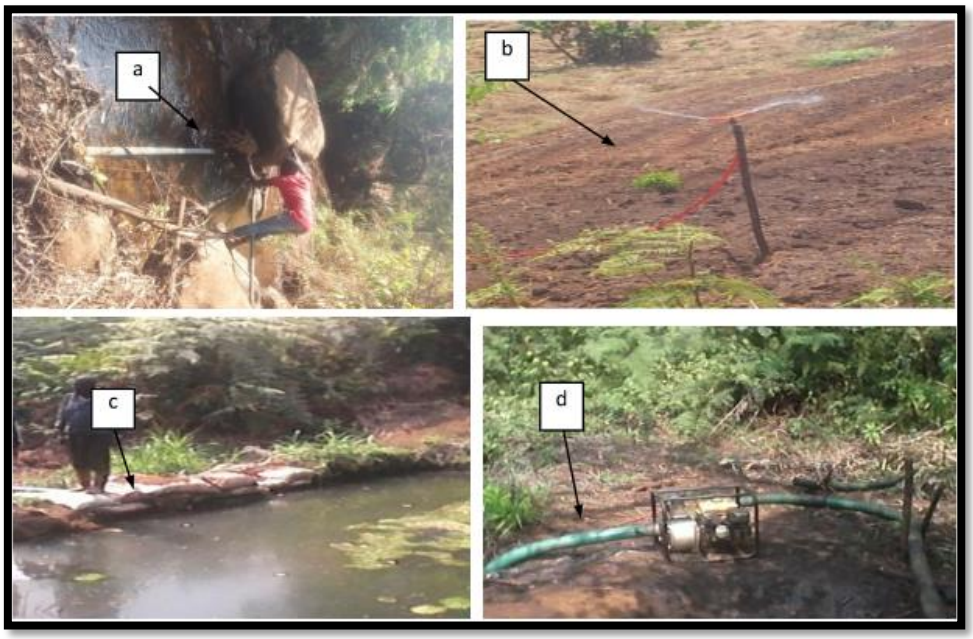

Figure 3: Show Different Methods of Irrigation Developed by Farmers
Source: Field Work 2019

- *'a' shows how a pipe is placed in water and covered with grass and stone, and the water which goes far to the farms*
- *'b' shows a locally fabricated sprinkler watering a potato farm before its emergence*
- *'c' shows the site where a man-made dam has been created. The dam is surrounded by vegetation which limits the rate of water evaporation*
- *'d' shows a pipe connected to water and relied on a motor pump that goes to the farms*

Through the force of gravity and wind action, these sprinklers can rotate, thus water a broader surface. Artificial dams are made in some valleys to retain water during the dry season. Farms are generally located far from these dams. Farmers, therefore, use motor pumps to which pipes are connected to travel long distances to the farms. Sprinklers are also used for watering. Contrarily to the simple pipe connection, motor pumps increase the speed of sprinkler rotation due to higher water speed and therefore reduce the time of a sprinkler on the spot.

4.2.2. Plant-Level Adaptation

At the level of the plants' adaptation, farmers respond that short-cycle Irish plants and more resistant varieties have been introduced even though there is no variety that possesses these two characteristics. Farmers explain that the resistant variety called CYPIRAL was introduced by IRAD in the 1990s and lasts for 4 months. Meanwhile, the short-cycle variety called MONDIAL was introduced in 2008 and lasts for 3 months. However, it is more vulnerable and costly to produce. Interviews with ACP explained that new varieties have varied over time due to vulnerabilities to climate variations and the high cost of production. The need for varieties like MONDIAL and CAESER was introduced because varieties like CHALLENGER and SPUNTA were too old, which made them less resistant and thus produced less.

The government, in its program to strengthen the *Solanum potato* sub-sector, introduced new varieties called MONDIAL and CAESAR in 2008. MINADER, through MIDENO (Trial and Demonstration Center), promoted the multiplication of these varieties. The farmers receive seeds of these new varieties and some input necessary for their activity as donations. The productivity of these varieties is still under observation. These varieties are said to be of short-cycle but not very resistant to situations of droughts and blights and therefore are less expected to adapt to the present trend of rainfall and temperature variations. These varieties can produce tubers with big sizes like those of Sweet potatoes and give a considerable number of tubers per plant, not given by the traditional seeds they know explained by some farmers. These seeds, in turn, demand much care. These farmers testified that for a basket received that occupied five farm ridges; they were able to harvest about 2 bags of considerable sizes. In order to perform this assistance, the government, through the Ministry of Agriculture and Rural Development (MINADER), reaches the grass root population through the Regional Delegation and the Sub-Divisional Delegations.

4.2.3. Farmers-Level Adaptation

At the farmers' level of adaptation, respondents reported varying planting dates, associating different varieties, and ameliorating planting and conservation methods (figure 3).

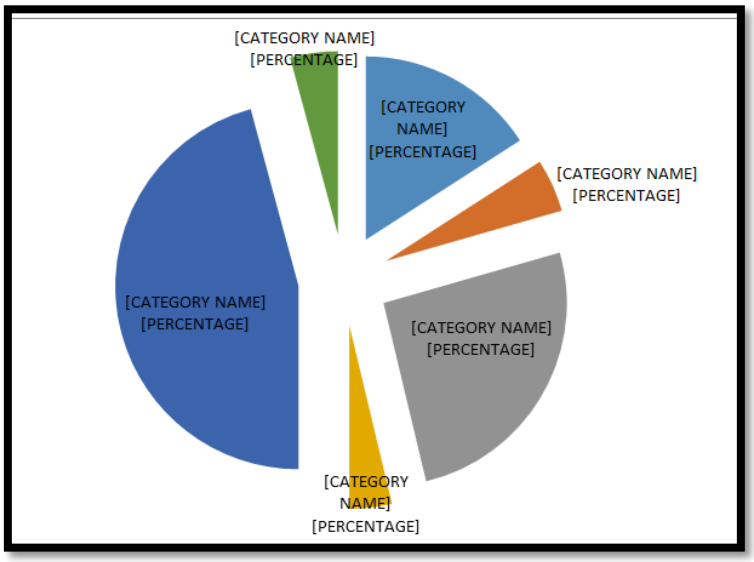

Figure 4: Farmers' Method of Adaptation
Source: Fieldwork 2019

Regarding planting dates, 16% of farmers reported that their planting had become late, attributing this to the defiance at the onset of the rainy season, and 4% said planting is now earlier, that is, as soon as the first rain set in. They constitute just a minority because their farms are located downstream near the water course. They are able to maintain crops till the effective onset of rains with irrigation. Meanwhile, 26% of other farmers say their dates are unpredictable, so their planting dates vary according to the onset over the years. Besides varying planting dates, farmers equally mix resistant and less resistant varieties because it limits the proliferation of pests and insects on farms which have ameliorated yields.

Some amelioration brought on how Irish potato is cultivated is followed by 46% farmers. These ameliorations include technics on how to plough, plant, maintain, manure, irrigate, harvest, and store potatoes. Ploughing farms has changed from slash and burn (Ankara) to slash and mulch. Slash and mulch is a method by which grasses are wrecked and gathered at the bonds of the farms which will serve as manure for the next crop planted (Unlike « Ankara », where the grasses are burnt). Also, flat planting for ploughing is used whereby ridges are created during weeding, which presents the advantages of deeper depth of tubers, reduce the possibility of tuber exposure to sunlight, and provide enough soil during the molding process.

Land Preparation	Planting	Maintenance	Manuring	Harvesting	Storage
-slash and burn -Ankara -Ridge formation	Sowing of cuttings with irregular spacing	-Weeding	Organic manure	Dug with hands and cutlasses	Transformed immediately into by-products

Table 3: Old Production Techniques of Irish Potatoes
Source: Adapted from Ngwega D.A. (2010) and fieldwork 2019

Land Preparation	Planting	Maintenance	Manuring	Harvesting	Storage
clearing, stumping, raking, tilling, harrowing, and ridge formation	Sowing of seeds using regular spacing	-Weeding -Moulding	-Compost manure -Chemical fertilizers	Dug with hand and cutlasses	Transformed into by-products Potato chips Potatoes diffused lighthouses

Table 4: New Production Techniques of Irish Potatoes
Source: Adapted from Ngwega D.A. (2010) and Field Work 2019

Contour ploughing is encouraged, given the hilly nature of the area, replacing the slope-wise method. With this method, soil erosion is reduced by 50-80%, and increase crop yields by 6-66% Nkwemoh, (1999). Farmers have also adapted from spot planting (zais) to row planting. With row planting, the feeding area for root displacement is not limited and, thus, promotes the multiplication of tuber formation, while it is limited with the zais method (Warsito et al., 2006). Farmers, too, rotate potatoes with crops not of the same family, like pepper or tomato though highly cultivated in the area. They rotate with nitrogen-fixing crops such as beans. Besides the high use of inputs, farmers cater for crops in their farms by:

- Removing plants that are damaged by pests and diseases to limit proliferation,
- Pulling and burying of weeds twice a season,

- Cutting foliage when tubers reach optimum sizes before harvest to avoid spreading viral diseases from the tuber to the tuber

Harvesting is done manually by digging from the edge of seedbeds not to damage tubers. The tubers are then spread out to enable them to harden and dry quickly, then are stored and packed. Storage is not easy, especially because of temperature fluctuation and excessive light, as these elements lower the quality of tubers and encourage the growth of diseases, given that part of the harvest serves as a seed for the next season. However, farmers spread tubers on shelves or on the floor and practise Diffused Light Storage (DLS), which helps shed tubers from direct solar rays and heat.

4.3. Barriers to Effective Adaptation

Limitations to adaptation strategies are those factors that make it harder to plan and implement adaptation actions. In this way, it is difficult for farmers to maximise their well-being because their abilities to identify, assess and manage risks are restricted. It can, therefore, prevent the implementation of adaptation strategies and spatial diffusion from taking place. In SSD, these factors, according to farmers' perception, are identified under socio-cultural, economic, technological, and institutional factors.

Socio-culturally, adaptation can be constrained by factors that are linked to:

- Ethics (how and what people value),
- Knowledge (how and what people know),
- Risk (how and what people perceive), and
- Culture (how and what people live)

These factors greatly influence perceptions of adaptation options and adoption (Mozaharul et al., 2014). Also, the low level of education and their attachment to local values make farmers reluctant to change.

Economically, farmers cannot keep up with all the farming technics because it necessitates important financial capital observed, especially during the period of crop tendering as the cost of agricultural inputs remains high. Low income and lack of access to credit to invest are two key barriers to the implementation of adaptation strategies.

Technologically, the limiting aspects include the following:

- The low level of training sessions hosted and the control or follow-up of the agents or ACPs,
- The low level of financial investment in farming operations,
- Non-intensification of potato cultivation,
- Absence of technics of tuber transformation into semi-finished or finished products

Also, the unavailability of storage facilities poses serious problems to farmers in food preservation, especially during harvest, which induces farmers to rush to send farm products to the market immediately after harvest, not mindful of the low prices associated.

To this is a barrier at the institutional level concerning inconsistent agricultural policies, which include:

- Erratic import policies characterised by frequent changes both in import Tariffs and quantitative import restrictions creating uncertainty,
- Failure to set up a satisfactory credit system for farming and agro-processing,
- Scanty and ill-equipped weather stations and agricultural infrastructures,

Since farming is still predominantly rainfed, it is particularly vulnerable to the impacts of climatic variations, which cause crop failure, high and rising food prices, hunger, and eventually famine, lack of infrastructure, sufficient personnel and materials amongst others.

5. Conclusion

From the results of the study, it was realized that coping strategies for climatic variations are developed by Irish potato farmers in Santa. This finding has been buttressed by an array of factors. It can be observed that variations in rainfall and temperature, especially their extremes, highly affect the growth of Irish potatoes at different stages of growth which greatly hamper its productivity. The variations induce effects such as diseases (blight, tuber rot), promote decay, stunted growth of plants, and uneven emergence, amongst others.

Different reactive and proactive adaptation strategies have been adopted in the area by both farmers and stakeholders (Government, NGOs, and Research Institutions). The first was at the farm level, which entails strategies like soil fertility improvement, water canalization and irrigational facilities, and farm sizes. The second was at the plant level, and it involves strategies like the use of more resistant plant species and the use of short-cycle species. Farmers' level of adaptation was the last and entailed the use of methods like ameliorating planting technics, varying planting dates, and planting different species.

To round up the study, we identified some barriers to effective adaptation methods. These constraints are mentioned under socio-cultural, economic, technological, and institutional factors. Some recommendations that we propose are presented below:

- Firstly, the Ministry of agriculture should reinforce the training of extension workers to assist the farmers in the area.
- Secondly, the government should encourage projects and initiatives like the transformation of Irish potatoes into flour and chips.
- Thirdly, the government should encourage the home consumption of locally produced items according to subsidies, decrease the importation of its substitutes, and improve farm-to-market roads.
- Fourthly, micro-credit schemes that are most appropriate to small-scale farmers should be embarked upon.

The interest rates on loans and the debt repayment schedule should tie in with the farming realities. Micro financial institutions should make available and in good time both financial and technical support to farmers. Fifthly, there should be the promotion of agro-forestry because it is economically viable, socially just, ecologically sound, flexible, and adaptable. Next, Meteorological Centers should be rehabilitated and well-equipped. Finally, the government should improve on aspects that will enhance the rate of adoption of innovative strategies of adaptation, for instance, through sensitization and training.

6. References

i. Ahmed S.A (1980): 'Irish potato production in Bangladesh' *Proceeding of Third International Symposium on Potato Production for South-East Asia and Pacific region*, Bandung, Indonesia. 50 p.
ii. Ambrose A.Z, Solomon Z, et al. (2013). 'Growth and yields response of Irish potato (*Solanumtuberosum*) to climate in Jos- South plateau state-Nigeria', Vol.13 version, 1.0 p. 4-5.
iii. Ayuk, E.T. and Kabore, S.T. (2013): 'Wealth through integration'. *Regional integration and poverty-reduction strategies in West Africa*, Berlin; Springer.
iv. Bryan E., Deressa T.T., GBETIBOUO G.A. and RINGLER C., (2009): 'Adaptation to Climate change in Ethiopia and South Africa: Options and Constraints'', *Environmental science* and policy, vol. 12. No. 4, p. 413-426.
v. Burton W.G., (1989): 'The potato veenman and zones', *Wageninges-Netherlands*, 382 p.
vi. Basin of Ethiopia', *Global Environmental Change*, Vol. 19, No. 12, p. 248-55.
vii. Ekpoh I.J, (2004): 'Climate change and tropical agriculture in the 21st Century', *in Journal of Applied and Social Sciences*, Presbyterian Printing Press, Limbe, Cameroon p. 151-159.
viii. Eldin M. (1989) : 'Du risque de secheresse au risque de mauvaise récolte: Un effort de clarification des concepts …'. In : eldin Michel (Ed), Milleville Pierre (Ed). *le risque en agriculture*. Paris :ORSTOM 19-23. (a travers champs). ISBN 2-7099-0960-X.
ix. Esculest J. Propitious, (2008): 'The potato in world history', *a Standard scholarly History*, 315 p.
x. F.A.O. (2015): '*Crop water information: potato, water depth, and management unit*', Retrieved on: 7 November, 2012.
xi. Gershon F., Richard E.J and David Z. (1985): 'Adoption of agricultural innovations in developing countries: A Survey'*. Economic development and cultural change 33 (2)*, 255-298.
xii. Henderson Bruce (1981): 'The Concept of Strategy', *Boston Consulting Group*. Retrieved on : 18 April, 2014.
xiii. Hounkponou, S.K (2015): 'Vulnerability of Benin's Agricultural Sector to Climate Change and Options for Adaptation'. International Research Center for Climate Change and Water Program, WRENmedia, 4p.
xiv. Ifenkwe O.P. and Okonkwo J.C., (1983): 'Determination of the most suitable time to plant Irish potatoes: taking into account the onset of rains'. *Annual reports*, Umudike-Umuahia, Nigeria.
xv. IPCC, (1996): '*Climate change; Impacts, Adaptations, and Mitigations of the change*, Cambridge', Cambridge University Press.
xvi. Karba, J.N. (2017): '*Susceptibility of Irish Potato production to the effects of rainfall and temperature variations in Santa Sub-Division'*. *Master Thesis*, University of Yaounde 1, Department of Geography. 165p.
xvii. *Levy, David; Veilleux, R. E. (2007): 'Adaptation of Potato to High Temperatures and Salinity A Review', American Journal of Potato Research 84: p. 487–506.*
xviii. Martin Steyn and Hennie du Plessis (2005): 'Soil, water and irrigation requirements', *WRC report* no. TT125/05, 15p.
xix. Mozaharul Alam, Frans G.H., DOW Kristin, R.M Rebecca Shaw, et al. (2014): 'Adaptation opportunities, constraints, and limits', *IPCC WGII AR5*, 79 p.
xx. Neville Fernando (2010): 'Irrigation-Potatoes', *Department of Environment and Primary Industries 1*, Spring Street Melbourne-Victoria, 6 p.
xxi. Ngwa N.E, (1979). '*Swamp rice production in the North West province of Cameroon: a case of agricultural innovation diffusion among traditional agrarian'*, Masters thesis, University of Yaounde 1, 221p.
xxii. Ngwega Doreen A., (2010): '*Farmers' Adaptation to Innovative Strategies in Agriculture: the Case study of rural areas of Mezam Division*', Memoire thesis, University of Yaoundé I, North West Region (Cameroon), 165 p.
xxiii. Nkiene Valery A., (2014): *'Vulnerability of Swamp Rice Production to the effects of Climate Variation: Case of Ndop Central Sub-Division*', Memoire thesis, University of Yaoundé I, 155 p.
xxiv. Nkwaklacha H., (1987): 'Weed interference studies in Irish potato', *Annual report of National Root Crops Research Institute*, Imudeke. p. 88-93.
xxv. Nkwemoh Clement A., (1991): '*Environmental degradation of the Pinyin-Awing area*', Maîtrise Thesis, University of Yaoundé I, 105 p.
xxvi. Nkwemoh Clement A., (1999): '*The impact of agro-pastoral activities on the physical environment of the Mezam-Ngoketunjia area*', Doctorat de 3em Cycle in Geography, University of Yaounde 1, 306 p.
xxvii. Nkwemoh Clement A. And KARBA J.N (2017): 'Rainfall variability and the susceptibility of Irish potato production in Santa Sub-Division, Cameroon'. *Environmental and Social Science Research Center, Buea, Cameroon*, *vol.8*, p 83-108.
xxviii. Olsen N. and Kleinkopf G. E., (2003): 'All storage management in potatoes production System', *University of Idaho agricultural coms.*, p. 363-381.

xxix. Patterson D.T. (1993): 'Implications of global climate change for the impact of weeds, insects, and plant diseases', In *International Crop Science* I. Crop Science Society of America. Madison, WI.

xxx. Ricardo D., Timothy E., Mohamed EL ASHRY (2009): 'Facilitating an international agreement on climate change: adapting to climate change', *Global Leadership for Climate Action Adaptation,* 40 p.

xxxi. Rosecrance R., Rogers S. and Tofinga M. (1992): Effects of alley-cropped *Calliandra Calohyrsus and Gliricolia Sepium Hedgerows* on weed growth, soil properties and taro yields in Western Samoa. *Agroforestry Systems.* 19: 57-66.

xxxii. Rosvall J. and Aleby S. (1989): Air pollution and conservation, safeguarding our Architectural heritage. Aleby S. (Ed.s), *Elsevier,* Amsterdam, pp 25-53.

xxxiii. Rowell B. (2006): 'Potatoes', *University of Kentucky Cooperative Extension Service*.

xxxiv. Rumelt Richard P. (2011): 'Good Strategy/Bad Strategy', *Crown Business*, ISBN 978-0-307- 88623-1

xxxv. Shimshe D. (1986): 'The effects of high temperature and water deficit on potato'. *Journal of the European Association for potato research,* Vol. 29, no.1, p. 95-107.

xxxvi. Shtienberg D., (1990): 'Integration of host resistance and fungicide to manage potato disease', *Canadian journal of plant pathology*, 111p.

xxxvii. Warsito T. and ELSKE V.F et al. (2006): 'All about potatoes', 90 p.

xxxviii. Weeraratna and Asgha M. (1992): 'Effects of grass and adapt mulch on some soils and (inceptisol) properties of taro (colocasiaexculanta (L.)', Schoff in Western Samoa', *Tropical Agriculture*, 69 (1), p. 83-89.

xxxix. Zaag D.E., (1981): *Water supply to potato crops Nivaa*, Pub. Ministry of Agriculture and Fishery, The Hague, the Netherlands, 20 p.

http://www.essortment.com/all/potatoes/diseaserdja.htm.

http://www.Foundationevs.weekly.com.uploads/2/3/8/1/238/7929/tolerance-range,html. Johann Heinrich Von Thunen (1826)