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Highlights

Environment-Friendly Pig Farming

Variability Impacts on Crop Productivity

Discovering Thoughts, Inventing Future

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Environment-Friendly Pig Farming using Eco-Feeds

By Yasuhiro Chihara, Ryoya Matumoto & Yasuhiro Ono
Kumamoto Agricultural High School

Summary- The feed self-sufficiency rate of livestock in our livestock management is 25%, which is the lowest in Asia, and most of it depends on imports. Among them, pig farming, which feeds large amounts of grain feed, is particularly low at 14%, and the soaring feed price is a problem for Japanese livestock farmers due to poor harvests in grain exporters and vigorous purchases by other countries. While it is an importing power, domestic food waste is a serious social problem with a large amount. We tackled this problem by thinking that the method of stable livestock management regarding the global feed situation is to effectively utilize food waste with a high amount of water and use it for livestock.

Keywords: *eko-feed, food waste, resource recycling.*

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Environment-Friendly Pig Farming using Eco-Feeds

Yasuhiro Chihara [α], Ryoya Matumoto [σ] & Yasuhiro Ono [ρ]

Summary- The feed self-sufficiency rate of livestock in our livestock management is 25%, which is the lowest in Asia, and most of it depends on imports. Among them, pig farming, which feeds large amounts of grain feed, is particularly low at 14%, and the soaring feed price is a problem for Japanese livestock farmers due to poor harvests in grain exporters and vigorous purchases by other countries. While it is an importing power, domestic food waste is a serious social problem with a large amount. We tackled this problem by thinking that the method of stable livestock management regarding the global feed situation is to effectively utilize food waste with a high amount of water and use it for livestock.

Keywords: eko-feed, food waste, resource recycling.

I. 研究の動機および目的

我が国の養豚業における飼料費は，経費の5割から7割を占めています。飼料の約7割は海外からの輸入に頼っており，飼料原料や輸送費の高騰により価格の高止まりが畜産農家を悩ませています。　本校　（熊本農業高校）　では豚を飼育しており，過去4年間の経費を見ると約6割が飼料費になっています（図1）。特に，肥育時には配合飼料を多給するため，肥育豚の飼料費は飼料費全体の約7割を占めています。　このため，　肥育時の飼料費をいかに削減できるかが本校の養豚経営において最も大きな課題です。私たちは，飼料費を削減する方法のひとつとしてエコフィード」があることを畜産の授業で学習してきました。エコフィードとは，環境を意味するエコ（eco）と飼料を意味するフィード（feed）を併せた言葉で，食品廃棄物を利用して作られる飼料のことです。修学旅行で神奈川県にあるフードエコロジーセンターを見学する機会がありました。　ここでは，食品廃棄物を加工し，　飼料製造を行っています。社長の髙橋氏からは，国内の食品廃棄物は多量であり，環境汚染の原因になっている。しかし，その多くは家畜にとって必要な栄養素を含んでおり，飼料としての利用価値がある。」　と教えてもらいました。そこで私たちは，　飼料費を削減でき，　自給率の向上にもつながる有効な手段として，養豚へのエコフィードの活用を試みました。エコフィードの給餌は，豚の肉質にも影響すると考えられるため，タンパク質等の栄養バランスを考えた飼料設計を行い肉質の向上を図りました。本プロジェクトでは，「低コストで高品質な豚肉生産」を目標に掲げ活動を始めました(図2）。

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II. 研究の方法と結果

a) 食品廃棄物の利用

飼料の開発に活用できそうな地域資源を探したところ，５つの企業から納豆，　パン，　米粉，もやしカス，　テングサを頂くことができました（表１）。　この5種類の原材料を活用して，飼料開発を始めました。

1) し好性

各種エコフィードに対する豚の好みを調べるため，　し好性の調査を行ったところ，　米粉は粉末状態で食べにくく，　低いし好性を示しました。そこで米粉に水を加えて給与すると，し好性が改善し飼料として活用できることが明らかになりました。

2) 水分含量

各食品廃棄物を恒温乾燥器で乾燥させ，水分量を調査したところ，　もやしカスとテングサ　の水分含量が原物中の約80%と多いことが分かりました。

b) 飼料調製

1) 飼料発酵調査

飼料の水分含量が多いほど腐敗が進みやすく長期間の保存が難しくなります。腐敗を防ぐ方法を東海大学農学部家畜栄養生理学研究室のプラダン准教授に相談したところ，飼料のpHを4以下に保つと雑菌の繁殖は抑えられる」とアドバイスを頂きました。そこで，牛の飼料で活用されている乳酸発酵を利用して保存性を高めることにしました。乳酸発酵について文献で調べると，水分含量・温度・期間が発酵に大きく関与することが分かり，以下の実験を行いました。

5種類の食品廃棄物を混ぜ合わせエコフィードを調製し，表2に示した4つの要因の影響を調べるため飼料のpHを測定しました。エコフィードの保存場所として倉庫とビニールハウスを設定し比較したところ，ビニールハウスの方が高温で温度変化が激しいが，発酵度合に差は見られず，どの試験区においても4週間の保存期間でpHは4以下に低下しました（図3）。また，乳酸菌を添加していない区でもpHが4以下であり（表3），すべての試験区で3か月以上保存が可能でした。しかし，なぜ乳酸菌なしでも発酵できたのでしょうか。その疑問を解決するために，　原材料の配合を変えて　（パンなし，　納豆なし，　両方

エコフィードによる環境に優しい養豚経営

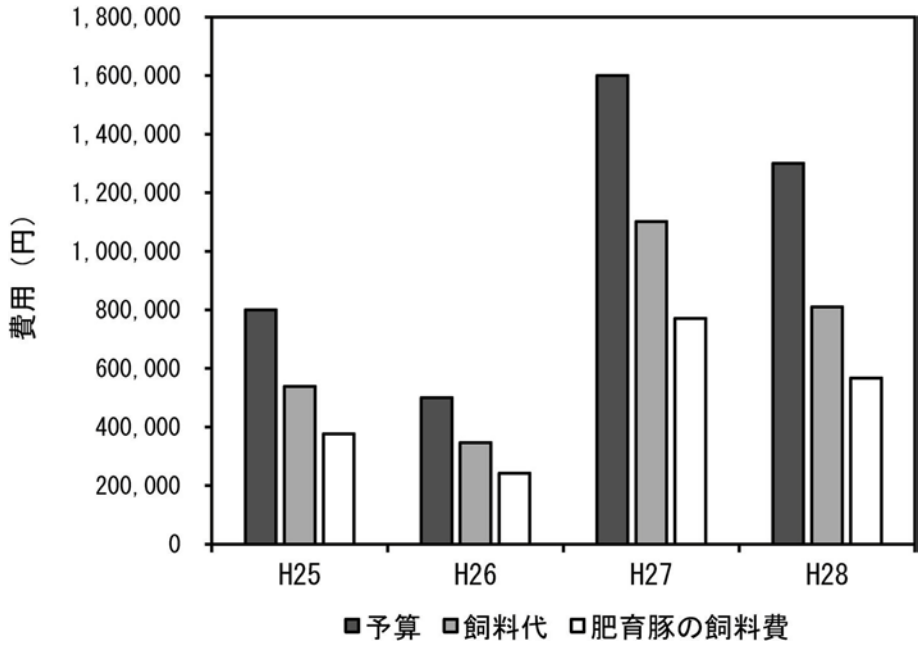

図1. 熊本農業高校における過去4年間の養豚経費.

「低コストで高品質な豚肉生産」に向けて

1．食品廃棄物の利用
2．飼料作製
3．豚の生育調査
4．豚肉の肉質調査
5．専門家による評価
6．情報発信

図2. プロジェクトの実施計画.

表1. 飼料活用候補となる地域飼料資源

提供元	飼料原材料
九州大豆食品	納豆
熊本県パン協同組合	パン
瑞鷹酒造	米粉
マルキン食品	もやしカス
熊本製萠	テングサ

表2. 飼料調製の試験条件

要因	水準
水分含量	40，50，60，70%
保存期間	1，2，3，4週間
保存場所	倉庫，　ビニールハウス
乳酸菌	添加，無添加

なし）乳酸菌を添加せずに再度発酵具合を調査しました。すると，納豆入りの飼料で低いpHを示し，納豆菌の働きにより雑菌の繁殖が抑制されていることが推察されました（図4）。この結果をもとに，納豆菌を活用した長期保存可能な本校独自の飼料を作製することにしました。

2)　飼料設計

家畜飼料設計データを参考に栄養バランスと肉質を考慮した飼料設計を行い，水分含量40%でエコフィード100%の配合飼料を作製し，「エクセレント」と名付けました。市販飼料の価格は1kg当たり55.3円に対し，「エクセレント」では2.7円であり，飼料価格を約20分の1にすることができました。

c) *豚の生育調査*

私たちは，三元交雑種を母豚とし，肉質の向上が　見込める黒豚で有名なバークシャー種を掛け合わせた四元豚を合計10頭実験に用いました。エコフィード区の飼料を「エクセレント」対照区の飼料を市販飼料として，各5頭ずつ，肥育期間80日間として比較実験を行いました。

1) *摂取量*

飼料の残さ量から摂取量を推定しました。対照区に比べてエコフィード区の方が約1.5倍多く食べており，食品廃棄物の有効活用にさらに貢献できることが示されました。

2) *健康調査*

エコフィードを給与しても豚の健康に影響がないかを調べるため，　熊本県家畜保健衛生所に依頼して調査前後での血液検査を実施しました。両区ともに大きな変化は見られず，エコフィードが利用可能であることがわかりました。

d) *豚肉の肉質調査*

1) *肉の見た目*

豚肉の赤身色・脂肪色の判定を，ポークカラースタンダー

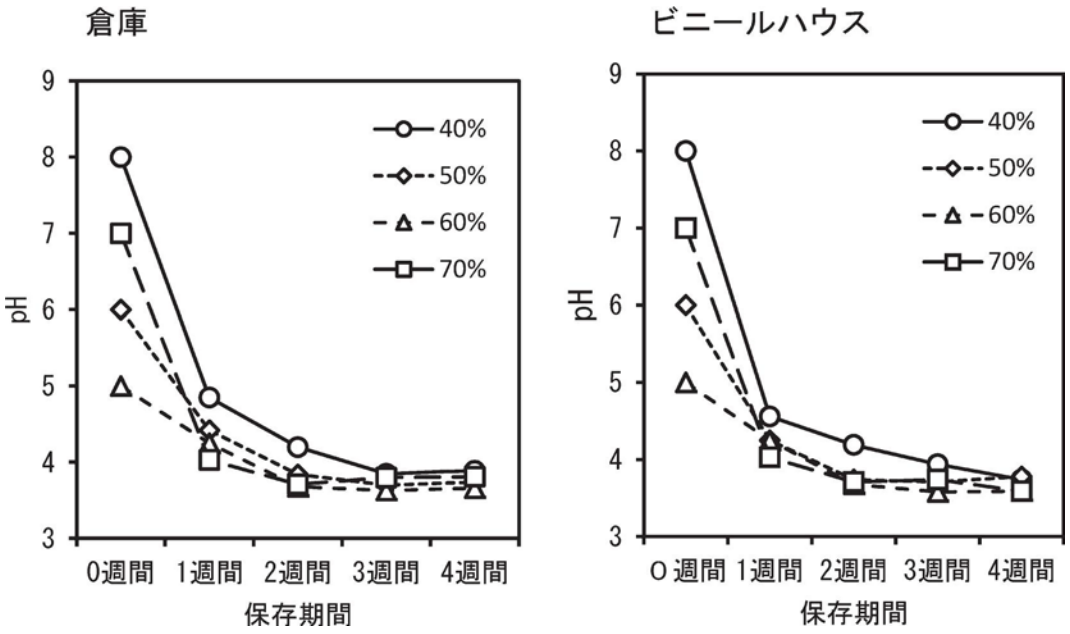

図3. 各飼料のpHの推移．（乳酸菌添付あり）

表3. 乳酸菌添加の有無による飼料pHの推移（4週間保存）

保存場所	乳酸菌添加	水分含量（%）			
		40	50	60	70
ビニールハウス	あり	3.7	3.7	3.5	3.59
	なし	4	8	9	3.54
倉庫	あり	3.9	3.7	3.6	3.81
	なし	6	2	9	3.63
		3.8	3.7	3.6	
		9	4	6	
		3.9	3.7	3.6	
		0	3	7	

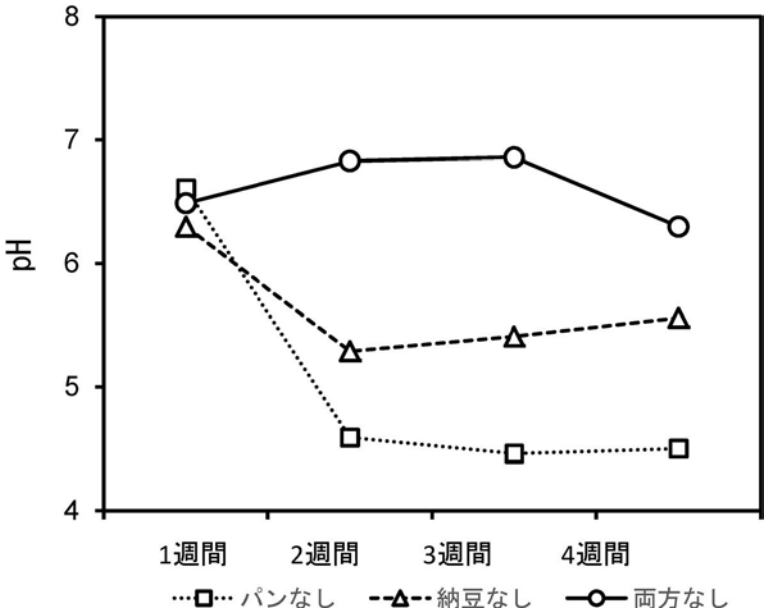

図 4. 乳酸菌無添加飼料のpHの推移.

エコフィードによる環境に優しい養豚経営

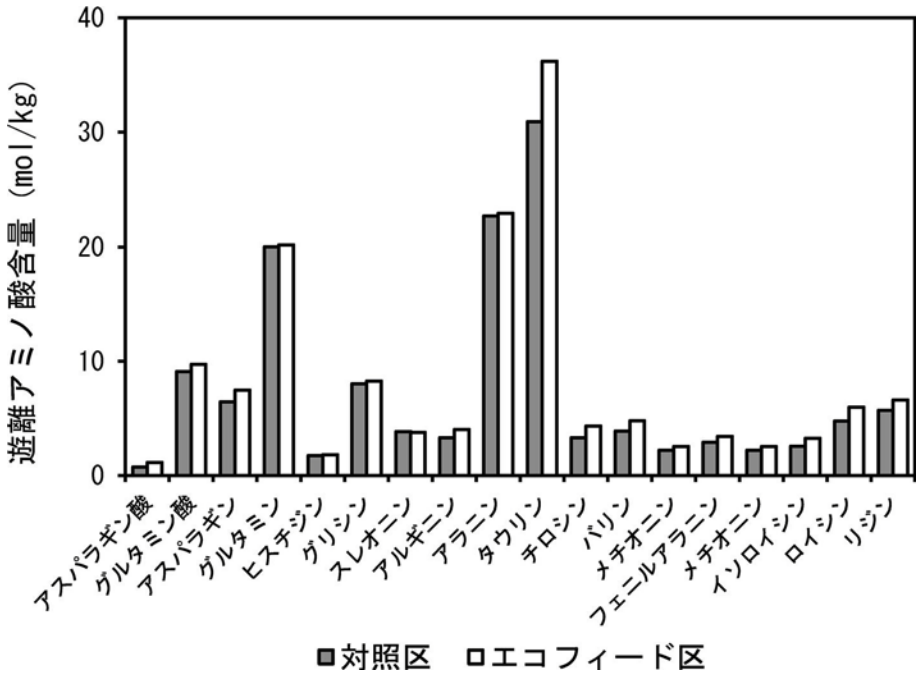

図 5. 豚肉に含まれる遊離アミノ酸含量.

図 6. 考案した「シンデレラポーク」のマスコット （上） と精肉販売会の様子（下）． 高品質な肉に仕上がり，精肉の販売許可を取得した.

表4. 食品廃棄物の削減効果

年	食品廃棄物量（t）
平成28年	186. 8
平成29年	149. 9

ドを使用して調査しました。赤身と脂肪の両方において，色と光沢が良く市販飼料で育てた豚肉よりも高い評価でした。

2) *遊離アミノ酸・遊離脂肪酸*

豚肉に含まれる遊離アミノ酸含量を調べるため， 熊本県産業技術センターの峯田氏に教わりながら分析を行いました。豚バラ，ロース，モモ100gに含まれる遊離アミノ酸含量を分析したところ，エコフィード区の方がうま味成分であるグルタミン酸や，美味しさに関与するグリシン，アラニンなどが全体的に高い数値を示しました（図5）。さらに，肉の美味しさの指標とされる遊離脂肪酸量を分析したところ， オレイン酸とα-リノレン酸もエコフ ィード区で高 い値を示しました。

e) *専門家による評価*

飼料成分を分析し，丸永株式会社の西氏に飼料設計を評価して頂いたところ，「バランスをよく考えてありこれは良い飼料と言えす。」と高い評価を頂きました。食品廃棄物を有効活用することで飼料費を大幅に削減でき，さらに美味しい豚肉生産に繋がりました。この魔法のような結果から，この豚を「シンデレラポーク」と名付けました。図6は私達が考案したマスコットです。

f) *情報発信*

多くの方に食べてもらいたくて，精肉販売会を実施しました（図6）。購入して頂いた方からも，「ここの豚肉はよそのとは味が違っておいしかったよ」 と好評でした。 また， この取り組みを発信するために， お披露目会を本校で開催しました。関係機関の方々を招待し，試食会を実施したところ 「脂が甘く臭みがないのでエコフィードを活用した肉とは思えない」，養豚農家からも 「我が家でもエコフィードを利用してみたい」と高い評価を頂きました。

III. 成 果

a) *経営面の変化*

肥育豚の飼料費は一頭当たり市販飼料区で13,880円，エコフィード区では950円となり12,930円削減され， 全体では47.5万円の飼料費を削減できました。また， 高品質な肉に仕上がり精肉の販売許可を取

得し，「シンデレラポーク」と　　して販売活動を行ったことで，1 頭当 たり約 2 倍の収益増加に繋たり約2倍の収益増加に繋がりました。

b) ***地域との連携***

食品廃棄物を活用したことで，5つの企業の廃棄物を合計約37トン削減し，廃棄処理にかかる企業経費を合計約 80 万円抑えることができました（表4）。この研究成果を発信したことで，地元の畜産農家5件が米粉や納豆の食品廃棄物を利用するようになり，私達の取組が徐々に広がりを見せています。今後は，エコフィード認証を取得して，さらなる情報発信を行い，　「日本の畜産農家が食品廃棄物を家畜用飼料として利用する資源循環型社会」，そんな未来を私達高校生の若い力で実現させたいです。「シンデレラポーク」 による魔法を信じて……。

文　献

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Genetic Variation and Heritability for Juice Quality and Yield Traits in Selection of Sugarcane Genotypes under Irrigation at Early Stage in Ferké 2 Sugar Estate of Northern Ivory Coast

By Crépin B. Péné, Yavo Michael Béhou & Marcel Silué
International University of Grand Bassam

Abstract- Genetic relationships between important attributes in studying sugarcane populations through breeding and direct selection, are crucial to understand how changes made by selecting one character may cause changes in others. The study aimed to determine the best yielding sugarcane genotypes tested at early selection stage under sprinkler irrigation, in comparison with a check variety (R579). The experiment was designed following a randomized complete block (RCB), with 30 cane genotypes in three replications. Each plot consisted of five dual rows of ten meters, with 0.5 and 1.90 m of inter-row spacing, i.e. 95 m^2 per plot and nearly 6,000 m^2 for the whole experiment. It was carried out on a commercial sugarcane plantation of Ferké 2, in northern Ivory Coast, over two seasons (plant cane and first ratoon) as an early-season crop from, November 29, 2018 to October 26, 2020. In each micro-plot, different agro-morphological traits were collected at harvest from three central dual rows.

Keywords: early season, phenotype, genotype, environmental influence, multivariate analysis, genetic advance.

GJSFR-D Classification: FOR Code: 079901

Genetic Variation and Heritability for Juice Quality and Yield Traits in Selection of Sugarcane Genotypes under Irrigation at Early Stage in Ferké 2 Sugar Estate of Northern Ivory Coast

Crépin B. Péné [α], Yavo Michael Béhou [σ] & Marcel Silué [ρ]

Abstract- Genetic relationships between important attributes in studying sugarcane populations through breeding and direct selection, are crucial to understand how changes made by selecting one character may cause changes in others. The study aimed to determine the best yielding sugarcane genotypes tested at early selection stage under sprinkler irrigation, in comparison with a check variety (R579). The experiment was designed following a randomized complete block (RCB), with 30 cane genotypes in three replications. Each plot consisted of five dual rows of ten meters, with 0.5 and 1.90 m of inter-row spacing, i.e. 95 m² per plot and nearly 6,000 m² for the whole experiment. It was carried out on a commercial sugarcane plantation of Ferké 2, in northern Ivory Coast, over two seasons (plant cane and first ratoon) as an early-season crop from, November 29, 2018 to October 26, 2020. In each micro-plot, different agro-morphological traits were collected at harvest from three central dual rows. The study showed that most relevant traits in genotype clustering were related to juice quality (recoverable sucrose, sucrose content, purity), yields and some yield components like single stalk height, and single stalk weight. Based on sugar yields, three genotypes over-classing the check variety (R579), namely RCI14/128, RCI11/112, and RCI11/190, were determined for the late selection stage, with 16.4, 15.8 and 15.0 t sugar/ha, respectively. Their cane yields reached 151.5, 164.2 and 132.6 t/ha, respectively, compared to 146.1 t/ha for the check, and belong to two clusters genotypes over six determined. Except for juice purity and cane fiber content, all agro-morphological traits investigated could explain the genetic variation of sugarcane genotypes tested, with stem borer infestation rate, cane and sugar yields, and number of tillers/ha as the most relevant traits in this regard.

Keywords: early season, phenotype, genotype, environmental influence, multivariate analysis, genetic advance.

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I. Introduction

For its high biomass production, and its well-established farming system and processing technologies, sugarcane is a top-ranking candidate for bio energy production and an important source of bio fuel for bio-refineries. Nevertheless, productivity improvements in sugarcane have been almost nil in the past three decades, and production statistics exhibit decreased yields globally [1]. In most cases, increased sugarcane production used to be explained by the expansion of land surface rather than increase in yield [2, 3].

Commercial sugarcane varieties under cultivation are complex polyploids, which heterozygous nature has resulted in generations of higher genetic variability. Information about the nature and magnitude of variability present in genetic materials is of prime importance for breeders to conduct effective selection programs[3-4].. Genotypic and phenotypic coefficients of variation, together with heritability and genetic advance, are key elements to improve any agronomic trait of sugarcane, as this would help in knowing whether or not specific objectives targeted could be achieved from a given crop material [3-5].

Sugarcane used to be the major source of sugar production in Ivory Coast and many tropical countries, where this crop used to be traditionally cultivated mainly for chewing purpose by smallholder farmers. Commercial sugarcane production in Ivory Coast started in 1974 at Ferké 1 plantations on about 5,500 ha[3]. Nowadays, sugarcane is grown on around 30,000 ha and the four sugar mills located in three different regions of the country produce, on yearly basis, about 200,000 t sugar [3, 6]. This production does not meet the domestic consumption, which is estimated to around 240,000 t. The production deficit is being offset by imported sugar, to alleviate the gap between supply and demand of sugar. Besides the expansion of existing sugar mill plantations, a productivity improvement and capacity-building project was implemented in the

country from March 2009 to June 2016, with the assistance of the European Union (EU) [7].

Cane and sugar yields are considered as complex characters in sugarcane, which phenotypic and genotypic interrelationships with their component traits would be of prime importance to breeders. Understanding associations between traits is of great importance in breeding and selection studies, particularly for low heritability or hardly measuring attributes [6, 8-10], like cane and sugar yields, recoverable sucrose, number of tillers/ha, and number of attacked internodes by stem borer. Genetic relationships between important attributes in studying sugarcane populations through breeding and direct selection are crucial to understand how changes made by selecting one character may affect the others [3, 6, 11-12]. This knowledge can be used when determining effective selection strategies for particular traits in a sugarcane breeding program [6, 13]. Likewise, the number of millable stalks/ha, single stalk height and single stalk diameter were reported to be positively associated with cane yield [6, 14-15]. Moreover, phenotypic associations between yields and their components in sugarcane showed that selecting for juice quality traits, number of tillers/ha, single stalk diameter and height, should be emphasized in variety development programs where high cane and sugar yields were the primary goal [3, 6, 16].

The objective of present study was to determine the best performing sugarcane genotypes under irrigation at early selection stage for different agro-morphological traits, based on their genetic variations and heritability.

II. Material and Methods

a) Site characteristics

The experiment was conducted on a small portion (0.6 ha) of 80 ha-sugarcane plantation(V4-043) at Ferké 2 sugar estate, under a center pivot irrigation system, in northern Ivory Coast (9°20' - 9°60' N, 5°22 - 5°40', 325 m a.s.l.). The climate of the region is tropical dry, with two different seasons: one, occurring from November to April, is dry and the other, from May to October, is wet. The rainfall pattern is unimodal and centered on August and September which total amount of precipitation reaches almost half of the average annual rainfall (500 mm over 1200 mm/yr). The average daily air temperature yields 27°C, ranging from 21 and 32.5°C as average minimum and maximum daily air temperatures, respectively[18]. Irrigation water requirements in this area for sugarcane reaches 650-700 mm/cycle [19]. Both Ferké sugar mill plantations cover nearly 17,000 ha with 11,500 ha under irrigation and 3,500 ha of rainfed village plantations, lie mainly on shallow or moderately deep soils built up on granites. Main soil units encountered are ferralsols and temporally waterlogged soils in valley bottoms of Bandama and Lokpoho river basins with a sandy-clay texture[18-19].

b) Cane genotypes tested

Except for the control, all genotypes tested were pre-selected sugarcane clones in Ferkéagro-pedological environment at the third stage, i.e. at one genotype per row stage. As genotypes of Reunion Island and Ivorian origin, they resulted from crosses made in Reunion Island, and selection under way at Ivorian sugar estates of Ferké.

c) Assessment of irrigation water requirement

The irrigation water requirement (I),over a given period, was calculated following the climatic water balance method as the difference between maximum evapotranspiration (ETm) and rainfall (R)collected from the closest rain-gauge to the Ferké 2 sugarcane plantation V4-043 subjected to the field experiment, as follows[19].:

$$I = ETm - R \quad (1)$$

$$ETm = Kc \times ETo \quad (2)$$

Where:

Values of crop coefficient Kc were equal to 0.5, 0.8 and 1.0 over tillering, early stem elongation, and late stem elongation stages, which last two, one and half and 8 months, respectively.

Reference evapotranspiration ETo is computed as follows[19].:

$$ETo = \Delta/(\Delta+\gamma) \times Rn$$

$$\Delta/(\Delta+\gamma) = 0.51 + 0.009 \times Ta$$

Rn: Net radiation = a Rg +b, a linear function of global radiation (Rg), which is measured as the average air temperature (Ta = (Tmax+Tmin)/2) in the local automatic weather station.

γ: psychrometric constant = 0.66 mb/°C

Δ: slope of the moisture saturation curve at air temperature E(Ta).

From the equation (1), irrigation water (I) is defined when positive (≥0), otherwise there is no need of watering because of rainfall excess compared to maximum evapotranspiration (ETm), particularly during the period of heavy rainfall from mid-July to mi-October.

d) Experimental design

The study was conducted over two consecutive years, as early-season trial in plant and first ratoon crops, from November 29, 2018 to November 17, 2019 and October 26, 2020 (i.e. 11.5 month-crop cycle), following a randomized complete block design (RCBD) with 30 different genotypes, including the check (R579), in 3 replicates. An experimental plot was made of 5 dual rows of 5 m long with narrow and wide spacings of 0.50 m and 1.90 m, respectively. Cropping operations, like sprinkler irrigation, fertilizer and herbicide applications

were performed following usual practices in commercial plantations. NKP fertilizer (16-8.5-23) was applied mechanically at the routine rates of 700 and 720 kg/ha in plant cane and first ratoon, respectively. Pre-emergence chemical weeding based on pendimethalin mixed with clorimuron-ethyl (3.5 l/ha) was also achieved mechanically, two days after planting or harvest.

e) Agronomic traits investigated

At harvest, burned cane fresh production of the three central dual rows of each plot was weighed *in situ,* separately, to determine cane yield. Moreover, 50 millable stalks were randomly chosen within every plot and split longitudinally with a machete, in order to determine the percentage of bored or attacked internode and cane (BIN%, BC%) by stem borer *Eldanasaccharina* W. (Lepidoptera: Pyralidae) [7].

Thirty millable cane stalks were also sampled per plot, on random basis, for juice quality analyses in the laboratory, to determine the recoverable sucrose content and therefore calculate the sugar yield with regard to the cane yield obtained. Prior to sample crushing operations in the laboratory for sucrose analyses, every stalk was cut into 3 pieces of almost equal length while separating them in basal, medial and top parts. This allowed to randomly reconstitute 3 batches of 10 stalks for a better homogenization of the initial field sample by permutation of the pieces so that each reconstituted stalk was composed of parts coming from 3 different initial cane stalks. Eventually, only one batch of 10 reconstituted stalks over 30 (1/3 of initial sample) were crushed for a series of sucrose analyses to determine the sucrose content (Pol%C), fiber content (Fiber %C), juice purity (Purity %C) and recoverable sucrose (SE%C) [6, 7]. Equipment used comprised a Jefco cutter grinder, a hydraulic press (Pinette Emideceau), a digital refractometer BS-RFM742 and a digital polari-meter SH-M100. Methods used in the determination of required juice qualitytraits were reported by Hoarau [20]. The recoverable sucrose was calculated as follows [6-7, 21]:

SE %C=[(0.84 × Pol%C) (1.6 -60/Purity) - (0.05 × Fib %C)] with:

Purity %C=(Pol juice/Brix) × 100 and Pol juice % =Pol factor × Pol read.

Pol%C=Factor n × Pol juice %

Sugar Yield (t/ha) = SE%C x Cane Yield (t/ha).

Factor pol depending on brix value (amount of soluble dry matter in juice measured with a refractometer), is provided by Schmidt table relative to a polarimeter for 26 g of glucose. The fiber content and factor *n* were provided by a table, depending on the weight of fiber cake obtained after pressing 500 g of cane pulp resulting from the crushing of every sample of cane stalks.

f) Determination of genetic parameters

The phenotypic and genotypic variances for each trait were estimated from the RCBD analysis of variance (Table 1). The expected mean squares under the assumption of random effect model were determined from linear combinations as follows (Burton and Davane [22], cited by Shitahum et al [23], Péné and Béhou [3, 6]:

Genotypic variance $(\sigma^2_g)=(MS_g - MS_e)/r$

Environmental variance $(\sigma^2_e)=MS_e$

Phenotypic variance $(\sigma^2_p)=\sigma^2_g + \sigma^2_e$

Where MSg and MSe are mean sum of squares for genotypes and error in the analysis of variance, respectively, and *r* the number of replicates.

Genotypic and phenotypic coefficients of variation (GCV, PCV) were computed as follows [3, 6, 24]:

$$GCV=\sigma_g \times 100/\text{grand mean}$$

$$PCV=\sigma_p \times 100/\text{grand mean}$$

According to Shivasubramanian and Menon [25], cited by different investigators [26-29], PCV and GCV values are ranked as low, medium and high with 0 to 10%, 11 to 20% and higher than 20% respectively.

$$\text{Broad sense heritability } h^2=100\times\sigma^2_g / \sigma^2_p.$$

Estimates of broad-sense heritability (h^2) are categorized according to Robinson [30] cited by different authors [25, 31, 38, 42] as low (<30%), moderate (30≤-<60%) or high (≥60%).

Genetic advance (GA) and genetic advance as percent mean (GAM):

$$GA=k\times h^2\times\sigma_p \text{ and } GAM=100\times GA/X.$$

With k: standard selection differential at 5% selection intensity (k=2.063) and X: grand mean of trait X.

Phenotypic and genotypic correlation coefficients r_p and r_g between particular pairs of traits A and B are defined as [24]:

$$r_p=Cov_p\,(A,B)/(\sigma_{pA}\times\sigma_{pB})$$

$$r_g=Cov_g\,(A,B)/(\sigma_{gA}\times\sigma_{gB})$$

where, Cov_p and Cov_g are phenotypic and genotypic covariances, respectively.

Phenotypic correlations between traits were determined following the Pearson correlation coefficient, calculated from means of observed traits for each cane genotype [25].

Genetic improvement in cane and sugar yields may be achieved by targeting traits closely associated to them. A number of attributes have been proposed as indirect selection criteria for genetic improvement of yields in plant breeding programs [26-27]. Heritability represents the relative importance of genetic and

environment factors in the expression of phenotypic and genotypic differences among genotypes within a population [3, 6, 28-30]. Therefore, the knowledge of heritability related to important traits and the correlations among them are key issues to determine the best selection strategy [31-32, 38]. Genotypic coefficient of variation (GCV) is another measure of relative genetic variation of a trait within a population [33]. Chaudhary [34] reported high GCV for single stalk weight and millable cane number per unit area. Genotype versus environment interactions (GxE) are a serious concern in breeding programs as they affect decision making in selection. When the ranking of genotypes changes across environments, it requires their evaluation environment-wise to determine their accurate performance [35, 38]. Studies in various sugarcane breeding programs have reported significant G×E interactions for cane and sugar yields [36-38].

g) Statistical analyses

Juice quality and yield traits recorded in this study were subjected to the analysis of variance, using statistical procedures described by Gomez and Gomez [39], and reported by Shitahum et al [23]. Calculations were made by means of R software package version 3.5.1 (Table 1). Differences between means of treatments were determined from Duncan test.

Table 1: Analysis of variance calculations regarding a Randomized Complete Block Design (RCBD)

Source of variation	Degree of freedom	Mean square	Expected mean square
Replication	r-1	MSr	$\sigma^2_e + g\sigma^2_r$
Genotypes	g-1	MSg	$\sigma^2_e + r\sigma^2_g$
Error	(r-1)(g-1)	MSe	σ^2_e

R: number of replicates; g=number of genotypes; MSr mean square due to replicates; MSg=mean square due to genotypes; MSe mean square of error; σ^2_g, σ^2_r, and σ^2_e stand for variances due to genotypes, replicates and error respectively.

III. Results and Discussion

a) Climatic conditions over plant cane and first ratoon

Total rainfall recorded in first ratoon decreased by 29% compared to that of plant cane (Figure 1), i.e. it varied from 936.4 to 762.4 mm, respectively. Total reference evaporation (ETo) decreased by 5% from plant cane to first ratoon, i.e. it varied from 1334 to 1267 mm, and the average daily temperature, from 27.5 to 26.3°C (-4%), respectively. Total water deficit over the dry season (from November to June) to be met by irrigation water gave 664 mm in plant cane and 561 mm in first ratoon. Total irrigation water applied reached 554 and 454 mm in plant cane and first ratoon, respectively.

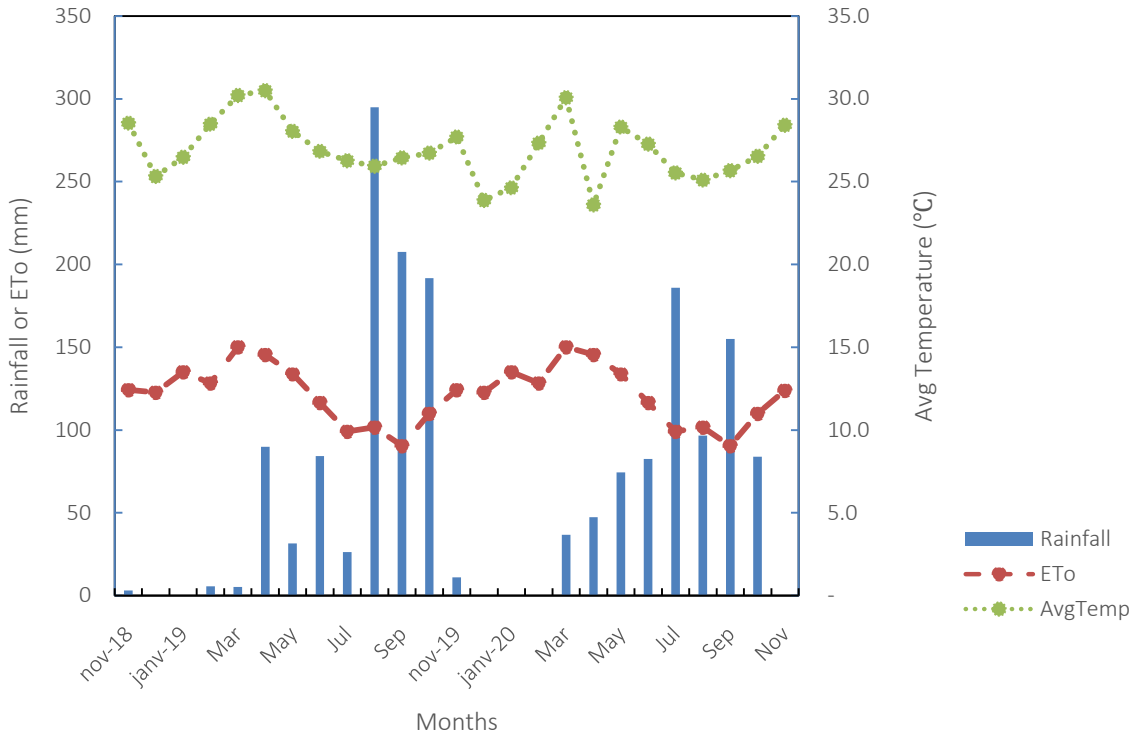

Figure 1: Climate of the experimental site over crop cycle (plant and 1rst ratoon) in Ferké 2, Ivory Coast. Total rainfall and irrigation water requirement: plant cane (R: 936.4, I: 664 mm), first ratoon (R: 762.4, I: 561 mm)

b) Performance of cane genotypes tested

Highly significant differences ($P<0.01$) were observed for all agro-morphological traits investigated, not only for the first ratoon but also for the aggregate data of both crop cycles (Tables3 and 4). Based on sugar yields, three genotypes, namely RCI14/128, RCI11/112, and RCI11/190 performed better than the control variety (R579), with 16.4, 15.8 and 15.0 sugar/ha, respectively, compared to 13.2 t/ha. Their cane yield performances reached 151.5, 164.2 and 132.6 t/ha, respectively, compared to 146.1 t/ha for the check. Higher juice quality traits, like purity, sucrose content, and recoverable sucrose percent and were obtained with genotype RCI11/190, while the higher cane yield with moderate quality traits were observed with RCI11/112. Genotype RCI14/128 was a good compromise with higher juice quality and yield traits.

Table 2: Mean values of sugarcane juice quality and yield traits at first ratoon in Ferké 2 Sugar estate

Genotypes	Juice quality traits					Yield traits (t/ha)	
	Purity%	Sucrose%	Fiber%	Recoverable sucrose%	Internode bored %	Cane	Sugar
R579_(T)	87.2 ab	13.3 ab	12.7 e	9.6 abc	4.7 ab	123.1 abc	11.7 bc
RCI11/112	88.1 ab	13.6 ab	13.4 bcde	9.8 abc	4.1 ab	164.5 a	15.9 ab
RCI11/134	86.7 ab	12.5 b	13.2 bcde	8.9 bc	3.1 ab	148.8 ab	13.2 abc
RCI11/135	86.7 ab	12.0 b	13.0bcde	8.5 bc	3.8 ab	130.5 abc	11.1 bc
RCI11/162	87.9 ab	13.5 ab	13.8 bcde	9.7 abc	3.8 ab	127.6 abc	12.4 bc
RCI11/165	85.3 ab	12.1 b	13.4 bcde	8.4 bc	6.0 ab	137.7 abc	11.6 bc
RCI11/166	89.3 ab	13.8 ab	13.7 bcde	10.0abc	5.6 ab	133.3 abc	13.4 abc
RCI11/190	91.5 a	15.7 a	13.8 bcde	11.8 a	2.5 ab	119.6 abc	14.1 abc
RCI12/191	87.7 ab	13.2 ab	14.2 abc	9.4 abc	1.9 b	115.5 abc	10.8 bc
RCI12/192	86.6 ab	14.8 ab	14.8 a	10.5 abc	1.7 b	116.1 abc	12.1 bc
RCI13/110	87.9 ab	13.1 ab	12.9 de	9.5 abc	3.1 ab	146.5 ab	13.9 abc
RCI13/13	88.8 ab	13.9 ab	13.6 bcde	10.1 abc	3.9 ab	132.3 abc	13.3 abc
RCI13/139	87.0 ab	12.5 b	13.8 bcde	8.9 bc	4.2 ab	115.7 abc	10.3 bc
RCI13/16	87.3 ab	13.0 ab	13.6 bcde	9.3 bc	3.0 ab	156.5 ab	14.5 abc
RCI13/173	88.0 ab	13.6 ab	13.7 bcde	9.8 abc	4.3 ab	130.7 abc	12.8 abc
RCI13/174	84.1 b	12.1 b	13.7 bcde	8.3 bc	2.3 ab	60.3 d	5.1 d
RCI13/177	89.5 ab	14.4 ab	13.3 bcde	10.6 abc	2.2 ab	99.8 bcd	10.5 bc
RCI13/179	87.9 ab	13.3 ab	13.8 bcde	9.6 abc	3.0 ab	115.7 abc	11.1 bc
RCI13/180	86.8 ab	13.0 ab	13.2 bcde	9.3 bc	3.6 ab	130.0abc	12.3 bc
RCI13/187	87.4 ab	13.2 ab	13.1 bcde	9.5 abc	3.4 ab	150.1 ab	14.3 abc
RCI13/193	87.7 ab	13.3 ab	13.3 bcde	9.5 abc	3.2 ab	115.8 abc	11.1 bc
RCI13/194	87.6 ab	13.8 ab	12.9 cde	10.0abc	4.0 ab	142.6 abc	14.1 abc
RCI13/195	83.7 b	12.1 b	14.3 ab	8.2 c	3.4 ab	129.7 abc	10.6 bc
RCI13/196	88.1 ab	14.2 ab	13.5 bcde	10.3 abc	2.1 ab	119.9 abc	12.3 bc
RCI14/111	88.1 ab	13.3 ab	13.2 bcde	9.6 abc	4.3 ab	147.7 ab	14.1 abc
RCI14/128	90.9 a	14.6 ab	13.4 bcde	10.8 ab	6.7 a	167.7 a	18.2 a
RCI14/159	87.6 ab	13.5 ab	13.2 bcde	9.7 abc	3.3 ab	123.1 abc	12.0bc
RCI14/171	86.5 ab	12.8 b	13.7 bcde	9.1 bc	5.6 ab	107.2 abc	9.6 bc
RCI14/188	90.1 ab	13.8 ab	14.0abcd	10.1 abc	2.4 ab	82.5 cd	8.3 cd
RCI14/189	86.9 ab	12.8 b	12.9 de	9.2 bc	6.2 ab	94.5 bcd	8.7 cd
Mean	87.6	13.3	13.5	9.6	3.7	126.2	12.1
CV (%)	2.7	8.5	4.2	10.7	54.0	22.5	24.7
Replications	*	ns	ns	*	***	ns	*
Genotypes	*	***	***	***	**	***	***

*CV: coefficient of variation. ns: non-significant *: significant ** or ***: highly significant*

Table 3: Mean values of sugarcane juice quality and yield traits regarding plant cane and first ratoon on aggregate, in Ferké 2 Sugar estate

Genotypes	Juice quality criteria					Yield traits (t/ha)	
	Purity%	Sucrose%	Fiber%	Recoverable sucrose%	Internode bored %	Cane	Sugar
R579_(T)	86.1 cd	12.9 bcde	12.2 e	9.2 cdef	4.9 ab	146.1 ab	13.2 abcde
RCI11/112	87.9 abcd	13.5 bcde	13.1 cde	9.7 bcdef	5.7 a	164.2 a	15.8 ab
RCI11/134	85.9 cd	12.3 efg	12.8 cde	8.6 efg	3.7 ab	153.5 ab	13.2 abcde
RCI11/135	87.0bcd	12.4 defg	12.9 cde	8.9 defg	3.9 ab	145.1 ab	12.9 abcde
RCI11/162	86.2 cd	13.1 bcde	12.8 cde	9.3 cdef	3.5 ab	136.9 ab	12.7 abcde
RCI11/165	85.1 d	12.3 defg	13.0cde	8.6 efg	5.6 a	117.4 bc	10.1 efg
RCI11/166	87.0bcd	13.2 bcde	13.0cde	9.4 bcdef	5.5 a	149.3 ab	14.0 abcde
RCI11/190	90.4 a	15.3 a	13.3 bcd	11.4 a	3.2 ab	132.6 ab	15.0 abc
RCI12/191	85.0 d	11.8 fg	13.8 bc	8.2 fg	2.0 ab	140.4 ab	11.2 cdefg
RCI12/192	87.5 abcd	14.5 ab	14.1 ab	10.4 abcd	1.4 b	121.1 abc	12.6 abcde
RCI13/110	86.8 cd	12.9 bcde	12.2 e	9.2 cdef	3.4 ab	157.0 ab	14.4 abcd
RCI13/13	87.5 abcd	13.4 bcde	12.9 cde	9.7 bcdef	4.2 ab	134.6 ab	13.0abcde
RCI13/139	86.7 cd	13.1 bcde	13.0 cde	9.3 cdef	3.6 ab	131.2 ab	12.4 abcde
RCI13/16	85.6 cd	12.6 cdef	13.3 bcd	8.9 cdefg	2.9 ab	153.9 ab	13.7 abcde
RCI13/173	87.8 abcd	13.8 bcd	13.3 bcd	10.0bcde	3.2 ab	136.1 ab	13.6 abcde
RCI13/174	84.9 d	12.6 cdef	13.1 cde	8.8 defg	2.1 ab	92.5 c	8.4 g
RCI13/177	88.9 abc	14.2 abc	12.9 cde	10.4 abc	3.0 ab	120.0 bc	12.5 abcde
RCI13/179	87.0bcd	13.0 bcde	13.5 bcd	9.3 cdef	4.2 ab	132.0 ab	12.2 bcde
RCI13/180	85.8 cd	12.7 cdef	13.3 bcd	9.0cdef	3.3 ab	141.2 ab	12.8 abcde
RCI13/187	86.5 cd	13.2 bcde	12.4 de	9.4 bcdef	3.0 ab	148.7 ab	14.0abcde
RCI13/193	87.2 bcd	13.0bcdefg	12.9 cde	9.3 cdef	3.9 ab	133.4 ab	12.4 abcde
RCI13/194	87.2 bcd	13.8 bcde	12.1 e	9.9 bcde	5.5 a	144.5 ab	14.3 abcde
RCI13/195	82.1 e	11.5 g	14.6 a	7.7 g	3.0 ab	135.6 ab	10.4 defg
RCI13/196	87.7 abcd	14.0abcd	13.0 cde	10.1 bcde	2.8 ab	137,5 ab	13.9 abcde
RCI14/111	87.5 abcd	13.5 bcde	13.1 cde	9.7 bcdef	5.4 a	152.7 ab	14.8 abc
RCI14/128	90.2 ab	14.6 ab	13.0 cde	10.8 ab	6.0 a	151.5 ab	16.4 a
RCI14/159	86.6 cd	13.1 bcde	13.0cde	9.4 cdef	2.8 ab	128.1 ab	12.0bcdef
RCI14/171	86.1 cd	13.0bcdef	13.4 bcd	9.2 cdef	4.9 ab	123.0 abc	11.2 cdefg
RCI14/188	88.2 abcd	13.4 bcde	13.6 bc	9.6 bcdef	2.3 ab	90.3 c	8.6 fg
RCI14/189	86.8 cd	13.2 bcde	12.4 de	9.5 bcdef	5.3 ab	114.2 bc	10.9 cdefg
Mean	86.8	13.2	13.0	9.4	3.8	135.5	12.7
CV (%)	2.7	8.6	6.6	11.0	56.5	20.5	21.9
Replications	*	*	ns	*	***	ns	**
Genotypes	***	***	***	***	***	***	***

*CV: coefficient of variation. ns: non-significant *: significant ** or ***: highly significant*

c) *Multivariate analyses of agronomic traits observed in sugarcane*

The principal component analysis shows that most relevant traits in genotype clustering are related to juice quality (recoverable sucrose, sucrose content, purity), yields and yield components (sugar yield, cane yield, stalk height, stalk weight), (Figure 2, Table 2). The three high yielding genotypes determined are RCI14/128, RCI11/112, and RCI11/190 with 16.4, 15.8 and 15.0 t/ha, respectively (Table 3). They belong to cluster 2, 4 and 1, respectively (Table 4). In contrast, the least relevant traits in genotype clustering are millable cane stalk/ha, number of internodes, fiber content, and bored internode rate. The least productive genotypes are RCI13/174 (8.4 t/ha) on the one hand, and RCI14/188 (8.6 t/ha) and RCI11/165 (10.1 t/ha) on the other hand, which belong to clusters 4 and 3, respectively. The dendrogram deduced from hierarchical ascendant classification analysis exhibits 6 different cluster genotypes(Figure 2), which average agro-morphological characteristics are displayed in Table 4.

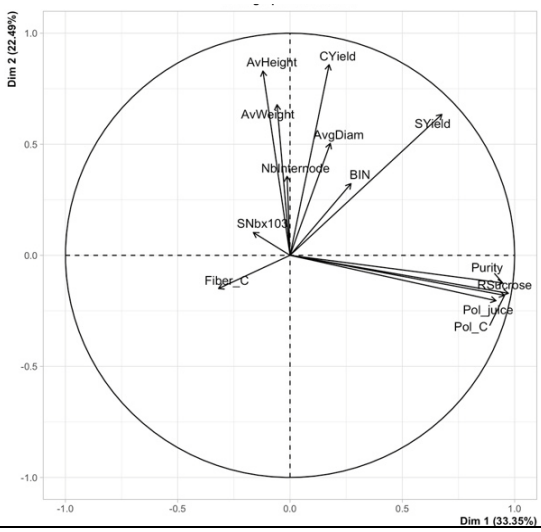

Figure 1a: Correlation circle of agronomic traits investigated, in 1-2 factor plane

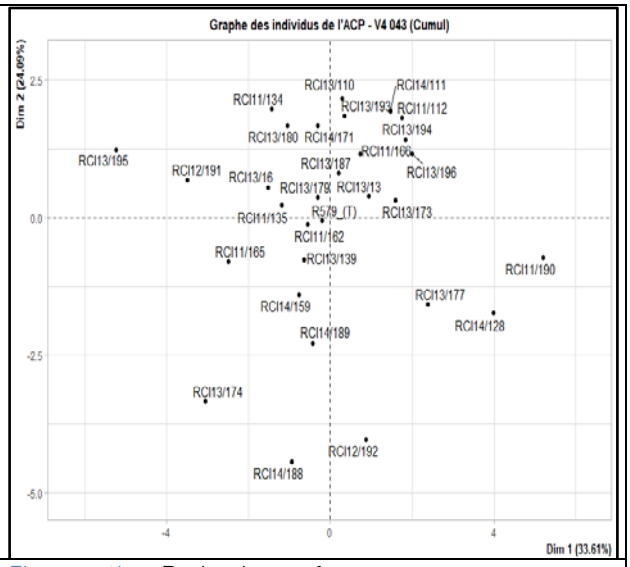

Figure 1b: Projection of sugarcane genotypes following their agronomic performances, in 1-2 factor plan

Figure 1: Results of principal component analysis regarding aggregate data of plant cane and first ratoon crops, obtained in Ferké 2 sugar estate

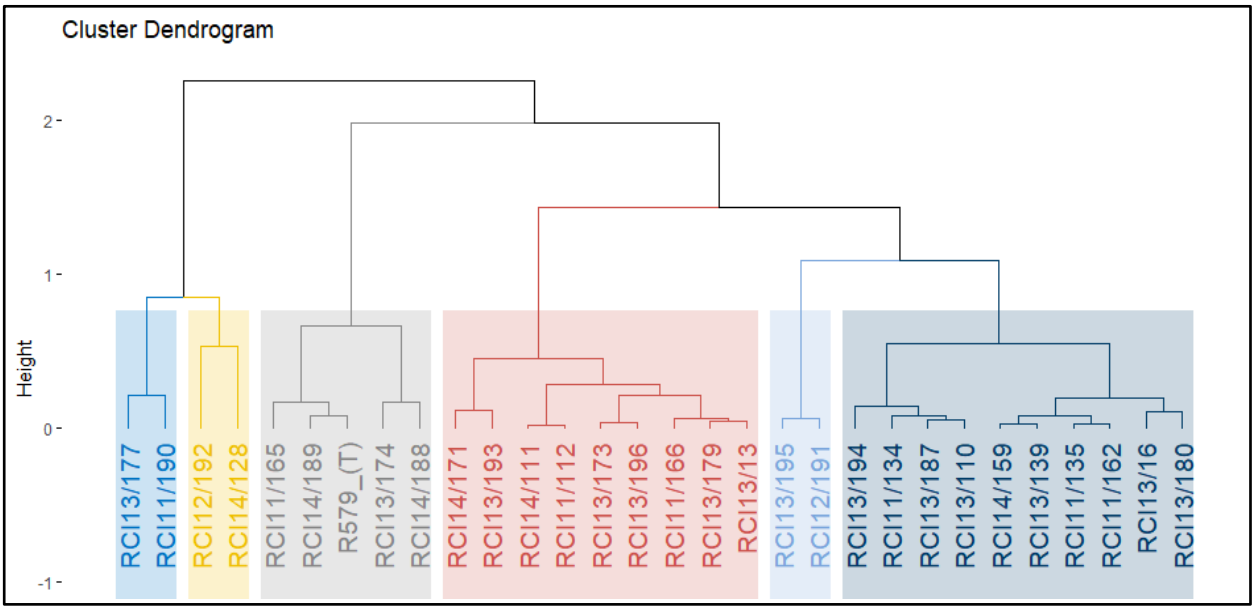

Figure 2: Dendrogram deduced from the cluster analysis of all 30 cane genotypes tested in Ferké 2 sugar estate, based on different agronomic traits observed in plant cane and first ratoon on aggregate

Table 4: Average juice quality, yield traits of sugarcane cluster genotypes over plant cane, and first ratoon on aggregate, in Ferké 2 Sugar Estate (Ivory Coast)

Cluster Genotyes	Juice quality traits					Yield traits (t/ha)	
	Purity%	Sucrose%	Fiber%	Recoverable sucrose%	Internode bored %	Cane	Sugar
Cluster 1	83.6	11.7	14.2	8.0	2.5	138.0	10.8
Cluster 2	86.3	12.9	13.0	9.1	3.8	103.6	9.5
Cluster 3	86.5	12.9	12.8	9.2	3.7	143.2	13.2
Cluster 4	87.3	13.4	13.1	9.6	4.5	141.4	13.6
Cluster 5	88.9	14.6	13.6	10.6	3.7	136.3	14.5
Cluster 6	89.7	14.8	13.1	10.9	3.1	126.3	13.8
Mean	87.0	13.4	13.8	9.6	3.5	131.5	12.6

d) Phenotypic correlations between pairs of agro-morphological traits

Juice quality traits (pol juice, purity, sucrose content, and recoverable sucrose) were positively, tightly,and highly significantly correlated between pairs with coefficients ranging from 0.80** to 0.99**. Similar correlation was obtained with cane and sugar yields which coefficient (r=0.86***) matches that magnitude. Juice quality traits were also positively, significantly correlated highly, but moderately, to sugar yield with coefficients ranging from 0.31 to 0.39. In contrast, they were loosely correlated negatively and not significantly (P=0.05) to cane yield, with coefficients ranging from -0.16 to -0.11. The millable stalk number per hectare was positively and moderately correlated to cane and sugar yields, with 0.27 and 0.21, respectively, as coefficients. Agro-morphological characters like stalk diameter and stalk height were moderately and significantly correlated to stalk weight with coefficients of 0.27 and 0.37, respectively. The cane Fiber content was correlated positively to internode number (r=0.32), but negatively to cane and sugar yields (-0.25, -0.23) as reported by different investigators [3, 5, 40-41]. It was negatively correlated to stem borer infestation rate (r=-0.18), in contrast of findings of these investigators. More importantly, it was positively correlated to the recoverable sucrose, in line of observations made by Péné and Béhou[42], and in contrast of findings obtained in the same agro-ecological context [43].

e) Genotypic correlations between pairs of agro-morphological traits

Juice quality traits were positively and strongly correlated between pairs with coefficients ranging from 0.89** to 0.98**. Similar correlation was observed not only with cane and sugar yields (r=0.83**). Other strong and positive correlations occurred between cane yield and the average stalk height (r=0.80**), and between single stalk weight and agro-morphological traits like single stalk height (r=0.77**) and single stalk diameter (r=0.70**). In contrast, a negative and strong correlation was observed between the millable stalk number and single stalk diameter(r=-0.71**), indicating that the higher the number of tillers/ha, the smaller stalk diameter was due to competition for light and soil nutrients. As reported by several researchers [27, 30], such tight genotypic correlations indicate that selection based on single stalk weight, and millable stalk number could lead to improvement in agro-morphological traits like stalk diameter, stalk height and yield traits. In the present study, correlations observed between the internode number and other agro-morphological traits were loose, in contrast of findings reported by these researchers.

Juice quality traits were also positively correlated, but moderately, to sugar yield with coefficients ranging from 0.49 to 0.63, in line of findings obtained by Péné and Béhou[3, 42] in the same agro-ecological context.

Table 5: Phenotypic and genotypic correlation matrix of agro-morphological traits investigated (respectively below and above diagonal) regarding aggregate data of both plant and first ratoon crops

Genotypes	Pol juice	Purity	Pol%C	Fiber%	CYield	RSucrose	SYield
Pol juice	1.00	0.89**	0.99**	-0.03	-0.07	0.97**	0.49
Purity	0.80**	1.00	0.94**	-0.36	0.11	0.96**	0.63**
Pol%C	0.98**	0.80**	1.00	-0.18	-0.01	1.00	0.55**
Fiber%	0.18	0.11	0.02	1.00	-0.34	-0.25	-0.43
CYield	-0.16	-0.12	-0.12	-0.25	1.00	0.03	0.83**
RSucrose	0.97**	0.87**	0.99**	0.00	-0.11	1.00	0.59**
SYield	0.33	0.31	0.38	-0.23	0.86**	0.39	1.00
SNbx10^3	-0.03	-0.02	-0.04	0.05	0.27	-0.04	0.21
AvWeight	-0.07	-0.10	-0.08	0.04	0.25	-0.09	0.19
AvHeight	-0.16	-0.24	-0.12	-0.24	0.50*	-0.13	0.39
AvDiam	-0.05	0.04	-0.02	-0.10	0.19	-0.01	0.16
NbInternode	0.13	0.13	0.08	0.32	0.02	0.08	0.07
BIN%	-0.09	-0.04	-0.06	-0.18	0.24	-0.05	0.21

Genotypes	SNbx103	AvWeight	AvHeight	AvgDiam	NbInternode	BIN%
Pol juice	-0.13	-0.14	-0.22	0.03	-0.03	0.05
Purity	-0.26	-0.22	-0.28	0.17	-0.14	0.34
Pol%C	-0.17	-0.13	-0.24	0.09	-0.09	0.14
Fiber%	0.20	0.06	0.21	-0.29	0.44	-0.59
CYield	0.41	0.51*	0.80**	0.23	0.13	0.44
RSucrose	-0.19	-0.15	-0.26	0.11	-0.12	0.20
SYield	0.23	0.34	0.50	0.24	0.05	0.50
SNbx10^3	**1.00**	-0.22	0.31	-0.71**	-0.44	-0.29
AvWeight	-0.01	**1.00**	0.77**	0.70**	0.41	-0.18
AvHeight	0.15	0.37	**1.00**	0.23	0.32	0.09
AvDiam	-0.19	0.27	0.29	**1.00**	0.32	0.30
NbInternode	-0.12	0.17	0.10	0.18	**1.00**	-0.01
BIN%	-0.14	0.10	0.07	0.01	-0.03	**1.00**

f) Phenotypic and Genotypic Coefficient of Variation (PCV, GCV)

All PCV and GCV values determined, which ranged from 4.8 to 89% on the one hand, and from 4.4 to 80.5% on the other hand, varied from low to high (Table 6). As far as PCV is concerned, higher values were observed for traits like cane yield, sugar yield, recoverable sucrose, millable stalk number/ha, single stalk weight, single stalk height, and stem borer infestation rate. Moreover, higher GCV values were observed for traits like cane yield, sugar yield, millable stalk number, single stalk weight, and stem borer infestation rate. In line of findings reported by different investigators [44 -45], higher GCV and PCV values indicated that selection might be effective on traits investigated and their expression be relevant to the genotypic potential. Agronomic traits exhibiting relatively high GCV, with values ranging from 29 to 80.5%, might respond favorably to selection, as reported by Ebid et al [46]. Regardless the trait considered in this study, the phenotypic coefficient of variation was higher than the genotypic ones suggesting that apparent variations were not only due to genetics but also to environmental influences. However, differences between PCV and GCV for most traits were small in line of observations made by different investigators [3, 25, 30,42,47], indicating a good perspective for genetic progress through selection under the agroecological conditions of this study.

g) Phenotypic, Genotypic and Environmental Variances

Regardless the trait considered, phenotypic variance data determined were higher than the genotypic ones. This shows a greater influence of environment on genetic variations, in line of observations made by different authors [19, 27, 46]. No matter the trait considered, genotypic variance calculated was higher than environmental one, suggesting important variations among genotypes, in line of their higher or moderate values of broad sense heritability ($h^2 \geq 56.8\%$) ranging from 53.6 to 87%. Except for the single stalk weight, the heritability observed ranged from 74 to 87%, which values are much higher than the threshold 60%.

h) Heritability and Genetic Advance

Except for the single stalk weight, higher heritability values ranging from 74 to 87% were observed on all traits investigated (Table 6). Estimates of mean genetic advance (GAM) are categorized similarly to GCV and PGV according to Falconer and Mackay [26] cited by several authors [27-28, 30, 47-48]. Therefore, except for juice purity (8.5%) and cane fiber content (19.8%), higher values of genetic advance were observed for all traits investigated likecane yield (57%), sugar yield (67%), millable stalk number (52%), single stalk weight (46%), and stem borer infestation rate (150%). Higher values of GAM suggest that a significant proportion of

the total variance might be heritable and selection of corresponding traits would be effective. In sugarcane, several authors reported similar values on single stalk weight [30, 51-52]. As indicated by Vidya et al [53], knowledge of variability and heritability of characters is essential for identifying those relevant to genetic improvement through selection. Moreover, the effectiveness of selection will depend not only on heritability but also on genetic advance, as reported by different authors [54-55].

Higher levels of mean genetic advance observed for yield (57%), sugar yield (67%), millable stalk number (52%), single stalk weight (46%), and stem borer infestation rate (150%) were the result of moderate or high broad sense heritability, combined with high GCV for these traits, in line of findings reported by Bakshi [54]. According to this author, cited by Péné and Béhou [55], heritability estimates together with expected genetic gain were more useful than heritability values alone in predicting the effects of selecting best genotypes. Chaudhary [34] also reported high heritability and genetic gain for single cane weight followed by number of millable cane in a study of 36 clones indicating substantial scope for cane yield improvement. On the other hand, sucrose content recorded low heritability and genetic gain suggesting little scope for improvement in this character [56]. Patel et al [57] also reported high heritability estimates for single cane weight, number of internodes, tiller number, hand refractrometer brix, cane diameter and millable cane length, which were associated with moderate to high genetic advance (23-190%). Findings indicated that these characters might be improved through selection. From the literature, findings on heritability, genetic gain, PCV and GCV for the same traits look sometimes controversial depending on locations, crop cycle (plant cane or ratoon), soil types, water regime (rainfed or irrigated), etc. [6, 22, 41, 58]. But still, this is all about the scope of experimentation in agronomy, findings being mostly site-specific.

Table 6: Variability and heritability among sugarcane genotypes tested in Ferké 2, Ivory Coast (aggregate data of both plant and first ratoon crops)

Agronomictraits	Mean	Variance			Coefficient of variation (%)		H^2 (%)	GA (-)	GAM (%)
		σ^2g	σ^2e	σ^2p	GCV	PCV			
Pol juice	16.1	5.79	1.02	6.71	15.0	16.1	86.3	4.6	28.7
Purity	86.8	14.88	2.85	17.28	4.4	4.8	86.1	7.4	8.5
Pol%C	13.2	3.96	0.66	4.56	15.1	16.2	86.8	3.8	29.0
Fiber%	13.1	1.80	0.28	2.07	10.3	11.0	87.1	2.6	19.8
CYield	135.5	1778.00	398.00	2219.33	31.1	34.8	80.1	77.9	57.5
RSucrose	9.4	3.35	0.54	3.84	19.4	20.8	87.1	3.5	37.3
SYield	12.8	21.06	3.85	25.35	36.0	39.5	83.1	8.6	67.7
$SNbx10^3$	116.3	1139.90	265.80	1461.90	29.0	32.9	78.0	61.5	52.9
AvWeight	1.3	0.14	0.07	0.25	29.6	39.3	56.8	0.6	46.1
AvHeight	260.7	2468.00	510.00	2848.50	19.1	20.5	86.6	95.4	36.6
AvDiam	21.9	13.05	2.63	15.47	16.5	17.9	84.4	6.8	31.2
NbInternode	22.6	10.35	3.61	13.93	14.2	16.5	74.3	5.7	25.3
BIN%	3.8	9.35	3.44	11.43	80.5	89.0	81.8	5.7	150.1

IV. Conclusion

The present study showed that most relevant traits in genotype clustering were associated to juice quality (recoverable sucrose, sucrose content, purity), yields and their components like single stalk height, and single stalk weight. Based on sugar yields, three high yielding genotypes compared to the check variety (R579), namely RCI14/128, RCI11/112, and RCI11/190, were determined for the late selection stage, with 16.4, 15.8 and 15.0 t sugar/ha, respectively. Their cane yieldsreached 151.5, 164.2 and 132.6 t/ha, respectively, compared to 146.1 t/ha for the check, and they belong to two clusters genotypes over six determined. Except for juice purity and cane fiber content, all agro-morphological traits investigated have explained the genetic variation of sugarcane genotypes tested, with stem borer infestation rate, cane and sugar yields, and number of tillers/ha as the most important traits in this regard.

References Références Referencias

1. FAO, 2014. FAO STAT, FAO statistical databases. Available at: http://faostat3.fao.org/(Last accessed June 07, 2016.
2. Jackson, P.A. (2005). Breeding for improved sugar content in sugarcane. Field Crops Res. 92(2-3): 277-90.
3. Péné CB, Béhou YM, 2019a. Evaluation of sugarcane genotypes under irrigation based on genetic variations and heritability for agronomic traits at early selection stage in Ferké, Ivory Coast. Am. J. Biosci. Bioeng. 7(6): 82-92.

4. Tyagi S.D. and D.N. Singh (1998). Studies on genetic variability for stalk characters in sugarcane. Indian Sugar XL VIII: 259-62.
5. Chaudhary, R.R. (2001). Genetic variability and heritability in sugarcane. Nepal Agric Res. 4 & 5: 56-8.
6. Béhou, Y.Y.M. and C.B. Péné (2019). Genetic variability and heritability among sugarcane genotypes in plant crop for some agronomic traits under tropical dry climate of Ferké, Ivory Coast. J. Exp. Agric. Int. 38(1): 1-14.
7. Péné, C.B., K.D. Kouamé, H. Dove and B.M. Boua (2016). Incidence des infestations du foreur de tiges *Eldanasaccharina* W (Lepidoptera:Pyralidae) en culture irriguée de canne à sucre selon la variété et la période de récolte en Côte d'Ivoire. J. Appl. Biosci. 102: 9687-9698.
8. Bakhsh, A., M. Arshad and A.M. Haqqan (2006). Effect of GxE interaction on relationship between grain yield and its components in chickpea (*Cicer arietinum* L). Pakistan J. Bot. 38: 683-90.
9. Da Silva, F.F., M.G. Pereira, H.C.C. Ramos, Jr. Damasceno, N.S. Pereira and C.D. Ide (2007). Genotypic correlations of morpho-agronomic traits in papayas and implications for genetic breeding. Crop Breed. Appl. Biotech 7: 345-52.
10. Tena, E., A. Ayana and F. Mekbib (2016). Heritability and correlation among sugarcane (*Saccharum* spp.) yields and some agronomic and sugar quality traits in Ethiopia. Am. J. Pant Sci. 7(10): 1453-77.
11. Jackson, P. (1994). Genetic relationships between attributes in sugarcane clones closely related to *Saccharum spontaneum*. Euphytica 79: 101-8.
12. Tyagi S.D., M.H. Khan (2010). Studies on genetic variability and interrelationships among different traits in Microsperma Lentil (*Lens culinaris*Medik). J. Agric Biotech Sust. Dev 2: 15-20.
13. De Sousa-Vierra O. and S.B. Milligan (2005). Interrelationships of cane yield components and their utility in sugarcane family selection: path coefficient analysis. Intersciencia 30: 93-9.
14. Milligan, S.B., K.A. Gravois, K.P. Bischoff and F.A. Martin (1990). Crop effects on broad-sense heritability and genetic variances of sugarcane yield components. Crop Sci. 30: 344-49.
15. Gravois, K.A., S.B. Milligan and F.A. Martin (1991). Additive genetic effects for sugarcane yield components and implications for hybridization. Trop. Agric. (Trinidad) 68: 376-80.
16. Tyagi, A.P. and P. Lal (2007). Correlation and path coefficient analysis in sugarcane. South Pacific J. Nat. Sci. 25: 1-9.
17. Péné, C.B., H.M. Ouattara and G.S. Koulibaly (2012). Late season sugarcane performance as affected by soil water regime at the yield formation stage on commercial farms in northern Ivory Coast. J Life Sci. 6(6): 644-651.
18. Konan, E.A., C.B. Péné, E. Dick (2017a). Caractérisation agro-climatique du périmètre sucrier de Ferké 2 au Nord de la Côte d'Ivoire. J Appl. Biosci. 116: 11532-11545.
19. Konan, E.A., C.B. Péné and E. Dick (2017b). Main factors determining the yield of sugarcane plantations on Ferralsols in Ferké 2 sugar complex, Northern Ivory Coast. J. Emerg. Trends Engin. Appl. Sci. JETEAS 8(6): 244-256.
20. M. Hoarau. La canne à sucre. Le technicien d'agriculture tropicale. Maisonneuve et Larose (eds), 1970, 165 p.
21. E. Hugot. Sucrerie de canne. Paris, Collection Tech & Doc, Lavoisier (eds), 1999, 1018 p.
22. Burton, G.W., E.H. Devane (1953). Estimating heritability in tall Fescue (*Festuca arundinacea*) from replicated clonal materials. Agron. J.: 45: 487-88.
23. Shitahum, A., T. Feyissa and D. Abera (2018). Performances evaluation of advanced sugarcane genotypes (Cirad 2013) at Metahara sugar estate, Ethiopia. Int. J Adv. Res. Biol. Sci.: 5(1): 91-104.
24. R.K. Singh and B.D. Chaundary. Biometrical methods in quantitative genetics analysis. New Delhi, Kalyani Publishers, 1977: 57-8.
25. Shivasubramanian, S. and M. Menon (1973). Heterosis and inbreeding depression in rice. Madras Agric. J. 60: 1139.
26. D.S. Falconer, T.F.C. Mackay. Introduction to quantitative genetics. 4th eds. Harmlow: Longman, 1996.
27. Mancini, M.C., D.C. Leite, D. Perecin (2012). Characterization of the genetic variability of a sugarcane commercial cross through yield components and quality parameters. Sugar Tech. 14(2): 119-25.
28. Li, C. (2017). Genotypic variations in transpiration efficiency, due to differences in photosynthetic capacity among sugarcane-related clones. J. Exper. Bot. 68(6): 2377-85.
29. Jackson, P., J. Basnayake, G. Inman-Bamber, P. Lakshmanan, S. Natarajan and C. Stokes (2015). Genetic variation in transpiration efficiency and relationships between whole plant and leaf gas exchange measurements in *Saccharum* spp. And related germplasm. J. Exper. Bot.: 67(3): 861-71.
30. Robinson H F (1966). Quantitative genetics in relation to breeding of the centennial of mendalism. Indian J. Gen. 26: 171-87.
31. Tadesse, F., T. Negi, A. Getaneh, Z. Dilnesaw, N. Ayele and Y. Teferi (2014). Genetic variability and heritability of ten exotic sugarcane genotypes at Wonji sugar estate of Ethiopia. Global Adv. Res. J. Phys. Appl. Sci. 3(4): 1-4.
32. Rebettzke, G.J., A.G. Condon, R.A. Richards and G.D. Farquhar (2002). Selection of carbon isotope discrimination increases aerial biomass and grain

yield of rainfed bread wheat. Crop Sci.: 42(3): 739-45.
33. Ram, B., G. Hemaprabha (1992). Genetic variability in interspecific progenies in sugarcane (*Saccharuim* spp.). Ind. J. Genet: 52(2): 192-98.
34. Chaudhary, R.R. (2001). Genetic variability and heritability in sugarcane. Nepal Agric. Res. J: 4: 56-9.
35. Kang, M.S., J.D. Miller and P.Y.P. Tai (1983). Genotypic and phenotypic path analyses and heritability in sugarcane. Crop Sci: 23: 643-47.
36. R.C. Parfitt. Genotype x environment interaction among secondary variety trials in the northern region of the South African sugar industry. Proc. S. Afr. Sug. Technol. Assoc, 2000: 74: 245-58.
37. Glaz, B. and M.S. Kang (2008). Location contributions determined via GGE biplot analysis of multi-environment sugarcane genotype-performance trials. Crop Sci. 48: 941-50.
38. Péné CB, Béhou YM, 2020a. GxE interactions in sugarcane under irrigation for agronomic traits at advanced screening stage in Ferké, Northern Ivory Coast. J. Exper. Agric. Inter. (JEAI) 42(2): 97-115.
39. K.A. Gomez and A.A. Gomez. Statistical procedure for agricultural research (2nd ed). John Wiley and Sons Inc, New York. 1984.
40. Gravois, K.A. and S.B. Milligan (1992). Genetic relationship between fiber and sugarcane yield components. Crop Sci. 32(1): 62-7.
41. Dumont, T., A. Thong-Chane, L. Barau, B. Siegmund and J.Y. Hoarau (2019). Genetic variability and genetic gains for yield components in regional sugarcane breeding program on Reunion Island. Sugar Tech. Available online http://doi.org/10.1007/s12355-019-00718-9.
42. Péné CB, Béhou M, 2019b. Screening of fifteen sugarcane genotypes under irrigation based on genetic variations and heritability for agro-morphological traits at early selection stage in Ferké, Ivory Coast. Am. J. Biomed. Sci. Res. 4(5): 362-71.
43. Péné, C.B., B.M. Boua, Y. Coulibaly-Ouattara and F.R. Goebel (2018). Stem borer (*Eldanasaccharina* W) infestation outbreak in Sugarcane plantations of northern Ivory Coast: Management strategies under implementation. Amer. J Biosci. Bioeng. 6(4): 27-35.
44. Ram, B. (2005). Estimation of genetic parameters in different environments and their implications in sugarcane breeding. In. J. Genet. 52(2): 192-98.
45. Dos Santos Silva, PP, M. Soussa and E.J. De Oliveira (2019). Prediction models and selection of agronomic and physiological traits for tolerance to water deficit in cassava. Euphytica 215(4):73.
46. Ebid, M.H.M., H.A. Khalil, A.M. Abd-ElAal and M.A. Fergany (2015). Heritability and genotypic and phenotypic correlations among sugarcane yield and some agronomic traits. Egypt L Plant Breed: 19(1): 159-71.
47. Fartek, B., S. Nibouche, T. Atiama-Nurbel, B. Reynaud and L. Costet (2014). Genotypic variability of sugarcane resistance to aphid *Melana-phissacchari*, vector of the Sugarcane Yellow Leaf Virus. Plant Breed. 133(6): 771-6.
48. Teklu, D.H., S.A. Kebede and D.E. Gebremichael (2014). Assessment of genetic variability, genetic advance, correlation and path analysis for morphological traits in sesame genotypes. As. J. Agric. Res. 8(4): 181-94.
49. Nair, N.V., K.G. Somarajan and Baasundaram (1980). Genetic variability, heritability and genetic advance in *Saccharum officinarum*. Int. Sugar J. 82(981): 275-6.
50. Singh, G.P., K.R. Maurya, B. Prasad and A.K. Singh (1994). Genetic variability in *Capsicum annum* L. J. Appl. Biol. 4: 19-22.
51. Vidya, KL, S.K. Oommen and K. Vijayaraghava (2002). Genetic variability and heritability of yield and related characters in yard-long bean. J. Trop. Agric. 40: 11-3.
52. Butterfield, M.K. and K.J. Nuss (2002). Prospects for new varieties in the medium to long term: The effects of current and future breeding strategy on variety characteristics. In: Proceed. S. Afric. Sugar Ind. Agron. Assoc., Kwa-Shukela: 41-8.
53. Shoba, D., N. Manivannan, P. Vindhiyavarman (2009). studies on variability, heritability and genetic advance in groundnut (*Arachis hypogea* L). Electron. J. Plant Breed. 1(1): 74-7.
54. Bakshi, R. (2005). Estimation of genetic parameters in different environments and their implications in sugarcane breeding. Indian J. Gen. 65(3): 219-20.
55. Béhou YM, Péné CB, 2020b. Genetic variability and heritability among sugarcane genotypes observed at early stage of the advanced selection for some agronomic traits in Ferké, Northern Ivory Coast. Agric. Sci. 2(1): 83-94.
56. Pandey, R.A. (1989). Variability study in the hybrid progenies of sugarcane (*Saccharumcomplex*). Bharatiya Sugar: 49-51.
57. Patel, MM, H.S. Patel, A.D. Patel and M.P. Patel (2008). Correlation and path analysis in sugarcane. Ind. Sugar 31: 911-14.
58. Tefera, A, A. Sentayehu, T. Leta (2017). Genetic variability, heritability and genetic advance for yield and its related traits in rainfed lowland rice (*Oriza sativa* L) genotypes at Fogera and Pawe, Ethiopia. Adv. Crop Sci. Technol. 5(2): 1000272.

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Identification of Functional Foods and Factors Influencing their Consumption in Port Loko District Northern Sierra Leone

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Abstract- Functional foods are foods that we eat daily and are found in market. The attitude towards limited because of poverty, traditional/religious believe, taboos, illness. Most of these foods are grow in the area of study, but because of poor processing, poor handling harvesting, preservation there are lots of wastages when these foods are in season as there is no know how of low to presence then, and there is a problem of proper handling of these foods due to poor road network and transportation, most of these foods weltered before they reach the final consumer and most of the nutrient find in these foods what have perished, people in this community farm, rear cattle, fishing but do not eat, then, prefer selling them to buy other basic Needs, all these factor contribute to nutritional deficiency which lead to ill health. Functional roads found in this community provides energy, body building, and protect the body from diseases. They have been. It was recommended that the government through the ministry of Agriculture provide resources like staff loans or farmer, fishermen, market sellers, cattle rarer etc, organize workshops, sameness, focus group discussion, Radio bud television talks shows, about the essence of eating functional foods and to deviate from certain believes and taboos about these foods.

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Identification of Functional Foods and Factors Influencing their Consumption in Port Loko District Northern Sierra Leone

Sylvia Kercher Bangura

Abstract- Functional foods are foods that we eat daily and are found in market. The attitude towards limited because of poverty, traditional/religious believe, taboos, illness. Most of these foods are grow in the area of study, but because of poor processing, poor handling harvesting, preservation there are lots of wastages when these foods are in season as there is no know how of low to presence then, and there is a problem of proper handling of these foods due to poor road network and transportation, most of these foods weltered before they reach the final consumer and most of the nutrient find in these foods what have perished, people in this community farm, rear cattle, fishing but do not eat, then, prefer selling them to buy other basic Needs, all these factor contribute to nutritional deficiency which lead to ill health. Functional roads found in this community provides energy, body building, and protect the body from diseases. They have been. It was recommended that the government through the ministry of Agriculture provide resources like staff loans or farmer, fishermen, market sellers, cattle rarer etc, organize workshops, sameness, focus group discussion, Radio bud television talks shows, about the essence of eating functional foods and to deviate from certain believes and taboos about these foods

- Nutritionist to give health talks at health clinics/health post
- Governments to build market stalls and lay emphasises on the seller of fresh, clean and quality body available foods in the market.

I. Introduction

Functional foods is a relatively new term used to describe food product which have been enrich with Natural substances/component with specific physiological effect. For the prevention and for health promoting effect (– www open. Access. pub org).

All foods eaten are regarded as functional foods because they all provide taste aroma, and has some amount of nutritive value, functional food can be defined as every modified food provide health benefit beyond the traditional nutrient it contains (National Academy of science food and Nutrition). The study is carried out in the Northern region of Port Look District. The following were interview by the researcher as they are fully involving in the producing these functional foods…farmers/gardeners ten (10) fishermen/fish mongers (!0) cattle readers/poultry (10) market sellers (10). A total of 50 respondents were involve in this research. The concept of functional foods originated from Japan in 1980 when the Government agencies slated the approval of food with proven benefit in an effort to better the health of the general population (trusted source 1) functional foods are foods that offers health benefits that extends beyond their nutritional values they also promote health and prevent & Nutritional deficiencies which led to most thermal cases like cancer of Lungs, , fallopian tube other childhood nutritional diseases like kwashiorkor or, marasmus, scabies, anaemia, complicated labour, haemorrhage, functional , etc. The basic functional is to supply nutrient to the body foods are not eaten only to prevent hunger but provide energy, physical mental wellbeing of individuals. Functional foods are bioactive compound which can occur naturally from doing industrial processing where by other sources are added such as phytochemicals eg vitamins/peptide/ polyphenol the compound, carotenoid and is of lavine which provide health benefit such as development, growth and regulations of metabolic process defence against oxidative stress, (card wvascalai and gastrointestinal physiology and physical and cognition performance (Ra of a ella bogie etal 2020.}

Examples of functional foods include modified foods, conventional foods. fortified foods with vitamins and probiotics or fibres nutrient – riels ingredients like fruits ,nuts, , vegetables seeds and grains are often considered functional foods as well oats ,, fibres called beta, glycan which help reduced inflammation and its enhance immune function ad improve heart health (trusted source).

Functional foods can be divided into two modified functional

II. Conventional Foods

Example of conventional Foods

- *Fruits* – apples, oranges, bananas, lime, , lemon, sour lime grape fruits , pear
- *Nuts* – cashew nuts., groundnuts coconut
- *Seeds* – pumpkin seeds, Bennie seeds, Ogosie seeds, cucumber seed

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- *Legumes* – Broad beaus, black eye beans, cashew beans, lentils, say beans
- *Whole grains* – Oats, brown rice, rough rice, parboiled rice, millet, barley
- *See foods* – Salmon, bongo herring, mackerel,
- *Herbs and spice* – ginger, garlic, onions, pepper, simigie turmeric…
- *Beverage* – Coffee, tea leaf, tea bush, black tea lemon grass.

a) *Modified functional foods*

- *Fortified juices* – Orange juice, grape fruit juice, lemon juice, mango juice tangerine juice, apple juice, carrot juice, black velvet juice, coconut juice

Fortified diary product, sour milk sweet milk., yogurt, ice creams.

Fortified milk alternative a rice, coconut cashew milk.

Fortified grains, rice cake, rice/flour bread pasta, macaroni, rice sticks

Fortified eggs – eggs of birds origin

These functional foods listed above have the potential benefit to prevent nutrient or diet related diseases. The introduction of fortified food has decreased diet related diseases. Such as rickets, goitre, birth defect (trusted source)

b) *Functional foods promote growth and development*

Nutrient are essential for the proper growth and development especially in infants, it is very important for humans or every stage of development for our diet to include. Nutritional needs according to their health status. All functional foods can either have any of the following food groups. body building foods, protective foods and energy giving foods. Which help the individual to stay healthy rice is our staple food and it is eaten with either source (vegetables leaves soup with either meat, fish or any other see foods its provides quality, taste and flavours which enhance appetite.

The soup source is prepared with either vegetable oil, soybean oil, palm cannel oil, corn oil which contain high oxidative stability with high oxidative capacity with green vegetables like garden eggs. better balls. onions, fish. chicken, meat,

Probiotics have the following effect on health.

- Actions on the immune system
- Antihumoial and help the protective actions
- Prevented diarrhoea caused by rota vines, clostridium
- Balanced of intestinal micro flow energy, protect from illness or diseases and the repair one out tissues, these functional foods are rich in omega father acids, iron, zines, calcium and vitamin B12, folic acid vitamins and minerals. All these give support to the overall growth and development and a send health in

The prevalence of nutrient deficiencies is gradually decreasing in the Port Loko as there are sensitization at both antenatal clinic and post-natal clinics at all peripheral Health unit and community Health post and Government Hospitals, displays of such foods are sometimes carried out during Nutrition health talks as demonstration and food corner were foods are displayed. People are becoming conscious with the advent of covid 19, were, food stores were closed and were locked down. most houses has back yard, these foods were utilize and help greatly. As now local markets are selling these food stuff.

In this community when fruits and vegetables are in season there is always a wastage of them as there is few or no knowledge about the preserving of these foods. Therefore, they are only available when they are in season. The processing of some of these foods are done locally and there is small or no hygiene in handily processing and consumption of the food. Therefore, foods withered or become more infected and become unfit for human consumption and become prone to health hazards, eg E.coli, diarrhoea, worm infestation, vomiting, foods or compose of all biologically active components that have the potential to optimize their physical and mental wellbeing and which in the long run help prevent chronic disease. These foods contain minerals, vitamins and probiotics that balanced the diet which provide the body with all nutrients its needs people are now embarking on farming, fishing cattle or poultry rearing and business of its benefits, accessibility, affordability of these product. (functional foods related news)

III. Statement of the Problem

Functional foods are foods that will eat in other to promote growth and development and to prevent diet related diseases. In the community foods that should be eaten to promote growth and development and present diet related diseases are net known and even with the little they know as foods are seldomly only eaten because of traditional religious believes, Taboos, Societal norms. Certain aliment illness unknown functional in the Region, dislikes allergies.

There is also a problem of processing preservation, handling transportation and good storage of these foods and therefore when most of the foods are in season, they are wasted and one could not get access to them throughout the year.

- There are no factories even modified their foods so that they can be used all round the year or even when out of season

The prevalence of diet related diseases especially moneys in fact and adults, pregnant women and lactating mothers are due to etc factors stated above. The researcher has tough it if to identify functional foods and und solution for proper harvesting,

handling, processing, preservation, transportation of consumption of foods

IV. Aims and Objectives

Aim – The aim of this research is to identify the functional foods and factors influencing the consumption of these foods in Port Loko, Northern Sierra Leone.

Objective –

The objectives of these studies are as follows:

i. To identify the different types of functional foods
ii. To find out factors that limit the consumption of these foods
iii. To raise awareness in the community about the benefits and medicinal values in the consumption of functional foods
iv. To suggest or recommend on the consumption of these foods to the Government and other NGO dealing with agriculture and nutrition

V. Methodology

The research was carried out in Port Loko District Northern Sierra Leone. The targeted group comprises of fifty (50) respondents. farmers/gardeners (10) fishermen/fish mongers/ (10) cattle/poultry rears /market sellers Transporters (10). It composes of both male and female who provided the necessary information about the different functional groups and how often it is consume.

VI. Analysis of Data Collection

The chapter deals with the analysis of data gathered from verbal interview, through focus group discussion with a guided questionnaire, Both quantitative and qualitative analysis of the research was carried out. With these research.

Table 1: Occupation of Respondent and Sex

No.	Occupaation	Male		Female	
		NO	%	NO	%
1	Farmers/gardener	6	60	4	40
2	Fish mongers/fishermen	7	80	3	30
3	Cattle rearers/poultry	8	80	2	20
4	Market sellers/consumers	4	40	6	60
5	Transporters	8	80	2	20

The table above shows the respondent interview and their sex, farmers 60% male 40% female, fish mangoes fishermen 70% male 30% female, cattle rears/poultry 80% male and 20% female, market sellers/consumers 40% male, 60% female transports 80% males and 20% farmers.

These functional foods help in the repair of worm out tissues. Cattle/poultry rears – They rear and sell cattle's and poultry products to market sellers who in turn sell to consumers. All edibles animals cow, pig, monkey, snakes, goat, sheep etc chicken, birds and their products like eggs

Farmers – With farmers there are low scale farmers and high of grade farms and

Sources – Grain, millet, barley, beans, groundnut, plantation (oranges, mangoes, grapes, cheshwenut water melon, pineapple, rears, bananas, grapes etc

Fishermen/ - They do deep fishing. All type of sea foods – tortoises. All type of fish, snails shipe.

Market seller – They do both whole sales and retails of goods brought from the farms its can be any of the functional food groups. Conventional/modified medicinal.

VII. Classification of Functional Foods

Conventional foods - These are foods that contain Natural probiotics substance such as:

Fruit – apples, mangoes, bananas, grapes lemon, sweat sharp, sour lime pears, paw-paw, oranges, water melon, guava, pineapple, cucumber, seed tomatoes …., potatoes leaves, garden eggs, better balls, pumpkin, cabbage, mushrooms, potatoes

Nuts – Cashew nut, groundnuts, cocoanuts, palm-kernel nuts, cocoanuts

Seeds – Pumpkin seeds, cucumber seeds Bennie seeds Ogosi seeds, groundnut, paw-paw seeds, orange seeds corn pumpkin seeds

Legumes - Bread beans, black eye beans, lentils, soy beans, cashew.

Whole grains – Funday, rough rice, parboiled rice, millet, surgeon, brown rice, Gari, barley.

Seafood's – Salmon, bongo, snapper tortoise, shrimps, cuta, herring, snails, crabs,

Animal/birds origin – Flesh of cow, pig, goat, sheep, freetownbo, monkey, chicken, turkey, snakes, frogs.

II Fermented foods –

Herbs and spices – Onions, garlic, simigie pepper, turmeric, ginger

Beverage – Coffee, Tea leafs, tea bush, lemon grass, black velvet, Moraga, mango leaves.

Tables 2: Level of Understanding on the Information Provided by Respondent on Functional Foods

	Low	Medium		High			
NO.		No	%	No	%	No	%
1	Farmers/grandees	6	60	3	30	1	10
2	Fishermen/fish monger	7	70	2	20	1	10
3	Cattle rearers/poultry	7	70	30	30	0	0
4	Transporters	7	70	3	30	0	0
5	Market seller	5	50	30	30	2q	20

The knowledge of understanding about the information provided by respondent were as follows farmers 70% of fishermen/cattle rearer /transporters are low, whole 60% farmers, 50% of market sellers name cow, 30% farmers, fishermen, cattle rears, transporters and market sellers has a medium level of understanding and only 20% fish sellers an average of 10% high for farmers, fisher men

VIII. Nutrient Found in Functional Foods and their Sources

Mineral/include vitamins irons, etc. they are fund in the following foods meat, cereal grain, fish milk and dairy product, cabbage, carrot ground Nuts.

Fats and oil – Cocoanut oil, butter, filthy meats, vegetable oil, palm oil, palm kennel nut oil beef, lands, pork, corned

Fats and oil makes up the major classes of food soybean oil, sunflower oil, olive oil, mustard seeds/functional foods also provide energy.

Carbohydrate - rice, bulgur, barely, millet, cassava, potatoes, yams, foo. These provides energy for the body.

Proteins - fish, salmon, crab, ouster, shrimps, herring, bongo tortoise.

Attitude and culture – The attitude and culture plays an important aspect in the complication of foods, culture interferes with the consumers wants and behaviour as there are set of rules and behaviour binding some of these foods and is varies from Region to region and tribe to tribe. traditional, Religious, taboos are said to inter facing in the consumption of foods that are nutritive and medicinal that are of important

Table 3: Factors That Forbid the Consumption of Functional Foods

NO.		NO	%
1	Traditional believes	10	20
2	Religious believes	08	16
3	Taboos	10	20
4	Societal norms	05	10
5	Allergy	05	10
6	Poverty	12	24
	Total	50	100

According to the table above traditional believes and taboos 20 %., societal norms and allergy 10%, religious believes 16%. have been cause of people not eating these functional foods.

24%. Poverty. Poverty is the leading factors for all these problems of people not consuming these foods. if one is rich and has an allergy with one food he or she can go in search for another religious, etc.

IX. Medicinal Foods and what they Treat/Prevent

Turmeric-Reducing inflammation and tendency of cancer

- Honey Best for healing. digestive trouble, by decreasing intestines obstructions
- Eggs- Enhance recovery and wound healing
- Apple-/ vinegar –Best for burning fats and harmful blood lipids
- Paw paw---prevent constipation
- Green vegetables – eg potatoes leaves, greens, cassava leaves, increase blood, prevent anaemia
- Sweet potatoes –Good for weight loss
- Fruits –oranges, - lemon, good for healing process and prevent common cold and cough

Fatty fish - salmon, herring and fight inflamation9 contain omega 3 fatty acid which prevent heart diseases

- spices eg --- ginger, onions, help reduce inflammation and lower disease
- Green tea ---eg simigie lemon grass, Reducing inflammation and lower disease risk

Nuts seeds - good source of protein and help to protect the body and build worn out tissues

Honey and lime - treatment of cough and cold

Hibiscus tea - prevent high blood pressure

Ginger - treat menstruation cramps

Seed tomatoes - prevent the risk of prostate glands
Okra increase blood and prevent anaemia

Beans - lower blood sugar

Palm oil - prevent anaemia

Palm kennel nut - treatment of burns

Mangoes - lowering of blood sugar

X. Conclusion and Recommendations

a) Conclusions

Functional foods are essential in the prevention of diseases it is important bin our daily living as its provides the body with growth and development, prevent nutrient deficiencies and protect the body against disease, most of the consumer purchase their foods. There is low yield production due to poor machinery, techniques; poverty is the leading factor of consumers not eating functional foods, They prefer to sell them to others for them to buy their basic needs for the family, religious; traditional, taboos, allergy societal norms and an overall positive altitude should be reinforced in other to influence through support these people in these community to eat functional foods

b) Recommendations

The researcher wishes to recommend the following

The government through the ministry of Agriculture and food security to provide soft loan, machinery, seeds tractor, fertilizers for farmers, fishing boats, fishing 8nets for fisher men; young cattle's poultry, market stalls for service provider.

Ministry of agriculture and nutrition directorate to conduct workshops seminars, and other training relating to functional foods.

Nutritionist to conduct health talks through radio, television, news health corners, at ante natal clinic and post-natal clinics, including outpatient. On the impotent of consuming functional foods

Government to provide factories for processing foods so that these foods will be available throughout the year

References Références Referencias

1. Clara m. Hasier – functional foods, benefits, concerns, challenge (A position paper from America council on science and Health
2. Kris Gurnard – Delicious Hugh protein foods (medically reviewed by all am arson BSc phd.
3. Racheal links MS RD Jamey 2020 – medically reviewed
4. Lath eenmilik – consumption of functional food.
5. Shiu-Yuan 2 hang etal 2018
6. Medicinal mushrooms source direct. Com
7. Racheal Links MS 2020---medically reviewed
8. Nat alle Butter(PD)Foods with power

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Climate Change and Variability Impacts on Crop Productivity and its Risk in Southern Ethiopia

By Genene T. Mekonnen & Lacha Garuma
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Abstract- Climate change and variability coupled with weak utilization of agricultural technologies led to lower agricultural production and productivity in southern Ethiopia. Climate change mainly increases temperature, change of rainfall pattern, precipitation and its short and long-term variability affects agricultural production and productivity. Given the technological and institutional conditions, in southern Ethiopia, the yield of major crops has not shown significant change in productivity over the years. Based on time series, and secondary data, this research aimed to address the crop productivity trend and the likely impact of climate change and variability on crop productivity. The study covered Sidama, Walaita, Gurage, Hadiya, Gamo Gofa, and Halaba. Time series climatological and secondary data of major crop yields used as data sets. Mean difference tests to show the trends, and stochastic production function to analyze the likely impacts of climate change on crop yield were employed. The seasonal rainfall differences posed a negative impact on the mean yield of maize and wheat whilst a positive effect on other cereals, common bean, taro, sweet potato, coffee, and red pepper.

Keywords: *climate change, climate variability, productivity trend, impact, risks.*

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Genene T. Mekonnen [α] & Lacha Garuma [σ]

Abstract- Climate change and variability coupled with weak utilization of agricultural technologies led to lower agricultural production and productivity in southern Ethiopia. Climate change mainly increases temperature, change of rainfall pattern, precipitation and its short and long-term variability affects agricultural production and productivity. Given the technological and institutional conditions, in southern Ethiopia, the yield of major crops has not shown significant change in productivity over the years. Based on time series, and secondary data, this research aimed to address the crop productivity trend and the likely impact of climate change and variability on crop productivity. The study covered Sidama, Walaita, Gurage, Hadiya, Gamo Gofa, and Halaba. Time series climatological and secondary data of major crop yields used as data sets. Mean difference tests to show the trends, and stochastic production function to analyze the likely impacts of climate change on crop yield were employed. The seasonal rainfall differences posed a negative impact on the mean yield of maize and wheat whilst a positive effect on other cereals, common bean, taro, sweet potato, coffee, and red pepper. On the other hand, the annual average temperature imposed a positive effect on cereals, root crops, and coffee. The stochastic production function revealed rainfall variability and change in temperature on mean yield showed a positive and statistically significant effect. The climate variability showed an increasing trend posing a positive and negative impact on crop yield. To cope up the climate change and its variability, different adaptation, and resilience-building strategies should be plan, and site-specific actions should be implemented to manage the risks and vulnerability associated with climate change.

Keywords: climate change, climate variability, productivity trend, impact, risks.

I. Introduction

The key source and means of livelihood of most Ethiopians is agriculture. Though agriculture remains the most important sector in the Ethiopian economy, the contribution to speeding up its overall socio-economic development is becoming less and less. Declining land productivity and crop yield resulted from farm size fragmentation coupled with high population growth; subsistence farming with weak agricultural technologies and extension service; land degradation problems; inappropriate policies, and the prevailing climate change and its variability are the prime challenges facing the agricultural sector (Temesgen & Hassan, 2009, Welde gebriel and Prowse, 2013).

The agricultural system of Ethiopia is known as a subsistence mixed farming system comprising of crop and livestock farming with a low supply of agricultural technologies and extension services (Belete *et al*., 1991). In a mixed farming system, the farming community in rural and peri-urban areas practiced cultivation of crops, rearing of livestock, exploiting of the natural resource endowments, and few of them involved in off-farm and non-farm income-generating activities for their livelihood. The choice for crop production explicitly depends on the agro ecological conditions of the area, such as soil type, moisture availability, agro climatic conditions, institutional accessibility, and socio-demographic conditions. Akin to crop production, agro-climatic conditions such as rainfall, temperature, and humidity are deterministic factors for livestock production.

The natural environment in which the human being is living and the overall socio-economic development is affected by climate. Climate is a long-term summary of weather conditions, taking accounts of the average conditions and their variability(IPCC, 2007). The long-term variability of weather conditions over time and space is climate change. The variability in weather conditions includes the change in temperature, rainfall pattern and precipitation. Climate change is an emerging global challenge in the 21st century that explicitly affects the socio-economic development of nations in which Ethiopia is the one that has been adversely affected. In Ethiopia it has imposed some adverse impacts on the agriculture exacerbating the food insecurity problem of the country (Weldegebriel and Prowse, 2013). The climate change adverse effects in developing countries are more drastic than in developed countries because of the fact that developing countries' population depends on agriculture for their livelihood, have limited capacity to adapt, and mitigate the changes and have a high poverty level(Pereira, 2017;Sejian, 2013). It has a substantial impact on agricultural production of both crop and livestock productivity and aggravates the poverty level of countries of which developing countries, including Ethiopia, are severely affected (Shumetie *et al*., 2017). In the climate variability, there is severe moisture stress, drought, rainfall patterns variability, atmospheric

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temperature change, high sunshine intensity, and low precipitation affecting agricultural productivity.

The change in climate variability posed crop loss, livestock productivity decline, pest infestation, disease outbreak on livestock and crops, human displacement, life loss, and an overall socio-economic disturbance and tension of the entire society. To reduce and mitigate the negative impact of climate change and variability, countries adopt and implement various climate abating mechanisms. Unless the negative impact of climate change is abated through adaptation mechanisms, the damage it posed increases with time increment(Pereira, 2017;Temesgen &Hassan, 2009).

In the South Nation Nationalities and Peoples' Region (SNNPR), climate variability, mainly rainfall pattern, temperature, and relative humidity have affected agricultural productivity, mainly crop production. For the last two decades, i.e., 1994 to 2017, climatological data in rainfall, temperature, and relative humidity obtained from the weather stations of the central zones of SNNPR showed different patterns responding differently to crop production. The crop production data obtained from the Central Statistical Agency (CSA) of Ethiopia in cereals, pulses, root crops, and coffee showed different productivity trends.

Given the agricultural technologies availability, extension services, input availability, high market price for food grains, and the policy environment functioning in the region, the agricultural yield of the major crops have not shown significant change over the years. Based on a review of literature, secondary data obtained from CSA, and time series climatological data of the National Meteorological Service Agency (NMSA), this paper tries to address and synthesized the crop productivity trend and the likely impacts of climate variability on crop production. The in-depth empirical analysis of climate change on agriculture and its simulation on crop yield and productivity is out of the scope of this paper that need further empirical research.

II. Literature Review

a) Climate Change and Variability

Climate change in Intergovernmental Panel on Climate Change (IPCC) usage refers to a change in the state of the climate that can be identify by changes in the mean and the variability of its properties that persists for an extended period, typically decades or longer period (IPCC, 2007). IPCC further defined climate change as any change in climate over time, whether due to natural variability or human activity. Climate change may be due to natural internal processes or external forcing or to persistent anthropogenic changes in the composition of the atmosphere or land use(IPCC, 2012). Other scholars define climate change as a process of global warming, in part attributable to the 'greenhouse gases' generated by human activities and the likely changes are both global such as rising sea levels attributable to ice -melt and local such as changes in rainfall patterns (Slateret al., 2007). It is also define as the fluctuations in the patterns of climate over long periods(Ngaira, 2007).

Plausible climate change scenarios include higher temperature, change in precipitation, and higher atmospheric CO_2 concentrations (Adamset al., 1998). On the other hand, the greenhouse gases such as carbon-di-oxide (CO_2) lead to changes in climate conditions such as a change in temperature, precipitation, soil moisture, and sea levels (Kelbore, 2013). If the changes in climate parameters such as a change in temperature, precipitations, sea levels, and soil moisture show year-to-year variations or cyclical trends, it is known as climate variability (IPCC, 2007).Weather is the set of meteorological conditions such as temperature, rainfall, wind, humidity, sunshine intensity, snow, and others observed at a particular time and place. Usually, the weather condition of a specific place at a specified period recorded in meteorological stations. The climate, on the contrary, describes the long-period summary of weather conditions taking account of the average as well as the variability of the climatic conditions experienced at a place (IPCC, 2007). The fluctuations that occurred from year to year and the statistics of extreme conditions such as storms, floods, rise in temperature, and any other extreme weather conditions are consider as part of climate variability (ibid).

b) Impacts of Climate Change on Agriculture

Globally, climate change and variability become debating issues and political agendas of both developed and developing countries. Climate change and fluctuation have become a global and real issue (Ngaira, 2007), affecting billions of people, including the natural environment. The presence of people, livelihoods, environmental services and resources, infrastructure, or economic, social or cultural assets in places can be exposed and could be adversely affected by climate change (IPCC, 2012). It causes wide-ranging impacts and effects on the natural and environmental resources, ecology, human and animal health and socioeconomic status of citizens of every country.

The change in climate parameters such as a change in temperature, precipitation, or rainfall patterns affects crop yield and productivity. Although temperature increase has both positive and negative effects on crop yield, it has adverse effects in reducing yield and quality (Adams et al., 1998). Temperature increase leads to higher respiration rates, shortens the period of seed formation and grain filling period, lowers biomass production, and finally reduces the required crop yield or its productivity. Equally important, the change in temperature also has imposed a negative impact on livestock production. It lowers forage

production which limits feed supply to animals (Adams et al., 1998); change in temperature, specially heat stress, adversely affects the livestock production and threatens the survival of animals (Sejian, 2013).

Agricultural activities, mainly crop, and livestock productivity, is primarily dependent on climate (Adams et al., 1998). Climate change has imposed a negative impact on the agriculture, affecting crop and livestock production (Pereira, 2017). The possible physical and economic effects of climate change on agriculture are changes in crop and livestock yields as well as the economic consequences resulted from these potential yield changes (Adams et al., 1998). Increased temperature, precipitation, erratic rainfall, recurrent drought, flooding, and frost are the main climatic variables affecting agricultural activities. As witnessed from Ethiopian Central statistical Agency, climate-related events such as drought, excessive rainfall, high temperature, frost, etc. affect specific crop yields negatively and to different degrees (Berger *et al*., 2017).

Climate change influences crop and animal production, hydrologic balances, input supplies, and other components of the economy(Adams *et al*., 1998). Moreover, climate change has adverse impacts on plant and animal health (Pereira, 2017); it creates negative pressure on crops and livestock by aggravating pest, weeds, and disease infestation; it entails series damage on crop production and productivity (Shumetie et al., 2017); it reduces net crop revenue per unit area during summer and winter season (Temesgen & Hassan, 2009). A study made in Nigeria by Ngaira (2007) reported that reduced agricultural land use, increased aridity, increased incidences of farm pests and diseases, over-cultivation including marginalized land, food insecurity, and poverty are some of the effects of climate change occurring in Africa.

The major climate attributes such as the rise in temperature, the change in frequency and intensity of precipitation, the increase in the level of CO_2 available for photosynthesis have direct impact on agricultural productivity (Nastiset al., 2012). High soil and atmospheric temperature, low rainfall or precipitation, and high level of CO_2 result in severe drought occurrence that lowers agricultural productivity, which ultimately affects the farming community whose livelihood and employment directly depend on agriculture. As the farming community is adversely affected by climate change and variability, the food supply to the market, raw material requirement of agro industry, foreign exchange earnings, and other income-generating activities gained from the sector will be dramatically affected negatively, which ultimately impose significant loss to the entire economy of a given country.

c) Risks of Climate change and Variability on Agriculture

Agricultural production variability is a main risk that is manifested in loss of crop yield and reduction of livestock, deterioration of product quality, and dramatic change of market price in crop and livestock products. The major sources of production risks in agriculture are variation in complex weather conditions such as erratic and variable rainfall, rise in temperature, change in humidity and precipitation patterns; pests and disease occurrence; application of outdated technology and practices; inefficiency of farm machinery and low quality of agricultural inputs. At the same time, marketing, financial, human resource risk caused by improper operation and application of production systems, and legal risks caused by inappropriate rule and policy are important sources that need focuses in managing and mitigating the consequences in agricultural production. Ethiopia is frequently reported as the most vulnerable country in climate change and variability risks imposed on its rain-fed and subsistence agriculture (Tessema and Simane, 2019). It has imposed adverse effects on the agricultural sector (Weldegebriel and Prowse, 2013); smallholder farmers are highly vulnerable to climate change and variability ((Tessema and Simane, 2019) resulted in low agricultural production and consequently in food insecurity. All the climate change and variability attributes have imposed deterministic effects in crop and livestock production in lowering the amount produced and the expected quality.

Sub-Saharan African countries including Ethiopia are experienced by climate change and variability mainly by the rise in mean temperature and erratic rainfall. The climate change and variability risks have resulted in the occurrence of frequent drought, floods, pests and disease, and other risk extremes (Weldegebriel and Prowse, 2013). On the other hand, the heavy dependency of the economy on subsistence and undeveloped agriculture; low level of transfer, and adoption of improved agricultural technologies and practices have exposed the farming community to a high level of vulnerability and risk (Tessema and Simane, 2019). African countries including Ethiopia are more exposed to the risks of climate change and variability not only to their exposure to climate change but also due to the lack of their capacity to respond or adapt to the impacts of climate change (Berger *et al*, 2017).

d) Adaptation and Mitigation of Climate Change

Adaptation measures and mitigation of climate change are vital in countries whose economy is dependent on rain-fed type of agriculture ((Weldegebriel and Prowse, 2013). Climate change is not only the determinant of agriculture, but on the contrary, agriculture is also one of the drivers for climate change. Countries whose economy largely depends on

agriculture are more vulnerable to climate change risks. To overcome the short and long-run climate risks, countries stand differently. For example, Ethiopia stands 7th among the first ten worst performing countries to climate change risk in 2015, next to the four severely attacked African countries, namely Sierra Leone, South Sudan, Nigeria, and Chad (Maplecroft, 2015). The vulnerability in Ethiopia and other African countries emanates from the underdeveloped agricultural system and low level of economic development. The susceptibility in African's agriculture to climate change is high due to the facts that its agriculture system is commonly rain-fed and underdeveloped with low technological inputs, majority of African farmers are small-scale farmers or at subsistence level with few financial resources, limited access to infrastructure, and information (Pereira, 2017).

Climate change and variability impacts and effects differ from nation to nation *(Shumetie* et al., 2017). In those countries whose livelihood and employment directly depend on agriculture, the effects, and impacts of climate change and variability are much more drastic than the developed countries whose economy is largely dependent on other sectors (Sejian, 2013). To overcome such vulnerability and climate change risk on agriculture and socio-economic development of countries, different coping mechanisms and adaptation strategies have been implemented. Ethiopia, including the SNNPR has implemented community-based watershed development as a green economy strategy to rehabilitate, conserve and protect the land resources (MoARD, 2005). Since 2011, SNNPR in implementing community-based participatory watershed development, farm-level soil and water conservation (terracing, contouring, bunds), communal land rehabilitation and conservation, agro forestry practices, on-farm agricultural technologies introduction and adaptation (improved crop varieties, livestock breeds, management practices), the introduction of off-farm and non-farm income generating schemes as climate adaptation strategies to cope with climate changes(SARI, 2018).

Climate adaptation to overcome or mitigate the short-run climate variability and extreme weather or climate events (climate extremes) can serve as the basis for reducing the vulnerability of long-term climate change (IPCC, 2012). In the agricultural sector, switching towards using improved crop varieties, agronomic and plant protection practices, use of improved animal species, diversifying crop types and animal species, use of animal husbandry practices, use of irrigation, access to financial resources, market and agro-climatic information are climate adaptation strategies that the farming communities should practice and implement (Weldegebriel & Prowse, 2017). In SNNPR, productive safety net program (PSNP) has introduced as a climate-change adaptation strategy as livelihood diversification for food-insecure, poor households (ibid). From a policy perspective, the government should consider and respond to the likely impacts of climate change on the economy as a whole and the agriculture sector in particular. Responding to climate variability sooner, incorporating agricultural practices into mitigation policies, strengthening research and development (R&D) to enable the farming community livelihoods to be more resilient are some of the measures that need to be considered by policymakers (Slater et al., 2007).

III. Research Methodology

a) *Geographical and Socioeconomic Description*

The Southern Nations, Nationalities, and Peoples' Region located in the south and south-western part. Geographically it is situated between the coordinates of 4^0 27'' to $8^0$30''N, and 34^0 21''to 39^0 11''E with altitude ranging from 376 to 4207 m asl and with mean annual temperature from 15^0c to 30^0c. It covers a total area of 110931.9 km^2 divided into 17 zones.

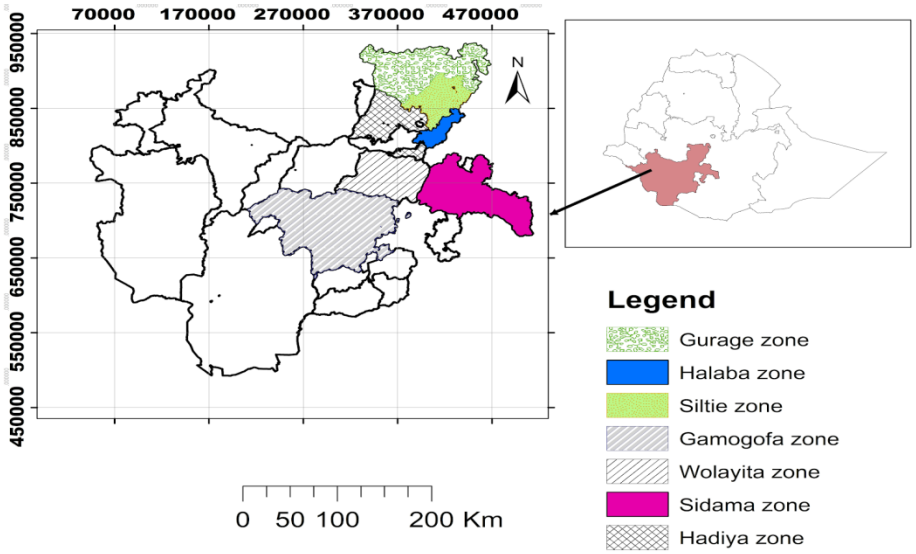

Fig. 1: Geographical location of the study areas

The study covered the central areas of the southern Ethiopia, namely Sidama, Walaita, Gurage, Hadiya, GamoGofa, and Halaba where there arehigh agricultural activities mainly crop production. Theseareas are known for their high population density, andtheir main livelihood is derived from agriculture, mainly from crop production. The area covered by crops in central zones of SNNPR is estimated to be 50.7% of the total regional cropland of which Sidama, Gurage, Waliata, Hadiya, GamoGofa, and Halaba accounts for 6.91%, 9.87%, 6.49%, 10.84%, 12.94% and 3.65% of the regional total respectively (CSA, 2017).

b) Data Type and its Source

The data from CSA's annual rainy season agricultural sample survey report and climatological time series data collected from weather stations of NMSA. The secondary data obtained from CSA includes the private peasant holding the main season area and production of major crops. Time series data from NMSA comprises the seasonal (*Kiremt*[1], *Bega*[2] *and Belg*[3]) and annual rainfall, the temperature of the nearby weather stations located in central zones of SNNPR.

c) Crop Yield Data

Area, crop yield, and crop yield per unit area of major cereals, pulses, root crops, coffee, and red pepper were taken for this study. For this study, only crop productivity for 12 crop types, namely maize, *tef*, wheat, barley, sorghum, finger millet, faba bean, common bean, sweet potato, taro, coffee, and red pepper was considered for the years 1998 to 2017. Due to the missed data reported in CSA's sample survey, the yield data for some crops, for example, sorghum and finger millet, were not available for 1998 to 2004, and yield data for sweet potato, taro, coffee, and red pepper for the years 1998 to 2001 was not included.

d) Climate Data

A time series rainfall data for *belg*, *kirmet* and *bega seasons* and annual total rainfall collected from NMSA. The rainfall data of all six stations, including rainfall and annual total rainfall computed for 1994 to 2017, was organized and tabulated into two periods (Annex Table 1). For simplicity, the seasonal and total rainfall amount is convert to the natural logarithm (ln). Similarly, the average minimum, maximum and average temperature value for 1994 to 2017 was taken from the weather stations and organized into two periods (see annex table 2).

e) The Econometric Model

The impact of climate change and variability on crop yield was analyzed using a stochastic production function developed by Just & Pope (1979). In the model, the dependent variables specified were the mean and variance of the yield of crops. The independent variables included were the average seasonal rainfall and annual average temperature for over 19 years for maize, *tef*, wheat, barley, faba bean, and common bean yield. For the root crops and coffee, 15 and for red pepper 14years considered. The production function allowed the effect and impacts of climate element on the mean yield of the major crops, and the variability of the yield of each crop were measured by the variance. The estimation was done based on the maximum likelihood estimation procedure.

[1] Kiremt is the Ethiopian local language term indicating 'main rains' season stays from June to September

[2] Bega indicates the dry season with high temperature and little rainfall extends from October to January

[3] Belgexpress the short or small rains season starts from February/March and extends to May

The stochastic production function for crop (i) and year (t) specified as:

$$y_{it} = f[X_{it}, \beta] + h^{1/2}[Z_{it}, \sigma] + \varepsilon_{it}$$

E(y) = F(X), V(y)=h(X), so that the effect of mean and variance on crop yield are independent.

y_{it} is the dependent variable, where the first function is the effect of the regressors on the mean yield, and the second part is the effects of independent variables on crop yield variance. In the stochastic production function, t denotes the production years (1998 to 2017), ε_{it} is the stochastic term with $E(\varepsilon) = 0$, $V(\varepsilon) = \sigma^2$, X_{it} is the independent variables affecting crop i in the year t, β and σ are estimate coefficient providing the effect of each X on mean and variance of crop yield.

IV. Results

a) *Rainfall Trends*

The inter-seasonal rainfall in six weather stations from 1994 to 2017 years showed fluctuating trend going up and down that the variations affect crop yield and productively differently (Fig.2). Except for *belg* in Hossana, and k*irmet* in Arbaminch, the mean difference test for *Kiremt*, *bega* and *belg* seasons, and annual rainfall in all stations for the periods 1994 to 2005 and 2006 to 2017 showed insignificant effect (Annex Table 1). The rainfall mean difference for the two periods showed little increment in Hawassa, Woliata Sodo, and Arbaminch weather stations figured to 13.67 mm, 23.93 mm, and 54.19 mm, respectively. On the contrary, at Hossana, Buie, and Halaba weather stations the mean difference showed a decrement and was found to be insignificant (Annex Table 1).

The mean difference and the statistical test for the main season (*Kiremt*) rainfall of the two periods showed increasing and decreasing trends. The mean difference for four meteorological weather stations, namely at WalaitaSodo, Hawassa, Arbaminch, and Hossana, showed an increasing trend of 36.67 mm, 40.61 mm, 74.52 mm, and 77.58 mm, respectively and found insignificant. At HalabaKulito and Buie weather stations, the mean difference showed a decreasing trend reaching 75.43 mm for both stations (Annex Table 1).

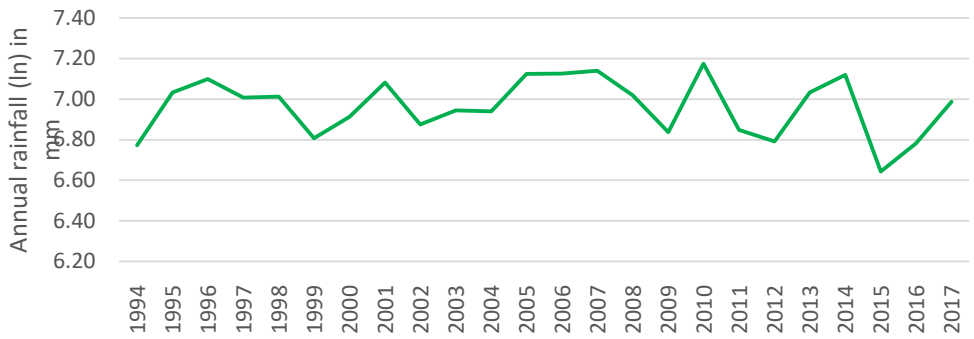

Fig. 2: Annual rainfall trend (1994-2017)

b) *Temperature Trends*

The observed and recorded average minimum, maximum, and annual temperature in 5 weather stations of the central zones of SNNPR for the years 1994 to 2005 and 2006 to 2017 showed an increasing trend (Fig3).The annual average temperature means difference for the two periods in Hossana, Arbaminch, Wolita Sodo, Hawassa, and Halaba Kulito was found to be 0.34 ℃, 0.42℃, 0.45℃, 0.91℃ and 1.53℃ respectively and showed significant difference (Annex Table 2). Similarly, the average maximum temperature for all stations showed an increasing trend, and with the exception of Hossana, the average minimum temperature for the rest weather stations also showed an increasing trend. The lowest minimum average temperature was ranging from 19.89 to 21.01℃.

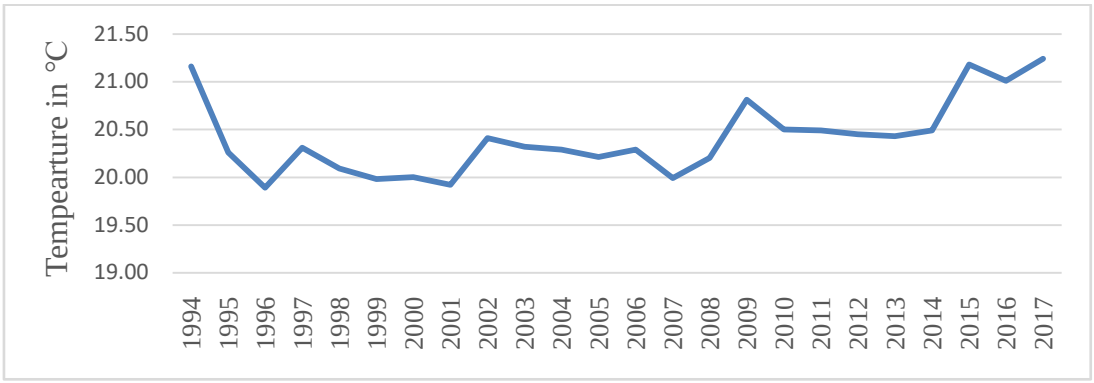

Fig. 3: Average annual temperature trend (1994-2017)

c) *Productivity Trend of Cereal Crops*

The productivity trend of cereals in 1998 to 2017 showed different trends(Fig.4). Maize average productivity showed the lowest in 2001 (13.68 Qt Ha-1), and the highest in 2017 (35.07 Qtha-1) and the productivity was lower than the national average (36.75 Qtha-1) in 2017 (CSA, 2017). Tef productivity ranged from 6.22 Qtha-1 in 2004 (CSA, 2004) to 13.91 Qt ha-1in 2017 and lay below the national average (16.64 Qtha-1) reported in 2017 (CSA, 2017). Similarly, the productivity of bread wheat ranged from 11.40 Qt ha-1 in 2000 (CSA, 2000) to 24.39 Qtha-1, and yet it was lower than the national average (26.75 Qtha-1) (CSA, 2017). Food barley productivity ranged from 11.26 in 2002 to 20.66 Qtha-1 in 2017 and it was below the national average reported in 2017 (21.11 Qtha-1).Sorghum productivity ranged from 8.32 Qtha-1 in 2006(CSA, 2006)to 20.17Qt ha-1 in 2017, and was lower than the national average (26.10Qt ha-1)(CSA, 2016). Halaba is the major finger millet producing area, where the lower productivity was 9 Qtha-1 in 2006(CSA, 2006)and the highest was recorded in 2015 (16.9 Qtha-1), and was lower than the national average reported in 2017 (22.30 Qtha-1).

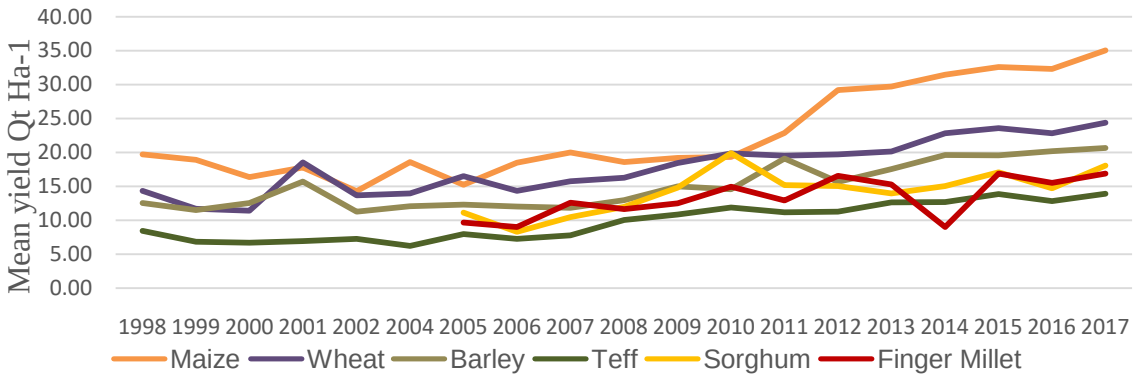

Fig. 4: Cereal crops productivity trend (1998-2017)

d) *Productivity Trend of Pulse Crops*

The productivity trend of major pulse crops, namely faba bean and common bean, showed an increasing trend(Fig 5). For the period 1998 to 2017, the lowest productivity of faba bean was observed in 2001 (9.04 Qtha-1) (CSA, 2001) and the highest yield in the year 2017 (22.07 Qtha-1) and was higher than the national average (20.53 Qtha-1) in 2017 (CSA, 2017). The mean yield productivity of common beans ranged from 6.65 Qt ha-1 in 1998 (CSA, 1998)to 16.09 Qt ha-1(CSA, 2017).

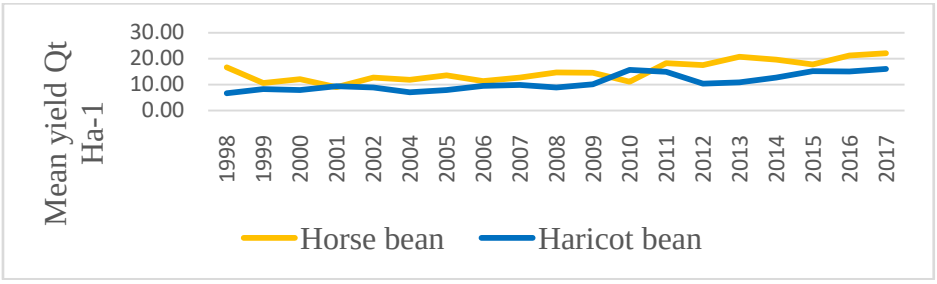

Fig. 4: Pulse crops productivity trend (1998-2017)

e) Productivity Trend of Root Crops

The productivity of taro and sweet potato showed a constant trend from the year 2002 to 2012, showing an average yield of 92Qtha^{-1}(CSA, 2012) and an increasing trend right from 2013and reached 336.4 Qt ha^{-1} of taro and 378 Qt ha^{-1} of sweet potato in 2015(CSA, 2015).

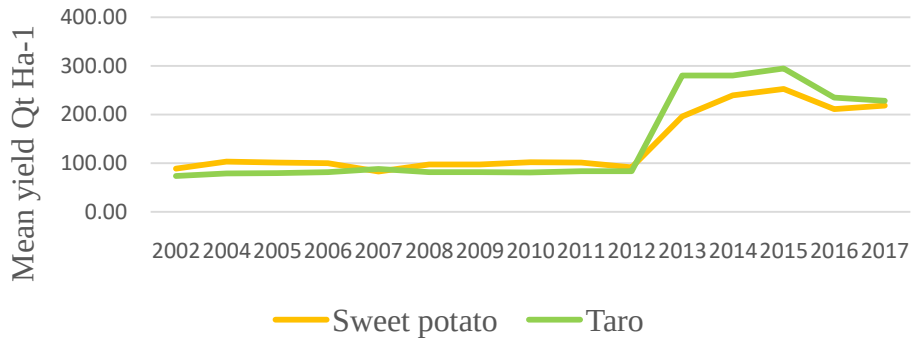

Fig. 5: Sweet potato and taro productivity trend (2002 - 2017)

f) Productivity Trend of Coffee

From 2002 to 2017, the productivity trend of coffee showed up and down with little change in productivity (Fig. 7). The highest productivity reached 6.94 Qtha^{-1} of clean coffee in 2013(CSA, 2013), and the lowest was 4.38 Qt ha^{-1}(CSA, 2004).

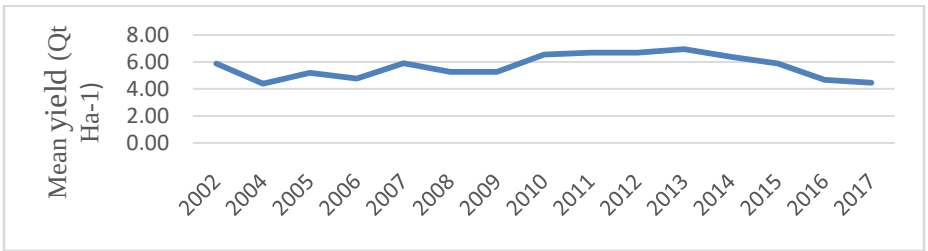

Fig. 6: Coffee productivity trend (2002-2017)

g) Productivity Trend of Red Pepper

Nationally, Marko, Meskan, and Halaba are known as the potential producer of red pepper. Due to the data unavailability in CSA's report, only Halaba was considered. The productivity trend in the first four years showed a sharp increasing trend up to 2007, and then it started to decline down to 17.4 Qtha^{-1} in the consequent years (Fig. 8). The productivity of red pepper reached its maximum (39.8 Qtha^{-1}) in 2007 (CSA, 2007) and the minimum (16.48 Qtha^{-1}) in 2016.

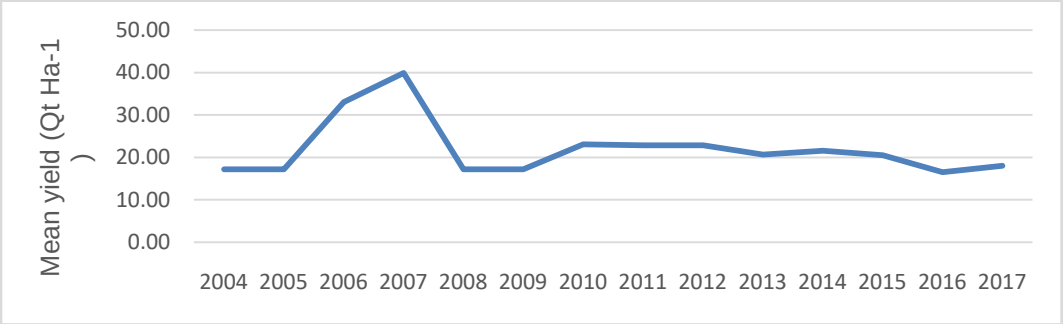

Fig. 7: Red pepper productivity trend (2004-2017)

h) Climate Variability Impact on Crop Production

The rainy season average rainfall has negative and insignificant impacts on maize and wheat yield; positive, and significant effects on *tef;* positive and insignificant effects on barley, sorghum and finger millet yield in the specified years. Similarly, the short season (*Belg*) rainfall has positive effects on the mean yield of major cereals. On the other hand, it imposed a negative and insignificant result on finger millet yield. The annual average temperature has also showed a positive effect on wheat, and other small cereals growing in the central zones of SNNPR (Table 1). The estimated variance coefficient of the rainy season rainfall for maize, wheat, and barley was negative and insignificant, while for *tef*, sorghum, and finger millet found to be positive, and insignificant (Table 2). The estimated coefficient in *Belg* season has positive impacts on the yield variance of all crops except finger millet. Lastly, except for the yield of barley, annual temperature showed a positive and significant effect on the yield variance of other cereal crops.

Table 1: Estimated coefficient of mean of cereal crops yield (Qt)

Description	Maize		*Tef*		Wheat		Barley		Sorghum		Finger millet	
	β	SE	β	SE	β	SE	β	SE	β	SE	β	SE
Kirmet rainfall (ln)	-0.100	0.402	0.796*	0.404	-0.372	0.382	0.334	0.358	0.560	0.495	0.576	0.512
Belg rainfall (ln)	0.077	0.208	0.082	0.208	0.197	0.196	0.315	0.185	0.393	0.245	-0.055	0.254
Average temp	0.523**	0.196	0.902***	0.197	0.148	0.186	0.566***	0.174	1.064***	0.291	1.056***	0.301
Constant	3.661	5.642	-11.688*	5.663	10.659*	5.347	-3.506	5.016	-16.242*	8.604	-15.024*	8.896
N	19		19		19		19		14		14	
R^2	0.385		0.584		0.167		0.452		0.605		0.601	
Adjusted R^2	0.263		0.501		0.001		0.342		0.487		0.482	

*Notes: ***, ** and * are significant at 1%, 5% and 10% probability level, SE stands for standard error.*

Table 2: Estimated coefficient of variance of cereal crops yield (Qt)

Description	Maize		*Tef*		Wheat		Barley		Sorghum	
	β	SE	β	SE	β	SE	β	SE	β	SE
Kirmet rainfall (ln)	-0.045	(0.929)	0.380	(0.703)	-0.162	(0.722)	-0.479	(0.758)	0.779	(2.328)
Belg rainfall (ln)	-0.605	(0.478)	0.071	(0.363)	0.473	(0.372)	-0.171	(0.391)	2.746**	(1.153)
Average temperature	0.994*	(0.452)	0.753**	(0.343)	1.022**	(0.352)	-1.222***	(0.369)	3.312**	(1.366)
Constant	8.489	(12.486)	5.375	(9.854)	2.418	(10.113)	51.665***	(10.618)	-67.50	(40.44)
N	19		19		19		19		14	
R^2	0.356		0.246		0.421		0.429		0.516	
Adjusted R^2	0.227		0.095		0.305		0.315		0.371	

*Notes: ***, ** and * are significant at 1%, 5% and 10% probability level, SE stands for standard error.*

The seasonal average rainfall observed during the periods 1998 to 2017 has imposed positive and insignificant impacts on the mean yield of faba bean, and common bean. On the other hand, the average temperature in the area has a positive and significant impact on both crop's mean yields (Table 3).The estimated variance coefficient of the rainy, and short season's rainfall for faba bean yield found to be positive and insignificant. On the other hand, it was a positive and significant for common be an yield. Lastly, annual temperature showed a positive and insignificant effect on the variance of faba bean and a positive and significant effect on the variance of haricot bean yield.

Table 3: Estimated coefficient of mean of pulse crops yield (Qt)

Description	Faba bean		Common bean	
	β	SE	β	SE
Kirmet rainfall (ln)	0.460	(0.343)	0.861	(0.721)
Belg rainfall (ln)	0.145	(0.177)	0.598	(0.372)
Average temperature	0.675***	(0.167)	1.708***	(0.352)
Constant	-6.473	(4.809)	-32.608***	(10.099)
N	19		19	
R^2	0.522		0.625	
Adjusted R^2	0.426		0.550	

, *, indicates significant level at 10% and 1% probability level respectively*

Table 4: Estimated coefficient of variance of pulse crops yield (Qt)

Description	Faba bean		Common bean	
	β	SE	β	SE
Kirmet rainfall (ln)	-0.203	(1.507)	1.955	(1.431)
Belg rainfall (ln)	-0.563	(0.778)	1.498*	(0.738)
Average temperature	1.051	(0.735)	3.271***	(0.698)
Constant	3.521	(21.12)	-65.782***	(20.052)
N	19		19	
R^2	0.188		0.618	
Adjusted R^2	0.025		0.543	

** and ***, indicates significant level at 10 and 1% probability level respectively*

A part from the technological availability of the crops, the regression coefficient also revealed that the seasonal rainfall and temperature imposed positive effects on the mean yield of taro, sweet potato, coffee, and red pepper from 2002 to 2017 (Table 5). Synonymously, the seasonal rainfall and annual temperature showed a positive effect on the variance of sweet potato, taro, coffee, and red pepper growing in central zones of SNNPR over 19 years (1998 to 2017).

Table 5: Estimate of coefficient of mean root crops and coffee yield (Qt)

Description	Taro		Sweet potato		Coffee		Red pepper	
	β	SE	β	SE	β	SE	β	SE
Kirmet rainfall (ln)	0.919	(1.201)	0.807	(0.803)	0.985	(0.697)	0.649	(0.627)
Belg rainfall (ln)	0.250	(0.631)	0.379	(0.422)	0.116	(0.367)	0.079	(0.312)
Aver.temp.	2.393***	(0.719)	1.148**	(0.481)	1.044**	(0.418)	0.898**	(0.369)
Constant	-43.178*	(20.903)	-17.062	(13,97)	-17.09*	(12.14)	-11.71*	(10.929)
N	15		15		15		14	
R^2	0.538		0.350		0.364		0.386	
Adjusted R^2	0.412		0.173		0.190		0.202	

****, ** and * indicates significant level at 1%, 5% and 10% probability level respectively*

Table 6: Estimated coefficient of variance of root crops and coffee yield (Qt)

Description	Taro		Sweet potato		Coffee	
	β	SE	β	SE	β	SE
Kirmet rainfall (ln)	3.487	(5.213)	0.829	(2.483)	2.512	(1.846)
Belg rainfall (ln)	2.161	(2.740)	0.862	(1.305)	0.266	(0.970)
Average temperature	7.154**	(3.126)	1.914	(1.489)	2.811**	(1.107)
Constant	-157.001	(90.753)	-22.889	(43.224)	-51.96	(32.202)
N	15		15		15	
R^2	0.343		0.151		0.373	
Adjusted R^2	0.164		0.081		0.202	

***, indicates significant at 5% probability level*

V. Discussions

a) Climate Variability Trends

Climate change refers to a change in the state of the climate that can be identify by changes in the mean and the variability of its properties that persists for decades (IPCC, 2007). It is the fluctuations in the patterns of climate over long periods (Ngaira, 2007). If the changes in climate parameters such as a change in temperature, precipitations, sea levels, and soil moisture show year-to-year variations or cyclical trends, it is known as climate variability (IPCC, 2007). Given other non-climatic drivers of environmental and human-made conditions, the change in climate parameters such as a change in temperature, precipitation, or rainfall patterns affects crop yield and productivity. The climate attributes such as the rise in temperature, the variation in frequency and intensity of precipitation, the increase in the level of CO_2 available for photosynthesis have a direct impact on agricultural productivity (Nastis et al., 2012).

The rainfall in most Ethiopian parts is characterize by seasonal and inter-annual variability (Seleshi & Zanke, 2004). In rain-fed agriculture, rainfall is the most important climatic factor influencing the growth of crops. Crops need water for their growth, photosynthesis of making their food, and to their overall performance. Rainfall provides water that serves as a medium through which nutrients transport for crop development (Ndamani & Watanabe, 2015). In Ethiopian agricultural activity, rainfall is the prime and important source of water to grow crops. The year-to-year variations and the aggregate long-run rainfall variability have imposed an impact on crop yield. Excessive rainfall condition such as flooding has a negative and devastating consequences on crop production. On the other hand, low rainfall or precipitation results in severe drought occurrence that results in crop failure by lowering its productivity that ultimately affects the farming community. The climatic condition of the central zones indicates that the variability in seasonal rainfall is higher in the short rainy than the rainy season and results in low crop yield.

Similar to the change in rainfall pattern, high temperature is likely to reduce crop productivity that a high-value perennial crops are starting to be negatively affected by the rise in temperature (Pereira, 2017). Temperature increase posed positive and negative effects on crop yields; it has adverse effects in reducing the yield and quality of crops (Adams et al., 1998). Temperature increases lead to higher respiration rates, shorten seed formation and grain filling period and lowers biomass production, and finally reduces crop yield. The increased temperature for the last two decades in all weather stations of SNNPR has shown a signal to a climate change as a whole. The fluctuations in average minimum, maximum, annual temperature, and average sunshine duration showed the climate variability scenarios of the areas. During the periods 1994 to 2017, the overall average temperature ranged from 20.26 to 21.24 ℃ for the highest peak characterized by adverse weather conditions resulted in low crop yield. The change in average temperature from 19.89 to 21.24 ℃ amounted to 1.35 ℃ has imposed a negative impacts on crop yield.

b) Productivity Trend of Crops

The productivity of crops depends on soil fertility, management practices, agro climatic conditions, and other practices applied in the area. The commonly grown cereals in the central zones of SNNPR are maize, *tef*, wheat, barley, sorghum, and finger millet. Sorghum and finger millet grow at low land parts where the relative humidity is less and physiologically demanded short rains. Typically, from the central zones of SNNPR, the whole Halaba and part of Gamo Gofa dominantly cultivate sorghum and finger millet as an adaptation strategy to overcome the excessive heat and moisture stress. Faba bean, and common bean are the dominant pulse crops growing in central zones. The productivity of faba bean and common bean showed an increasing trend and, in some years, when the climatic conditions were not favorable, it showed a declining trend. The lowest yield productivity of common bean was 6.65 Qt ha^{-1} in 1998 (CSA, 1998) and showed an increment of threefold in 2017(CSA, 2017).

Due to the favorable agro-ecological conditions, soil type, indigenous practices, and improved technology availability of root crops, southern Ethiopia leads to in producing and consuming root crops. *Enset (*false banana*)*, taro, sweet potato, cassava, and yam are the dominant root crops utilized as stable food sources, and supplied to the local and national markets. Due to the introduction of high yield varieties, improved agronomic practices, and consumer preferences to taro and sweet potato as substitute food against high priced cereals crops, the productivity has increased dramatically from an average of 83.4 and 101 Qt ha^{-1} to 336.4 and 378 Qt ha^{-1} for taro and sweet potato respectively (CSA, 2015). The mean productivity of taro in central zones is higher than the national average recorded in 2015 (297.76 Qt ha^{-1}), and the productivity of sweet potato is approximately equivalent to the national average, i.e. 455.8 Qt ha^{-1}. Most of the zones in southern Ethiopia are coffee producing, supplying, and exporting coffee. Apart from the non-climatic factors, the possible reason for low yield is the climatic effect that aggravates the coffee berry borer disease that adversely affects its productivity.

c) Climate Variability Impact on Crop Production

The IPCC report revealed that climate change and variability have multifaceted effects and impacts on people and the natural environment (IPCC, 2007). Climate change and fluctuations become a global issue(Pereira, 2017; Ngaira, 2007), affecting billions of people, including the natural environment. Climate variability has posed positive and negative impacts on agriculture by lowering and increasing production, productivity and affecting product quality. A study made in Rwanda noted that climate variability is one of the factors affecting year-to-year crop production (Mikovaet al., 2015). In the farming community whose agricultural activities are rainfed type, the change in climate element, mainly the change in temperature and precipitation level, affect production and productivity of crops (Shumetie et al., 2017).

High temperatures and changes in rainfall patterns impose negative impacts on cereal crop productivity (Pereira, 2017). Main season average rainfall has a negative consequences on maize and wheat yield; positive effects on *tef,* barley, sorghum, and finger millet yield. The negative impacts of rainfall patterns on maize and wheat yield were associated with the prevalence of vast rust and viral diseases that lowered the productivity of both crops in SNNPR. Moreover, maize water requirement for its growth and physiological maturity depends on the seasons that the major maize producing areas of SNNPR plant it during the onset of the short rainy season (usually from March to April). The negative estimated coefficient of mean yield of finger millet witnessed that it is usually plant at the end of the rainy season due to its low requirement of moisture and high soil temperature.

The seasonal change in rainfall showing positive coefficients of variance on the yield of cereal crops revealed an increase in covariates whose effects on crop yield lead to a higher yield variance or vice versa holds. Thus, the estimated variance coefficient of the rainy season rainfall on maize, wheat, and barley were negative resulted in lower yield variance. While for *tef*, sorghum, and finger millet it was positive and hence higher yield variance. The estimated coefficient in *belg* season has positive and insignificant impacts on the mean yield and variance of all crops except finger millet. Lastly, except for the production of barley, annual temperature showed a positive association and significant effect on the yield variance of other cereal crops.

Inter-seasonal rainfall and change in temperature have impacts on pulse crops, coffee, and on the yield of bi-annual crops such as taro and sweet potato. Faba bean and common bean yield hada positive association with seasonal rainfall patterns and to the average temperature. The coefficient estimation of mean yield was synonymous with the increasing productivity trend of both crops during the specified periods. When, there is an adverse climatic condition like low precipitation and excessive heat, it adversely affects crop yield and quality. For the periods 1994 to 2017, given other technological and input supply conditions, the productivity of coffee in study areas has not shown significant change, ranging between 4.38 and 6.94 Qt Ha^{-1}(CSA, 2013). The estimated coefficient in the stochastic production function also verified that the inter-seasonal climate variability showed an insignificant effect on the mean yield of coffee.

d) Adaptation and Mitigation of Climate Change

The farming community living in the different agro-ecological system have different climate resilience-building strategies to cope up the risks. A study made by Tessema and Simane (2019) in Fincha'a sub-basin of the upper Blue Nile basin in Ethiopia reported that farmers living in agroecology to high exposure to climate change with low adaptive capacity have exercised high vulnerability and conversely those living in low exposure with higher adaptive capacity have experienced low vulnerability shocks. Countries whose economy is largely dependent on subsistence rainfed agriculture are more vulnerable to climate change risks(Pereira, 2017). To overcome the short and long-run climate risks, countries stands differently. Apart from climate change, vulnerability in Ethiopia and other African countries emanates from limited capacity to abate or adapt against the change (ibid). The climate vulnerability is high in Ethiopia and many African countries due to the facts that, weak agricultural technological services (Belete *et al*., 1991); low supply of inputs, and few

financial resources (Pereira, 2017) and limited access to infrastructure and information (Mekonnen, 2013).

Cognizant of the facts, to adapt to climate change variability and its impacts, Ethiopia developed and has implemented various strategies and initiatives. Climate Resilient Green Economy Strategy (CRG-I) in 2011(FDRE, 2011),Adaptation and Resilience Strategy (CRG-II) in 2014, the first Growth and Transformation Plan (GTP-I) and the second Growth and Transformation Plan (GTP -II) or Ethiopian five-year development plan for 2015 to 2020 are the major strategies and initiatives. These are national adaptation strategies to overcome climate change and variability in the country and different economic sectors.

In Africa in general and in Ethiopia in particular, different climate change adaptation and mitigation measures have been implemented. For example, African farmers are increasingly adopting a variety of conservation and agroecological practices such as agroforestry, contouring, terracing, mulching, and minimum tillage or no-till (Pereira Laura, 2017). Introducing and promotion of new agricultural technologies, for example, new varieties of maize and wheat accompanied by policy intervention for example credit and fertilizer subsidy is recommended as an effective adaptation option (Berger *et al*., 2017). In Ethiopia, in highly degraded and food-insecure areas including the southern region 'adaptive social protection' framework, for example, Productive Safety-Net Programme (PSNP) have been implemented to restore the productive land through different land scape measures like integrated soil and water conservation measures as climate adaptation strategies (Weldegebriel and Prowse, 2013). All climate change adaptation practices will be expected to have twin benefits of lowering carbon emissions as well as diversifying the sources of livelihoods and it reduces the vulnerability to livelihood shocks for poor farmers who depend on agriculture (Weldegebriel and Prowse, 2013; Pereira Laura, 2017).

In the agricultural sector, there are climate adaptation strategies recommended for the farming communities to practice(Weldegebriel & Prowse, 2017). To overcome the challenges of climate change and variability, the research system of the country in general and that of the regional research system developed crop suitability maps as adaptation and mitigation strategies. The South Agricultural Research Institute (SARI) released a number of disease-resistant, drought-tolerant high yielding, and early maturing taro and sweet potato cultivars. After the intervention, right from 2013, the yield and productivity of taro and sweet potato increase nearly by four folds and reached its maximum productivity in 2015 (i.e., 33.6ton Ha^{-1} taro and 37.8 ton Ha^{-1}sweet potato) (CSA, 2015). In SNNPR, taro and sweet potato have twin benefits that in one hand, it boosts agricultural productivity, and on the other hand, acts as climate-smart crops growing in the moisture stress areas.

VI. Conclusion and Recommendation

The agricultural system in SNNPR is largely rainfed and underdeveloped type that uses low technological inputs and traditional practices. Due to these facts, it has been affected by climate change, mainly by change in rainfall patterns, humidity patterns and rises in temperature. Climate change and variability reduce yield, lower the quality of agricultural products, aggravate pests and diseases, endure health, affect the natural and environmental resources, and ultimately it affects livelihood of people. The climate variability in terms of change in temperature and inter-seasonal rainfall for 1994 to 2017 showed an increasing trend imposing effects on crop yield and livestock production. On the other hand, the yield productivity trend of major crops showed very little change in yield per unit area. Akin to climate variability, the crop productivity trend for major crops showed fluctuating type in years of the favorable climatic condition it resulted in better productivity and in worst seasons it showed a decreasing trend. The stochastic production function revealed that rainfall variability on mean yield showed a positive and insignificant association, and the change in temperature indicated a positive association and significant effect for most of the major crops grown in the central zones of SNNPR.

Different adaptation measures and climate resilience-building strategies are paramount importance measures to cope with climate change and variability. Before any physical interventions, the perception level of the community about impacts on the livelihood of people, assets, and environmental resources should be raise. Introduction and use of improved crop varieties, improved practices, and land enhancing practices, irrigation, and livelihood diversification, institutional services like credit, social protection and information access are some of the adaptation strategies to climate change, and its variability. From the policy perspective, R&D should be strengthen that enable the agricultural sector and the farming community to be more climate-resilient. In conclusion, policymakers and development practitioners should give due emphasis and take sooner developmental and policy actions to manage the risks associated with climate change and variability by incorporating climate change adaptation strategies.

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References Références Referencias

1. Adams RM, Hurd BH, Lenhart S, Leary N (1998). Effects of global climate change on agriculture : an interpretative review. Clim Res. 11:19–30.
2. Belete A, Dillon JL, Anderson FM (1991). Development of agriculture in Ethiopia since the 1975 land reform. Agricultural Economics. 6: 159–175.
3. Berger T, Troost C, Wossen T, Latynskiy E, Kindie T and Gbegbelegbe S (2017). Can smallholder farmers adapt to climate variability, and how effective are policy interventions?, agent-based simulation results for Ethiopia. Agricultural Economics. 48: 693-746.
4. CSA (1998). Agricultural Sample Survey 1997/98 (1990 E.C.):Report on Area and Production for Major Crops. Statistical Bulletin 189. Addis Ababa.
5. CSA (2000). Agricultural Sample Survey 1999/2000 (1992 E.C.): Report on Area and Production for Major crops (Meher season), Statistical Bulletin 227 (Vol. I). Addis Ababa.
6. CSA (2001). Agricultural Sample Survey 2000/2001 (1993 E.C.): Area and Major Crops (Meher season). Statistical Bulletin 245. Addis Ababa.
7. CSA (2004). Agricultural Sample Survey 2003/2004 (1996 E.C.): Report on Area and production of crops (Meher season). Addis Ababa.
8. CSA (2006). Agricultural Sample Survey 2005/2006 (1998 E.C.): Report on Area and Production of Crops (Meher season). Statistical Bulletin 261 (Vol. 1). Addis Ababa.
9. CSA (2007). Agricultural Sample Survey 2006/2007 (1999 E.C.): Report on Area and Production of Crops (Meher Season). Statistical Bulletin 388 (Vol. I). Addis Ababa.
10. CSA (2012). Agricultural Sample Survey 2011/2012 (2004 E.C.): Report on Area and Production of Major Crops (Meher Season). Statistical Bulletin (Vol. I). Addis Ababa.
11. CSA (2013). Agricultural Sample Survey 2012/2013 (2005 E.C.): Report on Area and Production of Major Crops (Meher season), Statistical Bulletin 532 (Vol. I). Addis Ababa.
12. CSA (2015). Agricultural Sample Survey 2014/2015 (2007 E.C.): Report on Area and Production of Major Crops, Statistical Bulletin 278 (Vol. I). Addis Ababa.
13. CSA(2016). Agricultural Sample Survey 2015/2016 (2008 E.C.): Report on Area and Production of Major crops (Meher Season). Statistical Bulletin 584 (Vol. I). Addis Ababa.
14. CSA (2017). Agricultural Sample survey 2016/2017 (2009 E.C.): Report on Area and Production of Major Crops, Statisical Bulletin 584. (Vol. 1). Addis Ababa, Ethiopia.
15. FDRE (2011). Federal Democratic Republic of Ethiopia Climate-Resilient Green Economy Strategy, The path to Sustaianble Development. Addis Ababa, Ethiopia.
16. IPCC (2007). Intergovernmental Panel on Climate Change Fourth Assessment Report, Climate Change 2007: Synthesis Report. (L. N. Jallow B, Kajfež-Bogataj L, Bojariu R, Hawkins D, Diaz S, Lee H, Allali A, Elgizouli I, Wratt D, Hohmeyer O, Griggs D, Ed.).
17. IPCC (2012). Managing the risks of extreme events and disasters to advance climate change adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. (and P. M. M. Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, Ed.). Cambridge University Press, Cambridge, UK, New York, NY, USA.
18. Kelbore ZG (2013). An Analysis of the Impacts of Climate Change on Crop Yield and Yield Variability in Ethiopia. University of Trento, MPRA Paper No. 49466. http://mpra.ub.uni-muenchen.de/49466/.
19. Laura P(2017, Climate Change Impacts on Agriculture across Africa, Oxford Research Encyclopedia of Environmental Science. Oxford University Press, USA.
20. Maplecroft (2015). Climate Change Vulnerability Index 2015. Maplecrafts's Climate Change and Environmental Risk Atlas (CCERA). United Kingdom (UK). www.maplecroft.com
21. Mekonnen GT (2013). Role of Infrastructure and Institutional Services in Socio-Economic Development of Rural People in Southern Ethiopia. International Journal of Management and Development Studies. 2(2): 33–41.
22. Mikova K, Makupa E, Kayumba J (2015). Effect of Climate Change on Crop Production in Rwanda. 4(3): 120–128.
23. MoARD(2005). Community Based Participatory Watershed Development: A Guideline. (D. Lakew, V. Carucci, W. Asrat, & A. Yitayew, Eds.). Addis Ababa.
24. Nastis SA, Michailidis A, Chatzitheodoridis F(2012). Climate change and agricultural productivity. African Journal of Agricultural Research. 7(35): 4885–4893. https://doi.org/10.5897/AJAR11.2395
25. Ndamani F, Watanabe T(2015). Influences of rainfall on crop production and suggestions for adaptation. International Journal of Agricultural Sciences. 5(1): 367–374.
26. Ngaira JK(2007). Impact of climate change on agriculture in Africa by 2030. Scientific Research and Essays. 2(7): 238–243.
27. Pereira L (2017). Climate Change Impacts on Agriculture across Africa, Oxford Research Encyclopedia of Environmental Science. Oxford University Press, USA. https://doi.org/10.1093/acrefore/9780199389414.013.292

28. SARI (2018). Evaluation of Government Initiated Participatory Watershed Based Land Resources Management Interventions in Southern Ethiopia: Performance and Sustainability. Hawassa, Ethiopia.
29. Sejian V (2013). Climate change: Impact on production and reproduction, Adaptation mechanisms and mitigation strategies in small ruminants: A review. The Indian Jiurnal of Small Ruminants. 19(1): 1–21.
30. Seleshi Y, Zanke U (2004). Recent Changes in Rainfall and Rainy Days in Ethiopia. International Journal of Climatology. 24: 973–983. https://doi.org/10.1002/joc.1052
31. ShumetieA, Belay K, Goshu D, Mwanjalolo M (2017). Impact of Climate Variability on Cool Weather Crop Yield in Ethiopia. International Journal of Agricultural Management and Development (IJAMAD). 415–428.
32. SlaterR, Peskett L, Ludi E, Brown D (2007). Climate change, agricultural policy and poverty reduction - how much do we know? Natural Resource Perspectives, Odverseas Development Institute (ODI). 109:1–6.
33. Temesgen D, Hassan R (2009). Economic Impact of Climate Change on Crop Production in Ethiopia : Evidence from Cross-Section Measures. Journal of African Economies. 18(4): 529–554.
34. Tessema I, Simane B (2019). Vulnerability analysis of smallholder farmers to climate variability and change: an agroecological system-based approach in the Fincha'a sub-basin of the upper Blue Nile Basin of Ethiopia. Ecological Processes. 8:5: 1-18.
35. Berger T, Troost C, Wossen T, Latynskiy E, Kindie T and Gbegbelegbe S (2017). Can smallholder farmers adapt to climate variability, and how effective are policy interventions?
36. Agent-based simulation results for Ethiopia. Agricultural Economics. 48: 693-746.
37. Weldegebriel ZB, Prowse M (2013). Climate-Change Adaptation in Ethiopia: To What Extent Does Social Protection Influence Livelihood Diversification? Development Policy Review. 31(S2): 35–56.
38. Weldegebriel ZB, ProwseM (2017). Climate variability and livelihood diversification in Northern Ethiopia: a case study of Lasta and Beyeda districts. The Geographical Journal. 183(1): 84–96.

Annex table 1: Rainfall mean difference test between 1994 - 2005 and 2006 - 2017

Weather station	Season	1994 – 2005		2006 -2017		MD	Test statistics	
		Mean (mm)	SD(mm)	Mean (mm)	SD (mm)		t	f
Hossana	*Belg*	430.90	91.87	397.01	112.24	33.89	0.809**	0.48
	Kiremt	562.56	47.55	640.14	94.17	-77.58	-2.548	5.125
	Bega	157.68	107.74	113.84	95.50	43.84	1.055	.009
	Annual RF	1151.14	140.05	1151.00	149.52	0.14	0.049	0.002
Hawassa	*Belg*	327.58	80.56	340.90	113.60	-13.34	-0.332	1.094
	Kiremt	458.90	80.76	499.51	117.63	-40.61	-0.986	1.737
	Bega	175.52	74.76	135.24	52.91	40.27	1.523	0.448
	Annual RF	961.99	127.69	975.67	180.16	-13.67	-0.215	1.591
HalabaKulito	*Belg*	279.93	151.39	306.38	176.55	-26.46	-0.394	0.296
	Kiremt	660.12	95.92	584.69	186.17	75.43	1.248	2.036
	Bega	92.50	50.42	55.63	62.30	36.87	1.593	0.208
	Annual RF	1032.54	201.00	946.70	289.96	85.84	0.843	0.970
WalaitaSodo	*Belg*	452.46	127.76	451.48	141.57	0.97	0.018	1.415
	Kiremt	601.50	152.84	638.18	176.24	-36.67	-0.545	0.343
	Bega	238.15	135.98	226.39	120.09	11.77	0.225	0.168
	Annual RF	1292.12	204.48	1316.05	222.61	-23.93	-0.274	0.100
GurageBuie	*Belg*	279.93	151.38	306.38	176.55	-26.45	-0.394	0.296
	Kiremt	660.12	95.92	584.69	186.17	75.43	1.248	2.036
	Bega	92.50	50.42	55.63	62.30	36.87	1.593	0.208
	Annual RF	1032.54	201.01	946.71	289.96	85.83	0.843	0.970
Arbaminch	*Belg*	412.07	105.04	387.11	105.67	24.96	0.581	0.204
	Kiremt	209.41	40.59	283.93	114.27	-74.52	-2.129*	4.179**
	Bega	269.05	137.93	273.69	111.31	-4.64	-0.091	0.005
	Annual RF	890.54	146.93	944.73	165.73	-54.19	-0.847	0.943
All stations	*Belg*	363.81	136.88	364.88	145.68	-1.07	-0.045	0.060
	Kiremt	525.43	181.82	538.52	190.92	-13.09	-0.421	0.030
	Bega	170.90	117.24	143.40	118,32	27.49	1.401	0.563
	Annual RF	1060.14	212.48	1046.81	258.01	13.33	0.339	0.658

Source: Computed from NMSA, 1994 to 2017

****, ** and * indicate the significance level at 1%, 5% and 1% probability level, SD is standard deviation*

Annex table 2: Temperature mean difference test between 1994 - 2005 and 2006 - 2017

Weather station	Temperature in ℃	1994 - 2005		2006 -2017		Mean	Test statics	
		Mean	SD	Mean	SD	difference	t	f
Hossana	Average Max. Temp	22.58	0.27	23.31	0.41	-0.73	-4.999***	2.836
	Average Min. Temp	10.8	0.31	10.79	0.69	0.01	0.037	8.887***
	Average Temp	16.70	0.23	17.04	0.45	-0.34	-2.270**	3.204*
Hawassa	Average Max. Temp	27.42	0.33	27.73	0.53	-0.32	-1.766*	2.893
	Average Min. Temp	12.83	0.40	13.73	0.58	-0.91	-4.462***	1.482
	Average Temp	20.11	0.22	20.73	0.44	-0.62	-4.309***	3.170*
HalabaKulito	Average Max. Temp	27.78	0.34	29.13	0.79	-1.35	-5.409***	2.284
	Average Min. Temp	13.53	0.42	15.25	2.40	-1.72	-2.437**	20.277***
	Average Temp	20.66	0.29	22.19	1.44	-1.53	-3.622***	13.243***
WalaitaSodo	Average Max. Temp	25.38	0.32	25.63	0.52	-0.25	-1.404	2.329
	Average Min. Temp	14.46	0.30	15.09	0.66	-0.63	-3.022***	3.381*
	Average Temp	19.92	0.22	20.36	0.48	-0.45	-2.938***	3.441*
Arbaminch	Average Max. Temp	30.53	0.31	30.83	0.56	-0.30	-1.606	3.377*
	Average Min. Temp	17.06	0.46	17,60	0.56	-0.54	-2.586**	0.665
	Average Temp	23.80	0.29	24.22	0.43	-0.42	-2.765**	3.215*
All stations	Average Max. Temp	26.81	2.65	27.33	2.71	-0.52	-1.053	0.295
	Average Min. Temp	13.78	2.08	14.49	2.53	-0.71	-1.664*	2.387
	Average Temp	20.29	2.26	20.91	2.49	-0.61	-1.400	1.134

Source: Computed from NMSA, 1994-2017 weather station data

****, **and * indicates significant at 1%, 5% and 10% probability level respectively*

Annex table 3: Crop productivity mean difference test between 1998 - 2005 and 2006 - 2017

Crops type	1998-2005		2006-2017		Mean	Test statistics	
	Mean	SD	Mean	SD	difference	t	f
Maize	16.98	4.35	25.80	7.22	-8.82	-7.518***	17.547***
Tef	7.18	1.65	11.23	2.24	-4.05	-9.848***	4.036**
Wheat	14.40	3.4	19.52	4.63	-5.11	-5.881***	2.824*
Barley	12.47	3.19	16.56	5.08	-4.09	-4.168***	4.457**
Sorghum	10.19	3.69	14.56	3.74	-4.37	-2.401*	0.062
Finger millet	11.20	2.14	13.65	2.82	-2.45	-1.421	0.734
Faba bean	11.66	2.3	16.81	4.61	-5.15	-5.591***	43.589***
Common bean	7.93	1.92	12.46	3.37	-4.53	-7.581***	7.782***
Potato	83.22	15.13	133.62	64.14	-50.40	-2.034*	35.279***
Sweet potato	97.79	13.14	149.15	85.06	-51.36	-3.461***	10.220***
Taro	77.53	2.90	158.42	96.13	-80.89	-2.034*	35.279***
Coffee	5.14	1.01	5.78	2.29	-0.63	-1.602	5.768**
Red pepper	17.14	0.00	23.08	7.57	-5.94	-2.716**	1.705

Source: Agricultural sample survey of CSA (1998-2017)

****, ** and * indicates significant at 1%, 5% and 10%probability level respectively*

Annex table 4: Crop productivity mean difference test (zonal) between 1998-2005 & 2006-2017

Zone	Crops type	1998-2005		2006-2017		Mean	Test statistics	
		Mean	SD	Mean	SD	difference	t	f
Sidama	Maize	17.63	2.05	27.83	6.37	-10.21	-5.109***	22.796***
	Tef	6.17	1.20	9.98	2.48	-3.81	-3.651***	2.840
	Wheat	13.28	1.39	17.10	3.92	-3.82	-2.517**	8.434**
	Barley	11.06	1.73	14.66	3.23	-3.60	-3.16***	2.435
	Faba bean	10.50	2.19	14.83	4.22	-4.33	-2.932***	2.111
	Haricot bean	8.15	2.24	13.18	3.01	-5.03	-4.149***	0.031
	Sweet potato	101.2	7.24	110.96	23.58	-9.76	-1.222	4.168*
	Coffee	5.45	1.19	8.01	2.47	-2.56	-2.576**	1.301
Gurage	Maize	21.13	2.67	30.17	7.77	-9.04	-3.674***	22.98***
	Tef	7.39	1.25	11.79	2.12	-4.39	-5.668***	2.825
	Wheat	14.33	4.29	21.33	2.59	-6.99	-3.886***	2.644
	Barley	15.74	2.13	21.73	5.07	-5.99	-3.581***	14.271***
	Faba bean	13.32	2.67	17.89	4.91	-4.57	-2.627**	5.20**
	Potato	83.22	15.13	133.62	64.14	-50.40	-2.282**	4.685*
	Coffee	3.95	0.74	3.15	1.29	0.80	1.421	0.467
Hadiya	Maize	16.01	1.09	24.91	7.32	-8.89	-4.127***	22.764***
	Tef	8.50	1.43	11.64	2.26	-3.13	-3.694***	0.989
	Wheat	16.55	3.06	22.76	3.82	-6.21	-3.886***	1.764
	Barley	11.54	3.62	16.99	4.16	-5.46	-2.997***	0.517
	Faba bean	11.16	0.98	17.71	4.39	-6.55	-4.959***	13.211
	Haricot bean	8.47	1.57	11.74	2.72	-3.27	-3.315***	1.506
	Coffee	5.34	0.67	5.71	0.83	-0.36	-0.804	0.238
Walaita	Maize	15.70	5.39	22.46	4.54	-6.76	-1.998	0.006
	Tef	5.7	0.29	10.93	2.11	-5.19	-8.218***	6.48**
	Wheat	13.61	2.31	17.32	4.15	-3.72	-2.071*	1.715
	Haricot bean	7.62	1.48	11.37	31.8	-3.74	-2.69**	6.017**
	Taro	78.13	3.23	175.50	113.6	-97.37	-2.965**	31.956***
	Sweet potato	100.9	22.21	195.76	121.3	-94.82	-2.542**	16.913***
	Coffee	6.17	0.62	7.35	1.40	-1.18	-2.203*	2.124
GamoGofa	Maize	8.59	4.34	23.43	8.69	-14.84	-4.185***	5.117**
	Tef	6.2	0.79	11.63	2.36	-5.43	-6.602***	0.977
	Wheat	10.68	1.73	16.08	3.92	-5.40	-3.582***	0.938
	Barley	10.32	0.94	12.86	2.93	-2.54	-2.523**	2.227
	Sorghum	7.66	1.77	12.92	3.37	-5.26	-3.722***	0.884
	Haricot bean	5.99	1.49	11.70	3.11	-5.70	-4.595***	4.651**
	Taro	76.92	3.08	141.35	76.04	-64.43	-2.925**	40.836***
	Sweet potato	91.25	6.91	140.74	60.91	-49.49	-2.744**	25.912***
	Coffee	4.83	0.51	4.68	0.90	0.15	0.389	1.247
Halaba	Maize	18.12	2.99	26.00	6.42	-7.88	-2.801*	1.845
	Tef	8.91	3.13	10.89	2.29	-1.98	-0.856	0.252
	Wheat	16.74	4.68	21.85	4.75	-5.11	-1.426	0.123
	Sorghum	13.99	0.45	16.21	3.47	-2.22	-2.108*	2.297
	Finger millet	11.20	2.15	13.65	2.82	-2.45	-1.421	0.734
	Haricot bean	8.60	3.01	14.32	3.68	-5.72	-2.062*	1.138
	Red pepper	17.14	00	23.08	7.57	-5.94	-2.716**	1.705

Source: Agricultural sample survey of CSA (1998-2017)

****, **, * indicates significant at 1%, 5% and 10% probability level respectively*

The t-test indicates for equality of means and f-test for equality of variances

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Response of Selected *Capsicum* F1 Species to Irrigation Regimes on Growth, Development and Fruit Yield

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Abstract- Experiments were conducted on the response of three selected Capsicum species to irrigation regimes on growth, development and fruit yield. Growth pattern among the three pepper accessions were not similar as they all responded differently to the imposed irrigation regimes. Height of *Capsicum chinense* was significantly higher compared to those of *Capsicum frutescens* and *Capsicum annum.* Continuous shoot growth was recorded at post-flowering and fruiting with *Capsicum chinense* compared to *Capsicum frutescens* in which flowering and fruit formation terminates plant height development. Leaves development across the three pepper varieties varies with irrigation regimes. Closer irrigation interval favours shoot development in term of stem height, stem branch development, flowering and fruit production. Fruit yield were influenced by irrigation regimes of 2 and 4 days irrigation intervals. Root development was also positively enhanced by irrigation regimes as tap and lateral root length were favoured by 4 and 6 days irrigation intervals.

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I. Introduction

Pepper (capsicum spp) of the genus capsicum belongs to the Family *Solanaceae* (Night shade). The Family contains about 90 genera and nearly 3000 species (Vidyarth and Tripatha 2002). Capsicum is a crop that is widely cultivated because of its spicy nature and nutritional value. *Capsicum annum* and *capsicum frutescens* are the most common species in Nigeria (Agele *et al.*, 2011).

The increase demand for high yield to meet consumers request has led the seed production companies to the era of using mainly F1 seeds as the most efficient means of facing food security challenges as well as retaining their names in the market. The increasing demand for pepper during the dry season in Nigeria for local consumption and export created opportunities for producers to increase their production. Declining soil moisture during this period has being the major hindrance to year round production of the crop hence the need for approaches to develop efficient soil water management strategies for sustainable production of the crop. More so, the circumstances of increasing challenges of producing more food to meet the ever increasing world population and to cope with the effects of changing climate also makes it imperative to improve on the understanding of moisture stress as it affects pepper production.

Crop yield completely depends on the available moisture to crops if climatic and agronomic conditions are normal. There are strong relationships between crop yield and water use. Under normal condition, when environmental conditions do not restrict crop production, crop yield is at maximum when the crop water requirement is met (Agele *et al.,* 2011). Certain growth stages of crops are more sensitive to water deficits than others. In fruit vegetable crops, the vegetative and flowering stages are very sensitive to water deficit (Dalla-Costa and Gianquinto, 2002). Crop water use depends mainly on the climate and the soil conditions of an area.

Large scale pepper production in Nigeria is mostly found in the northern part under irrigation system during dry season (September-March). The raining season crops (June-September) suffer serious pest and diseases damage, limiting the output during the season (FAO, 2003).

The amount and frequency of irrigations depends on soil type, bed type, plant size, humidity, wind, sunlight and prevailing temperatures (Njouajio *et al., 2007*). In the humid tropics pepper grown as a rain fed crop, with annual rainfall total of 650mm - 1250mm and relative humidity of 75% - 88% providing suitable growing condition. If the rainfall greater than this range is detrimental, as it leads to poor fruit set and rotting of fruits (Purseglove *et al*., 1981).

The objectives of this project are to determine the response of tested *Capsicumspecies* to different watering regime in terms of root shoot development and fruit yield

II. Materials and Methods

The experiments were carried out between November2017and April 2018 and October, 2018 to April, 2019 at the Teaching and Research Farm of the Federal University of Technology Akure (7° 16' N, 5° 12E) Nigeria. The treatment involves three irrigation regimes and three F1 pepper accessions. The irrigation regimes imposed were 2, 4, and 6 days intervals at 1litre

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of water per irrigation day/plant after transplanting while F1 accessions *Capsicum chinense*, Capsicum frutescens (cayenne pepper) and Capsicum annum (Bell pepper) varieties from East-West Seed Company. The experiments were 3x3 factorial experiment with three replications laid out in a randomized complete block design. The planting materials (seeds) were gotten from the Agro dealer of East-West Seed Company. The seeds were raised in the nursery for six (6) weeks using nursery trays before transplanting into the already prepared plots at one plant per stand on a 2 x 5 meter sub-plot at a spacing of 0.5 x 1.0 meter. The total plot size was 20m x 24m. Before transplanting, the plots were irrigated using gravity drip irrigation systems for four hours. Transplanting was conducted very early in the morning to reduce transplanting shock followed by 30minutes irrigation. Weeding was carried out as and when due during the period of the experiments. The watering regimes treatments were imposed beginning from one week after transplanting.

Data were measured on plant height, number of leaves and number of branches on a two weeks interval beginning from a week after transplanting. Tap root length, total length of lateral root, length of longest lateral root, fresh root weight and dry root weight were measured at termination of the experiments (36 weeks). Yield parameters which include numbers of days to flowering, total number of flower produced, number of fruits and the total fruit weight were also measured.

Analysis of variance was performed on the measured data using MINITAB and the mean were separated using Tukey test.

III. Results

The response of the selected pepper varieties to varying irrigation regimes were represented in table 1-6 below. Table 1 shows the response of pepper varieties to varying irrigation regimes on plant height development in 2017 and 2018 experiments. From the results, the growth patterns in the two experiments were similar (as seen in figure 2) but the height development of the three pepper varieties differs from each other. At transplanting, no significant difference in the seedlings height of the pepper varieties but beginning from the 8th week after transplanting *Capsicum chinense* had a significantly higher plant height compared to *Capsicum frutescens* and Bell pepper varieties. The variation in plant height continues till the termination of the experiment with *Capsicum chinense* having the highest significant plant height over the *Capsicum frutescens* and the bell pepper.

Figure 1, 2 and 3 represents the effects of varying irrigation regimes on height development of *Capsicum frutescens,* Capsicum chinense and the bell pepper respectively. From the results, no significant difference between 2 and 4 days irrigation interval on the plant height of *Capsicum chinense* but they were significantly higher in stem height compared to those under 6 days irrigation regimes, (Figure 1).Similar trends were also recorded under *Capsicum chinense* and bell pepper respectively.

Table 2 shows the response of three pepper varieties to varying irrigation regimes on number of leaves produced. It was clearly indicated that the morphological characteristic of the three pepper varieties in term of leaf production differs significantly from each other. The highest significant leaf numbers were produced by *Capsicum chinense* which was positively influenced by 2 days irrigation regimes over other irrigation intervals. No significant difference between Capsicum chinense under 4 day irrigation interval and those of *Capsicum frutescens* under 2 and 4 days irrigation regimes. Also, 6-days irrigation interval significantly lowered leaf development in the three pepper varieties as the plants increment in vigor which places more stress on the soil water which in turn leads to lower leaf area development across the three varieties.

Table 1: Response of pepper varieties to varying irrigation regimes on plant height 2017 and 2018 experiments.

Pepper Variety	Irrigation regime	Plant Height in weeks after treatment application(cm) 2017						Plant Height in weeks after treatment application(cm) 2018					
		4	8	12	16	20	24	4	8	12	16	20	24
cayenne pe	2days	20.3a	26.7a	34.1	48.0a	57.8a	57.8b	21.6a	30.3a	35.4a	47.0a	57.8a	58.3a
	4days	19.4a	24.3b	29.1	36.8b	47.8b	47.8c	23.9a	29.3a	32.3b	42.7b	49.0b	51.3b
	6days	439.2a	23.4b	24.8	31.6c	37.4c	37.7d	22.7a	25.4b	28.7b	33.7c	36.6d	37.6d
Wrinkle	2days	21.3a	27.5a	36.8	45.6a	58.2a	72.0a	18.3c	26.6b	39.8a	50.2a	64.5a	66.0a
	4days	20.5a	24.8b	32.3	41.7a	52.8a	61.9a	17.3c	24.9b	31.3b	43.2b	49.8c	52.6b
	6days	18.3a	22.2b	28.3	30.3c	41.4b	47.1c	20.2b	24.2b	30.3b	36.6c	41.4c	44.6c
Bell	2days	18.0a	25.2a	31.7	41.1a	42.4b	42.8c	23.0a	30.2a	38.5a	49.1a	53.4b	54.8b
	4days	16.7b	24.8b	30.3	37.2b	46.3b	46.5c	18.1c	22.3c	27.6b	32.2c	47.5b	47.9c
	6days	15.4b	22.7b	2[illegible]	31.2c	37.2b	41.3c	19.7b	23.7c	30.0b	35.7c	38.1c	40.6d

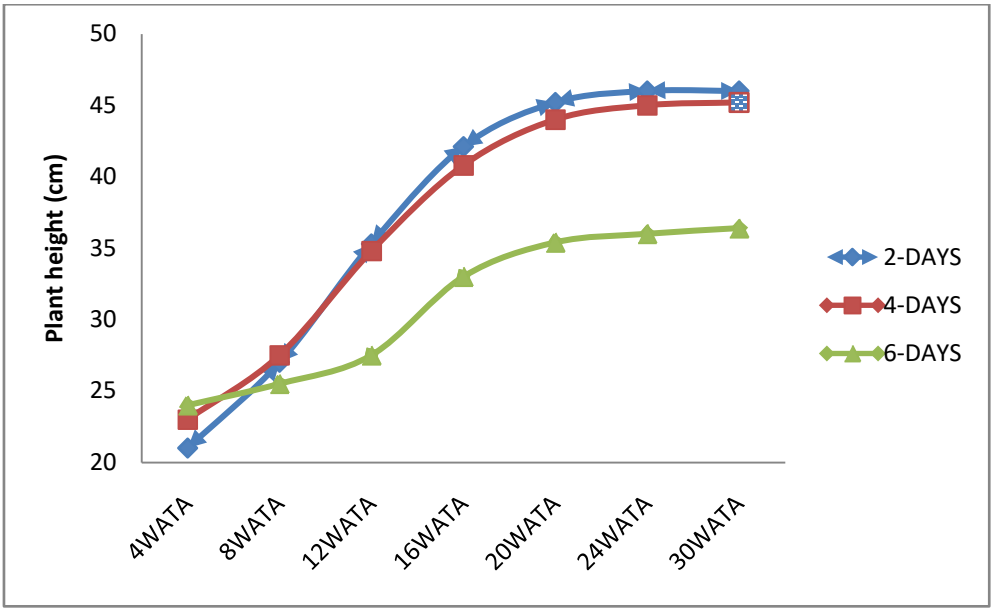

Figure 1: Effects of watering regimes on cayenne pepper plant height

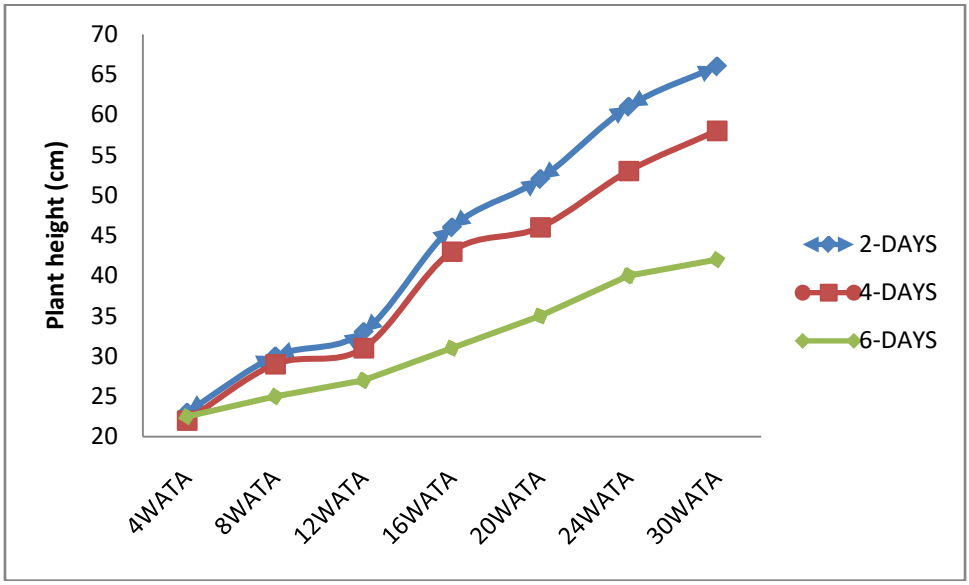

Figure 2: Response of Wrinkly pepper to watering regimes on plant height development

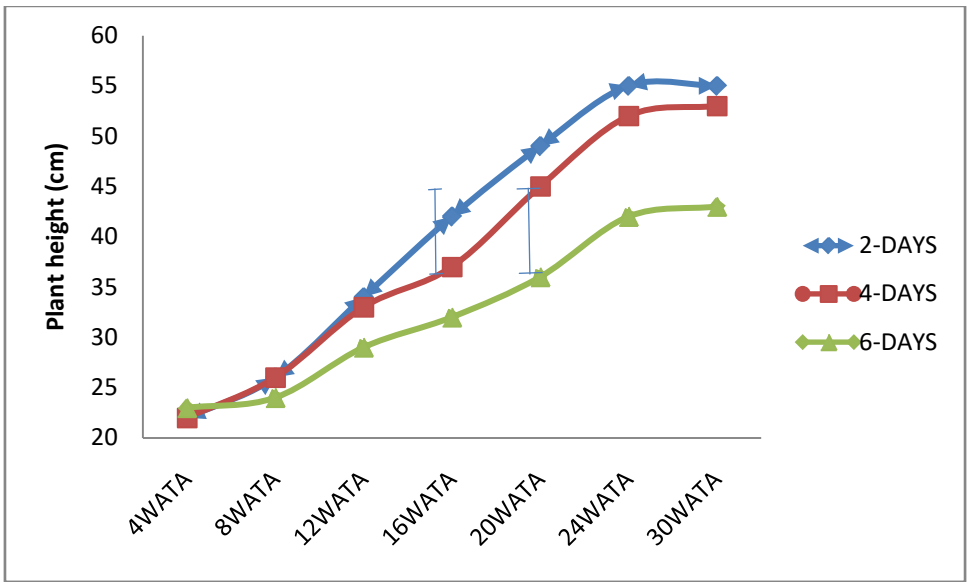

Figure 3: Response of Bell pepper to varying watering regimes on plant Height

Table 2: Response of pepper varieties to varying irrigation regimes on number of leaves produced during 2017 and 2018 experiments

Crop Variety	Irrigation regime	Number of Leaves produced in weeks, 2017						Number of Leaves produced in weeks, 2018					
		4	8	12	16	20	24	4	8	12	16	20	24
Cayenne pepper	2days	10.11.5a	24.6a	37.4b	53.1b	76.4b	89.2b	13.4a	29.3a	47.4a	63.1a	86.4a	89.2b
	4days	12.1a	21.2a	35.2b	54.0b	78.9b	91.9b	12.1a	31.2a	45.2a	64.0a	72.9a	81.9b
	6days	12.1a	22.1a	29.9bc	36.6cd	45.7d	55.3d	11.1a	22.1b	34.9b	42.6b	53.7b	58.3c
Wrinkle pepper	2days	11.4a	23.9a	41.3a	69.4a	106.4a	118.4a	11.4a	23.9b	53.3a	63.5a	86.8a	98.6a
	4days	12.7a	23.8a	53.6a	76.1a	96.8a	102.6a	12.7a	25.8b	48.6a	60.1a	76.8a	92.1b
	6days	11.3a	19.9c	34.2b	44.9c	58.3c	77.3c	12.3a	20.2c	34.2b	44.2b	51.4bc	60.4c
Bell pepper	2days	12.2a	17.0b	33.8b	44.6c	49.3c	56.7d	11.4a	20.7c	28.7c	47.0b	63.9b	67.5c
	4days	12.3a	18.3b	28.3bc	42.5c	46.3d	52.5d	12.0a	25.3b	32.3b	40.4c	57.7b	60.3c
	6days	9.0a	16.2b	22.3c	28.9d	34.3e	36.7e	12.7a	15.3d	21.8c	29.7d	36.6d	40.6d

Table 3 represents the response of three pepper varieties to varying irrigation regimes on branch development. The results indicated that branching in wrinkle and Capsicum frutescens pepper were not significantly different from each other when combined with four and eight days irrigation interval but were significantly higher compared with branch development under twelve day irrigation regime. Branch development in bell pepper under the three irrigation regimes was significantly lower compared with those of Capsicum frutescens and Capsicum chinense under the same treatments.

Table 4 shows the root parameters of the three pepper varieties as influenced by varying irrigation regimes. The result indicated that root development among the three pepper varieties were positively influenced by the irrigation regimes. Four days irrigation intervals significantly favoured higher root development compared to those plants under two and six day irrigation intervals. Tap root development, total lateral root length and longest lateral root length were significantly higher in four days irrigation intervals over two and six day interval. The fresh root volume was also higher significantly under four days irrigation interval compared to other treatments. Dry root weight was higher significantly among four days irrigation intervals across the three pepper varieties. Capsicum frutescens pepper showed a significantly higher fresh and dry root weight over wrinkle and bell pepper. The root weight of bell pepper was significantly lower compare with that of Capsicum chinense.

Table 3: Response of pepper varieties to varying irrigation regimes on stem branch development for 2017 and 2018 experiments

Crop Variety	Irrigation regimes	Number of Branches produced in weeks, 2017						Number of Branches produced in weeks, 2018					
		4	8	12	16	20	24	4	8	12	16	20	24
Cayenne pepper	2days	2.2a	4.6a	7.4a	11.0a	11.5a	11.5a	2.2a	5.0a	10.4a	11.7a	11.6a	12.8a
	4days	2.0a	3.5a	5.0b	8.5b	8.6b	9.2ab	2.7a	6.4a	8.6a	8.5a	9.3a	11.3a
	6days	2.1a	2.5b	2.8c	3.0c	3.2c	3.2c	3.4a	4.8a	6.8b	7.0b	8.1b	8.1b
Wrinkle pepper	2days	1.7a	5.8a	7.9a	10.0a	12.4a	12.7a	1.5a	5.7a	9.1a	11.3a	12.4a	14.0a
	4days	1.5a	2.0b	3.4c	6.5b	8.0b	8.0b	2.4a	3.8b	8.0a	11.5a	12.7a	13.5a
	6days	1.8a	2.0b	3.2c	3.2c	3.5c	3.5c	3.3a	3.5b	5.1b	6.8a	7.5b	7.5b
Bell pepper	2days	2.1b	4.5a	5.2b	5.6c	6.0b	6.5b	2.5b	4.5b	6.2b	7.3b	7.5b	8.0b
	4days	2.0a	4.3a	4.5b	6.0b	6.0b	7.2b	2.1a	4.0b	5.0b	7.4a	7.5b	7.5b
	6days	1.8a	2.0b	3.5c	3.5c	4.2c	4.2c	1.00a	2.5c	2.5c	2.9c	5.4c	5.4c

Table 4: Response of pepper varieties to varying irrigation regimes on roots parameters for 2017 and 2018 experiments

Plant Variety	Irrigation Regime	Tap root length (cm)		Total lateral root length (cm)		Longest lateral root length (cm)		Fresh root volume (cm^3)		Dry root weight (g)	
		2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
Cayenne pepper	2days	6.5b	7.2a	67.8b	58.6b	17.8c	19.1d	25.5a	26.0a	11.3a	10.8a
Wrinkle pepper	4days	5.3c	6.2b	62.4b	65.1a	18.9c	22.4c	22.7a	29.5a	10.6a	9.6a
	6days	7.5ab	7.8a	78.1a	68.4a	21.4b	23.2c	9.5c	13.0b	6.2b	5.2b
	2days	7.1ab	6.5b	58.6c	55.3b	22.3b	22.0c	26.5a	21.0ab	12.0a	11.3a
	4days	7.5a	7.0a	72.4a	53.8b	34.4a	29.5b	19.0b	27.5a	10.2a	7.4b
	6days	8.5a	8.6a	75.5a	68.1a	36.8a	35.8a	8.0c	15.0b	7.6b	5.4b
Bell pepper	2days	5.6c	5.2c	37.0d	45.7c	16.7d	77.5d	13.0c	12.0c	3.9c	3.2c
	4days	5.7b	4.5c	42.0d	48.5c	10.0c	7 19.4d	26.0c	11.0c	3.1c	3.0c
	6days	5.6c	4.8c	35.1d	46.8c	16.2b	24.6c	204.5d	6.5d	1.2d	1.5c

Table 5 shows the yield parameters of the three selected pepper varieties to varying irrigation regimes. The results show that flowering and fruiting in pepper is a factor of variety as the fruit yield data varied significantly with varieties. The highest significant flower and fruit yield was recorded from Capsicum chinense which was significantly higher than the values of both Capsicum frutescens and bell pepper. The lowest flower number and fruit number came from bell pepper which was significantly lower compared to the other two varieties. Interactions between irrigation regimes and varieties specifically influenced yield of the different pepper varieties. two and four days irrigation intervals induced flowering and fruit settings in wrinkle and cayenne pepper which led to high fruit yield. In bell pepper, increased frequency of irrigation (2 days interval) tends to promote flower abortion while irrigation at 4 days interval favours fruit setting and development.

The fruit weight(kg) were significantly enhanced in both wrinkle and Capsicum frutescens pepper by closer frequency of irrigation (2 days interval) which significantly differs from those of 4 and 6-days irrigation regimes. No significant difference was recorded between wrinkle and Capsicum frutescens pepper under 6days irrigation interval in term of fruit yield weight.

Table 5: Response of pepper varieties to varying irrigation regimes on yield parameters. 2017 and 2018 experiments

Plant Variety	Irrigation Regime	Total number of flowers/stand		Total Number of fruits/stand		Total Fruit weight (Kg)/stand	
		2017	2018	2017	2018	2017	2018
Cayenne pepper	2days	865.3b	980.5b	475.4b	398.9b	2.85a	2.94a
Wrinkle pepper	4days	662.8b	725.2b	380.2b	324.6b	1.54b	1.51b
	6days	325.2c	441.6c	197.8c	164.5d	0.82b	0.73c
	2days	1340.4a	1520.1a	580.1a	481.1a	2.64a	2.55a
	4days	1201.9a	1243.2a	420.9b	389.0b	1.35b	1.23b
	6days	732.0b	875.8b	230.5c	245.8c	0.91b	0.78c
Bell pepper	2days	135.4d	123.4d	19.2d	14.1e	0.13c	0.16d
	4days	93.7d	102.6d	16.4d	13.3e	0.12c	0.15d
	6days	61.3e	49.2e	4.7e	5.7e	0.04e	0.05e

IV. Discussion

The findings from this research shows that for sustainable and year round pepper production in the south western part of Nigeria, irrigation remains the only way out to meet the ever widening gap in between the production and consumption. Metin *et al.,* (2006) submitted that effective soil moisture managementis akey for sustainable pepper production. To meet the present world demand for pepper, a concerted effort is required in ensuring year round production through supplementary irrigation (Agele *et al*., 2011, Lodhi, *et al*., 2014).Considering the growth patterns of the selected pepper varieties that were similar across the two years

of the experiment Agele *et al*., (2011) reported that growth, senescence and other physiological processes in pepper is actively controlled by moisture and nutrient availability in the soil. The physiological traits of the pepper varieties were influenced by moisture availability. The significantly higher stem height development recorded in Capsicum chinense was as a result of gene composition which dictates character expression in plant. Wrinkle and Capsicum frutescens pepper were known to grow taller in stem height compared to bell variety (Lodhi *et al*., 2013).

The similarity in the developmental pattern of Capsicum chinense with two and four day irrigation intervals may be due to sufficient moisture at the rooting zone which permit continuous moisture absorption and production of assimilates for growth and development. This was in line with the submission of Hsiao, (1993) that uninterrupted moisture availability within crop root zone during active growth stages enhances crop development. The significantly higher stem height development and leaves production recorded in the pepper varieties with two and four days irrigation intervals over those with six days irrigation intervals were justified by the findings of Agele *et al;* (2003) that maintaining soil moisture level at field capacity enhances shoot development in pepper.

The importance of soil moisture availability to plant growth and development was revealed as leaf production in the three pepper varieties were significantly influenced by irrigation regimes. This was in tandem with the findings of Agele *et al*, (2011) that closer irrigation intervals enhanced soil moisture retention which aids growth and development in pepper. The maximum average plant heights, number of leaves and leaf area index recorded in the three varieties showed that the plants responded differently to both nutrients and moisture availability. Although closer regimes of irrigation was applied across the varieties, this did not translated to corresponding uniformity in stem height, leaf number and leaf area across the varieties. This was as a result of variation in the water use efficiency of the pepper varieties, canopy and root system architectures. It is most probable that the amount of applied water per time may be too much for the crop use hence percolation losses without any appreciable compensation in term of shoot growth/development. These was in agreement with the findings of Njouajio *et al*.,2007.that though water is one major factor required for increasing pepper production, voids in soil structure were also needed to allow expansion of soil aggregates and roots during changes in soil temperature. This is also similar to the report of Bahmani *et al*. (2009) that constant saturation and over-saturation reduces crop growth and development especially for a crop like pepper that does not require too much water.

The significantly lower performance of crops under six days irrigation regimes was as a result of regular occurrence of soil moisture deficit through evapotranspiration, percolation and infiltration below field capacity even to wilting point during active vegetative and productive growth stages. This scenario continuously created a lacuna in the absorption and growth processes in the crop thereby leading to poor crop performance.

The significantly higher root parameters recorded in four and six days irrigation intervals was as a result of partitioning of higher percentage of produced assimilates for root development to enhance moisture absorption from the soil. This was supported by Famuwagun and Agele, 2010, Famuwagun, 2016 that plants adapt to moisture stress by partitioning more assimilates for root development as moisture in the soils diminished. The results were in line with that of Khan *et al.* (2005) who reported that plants under moisture stress tends to shortened their life span and try to complete their lifecycle in haste which causes earliness to flowering, fruiting and higher root volume development.

V. Conclusion

From the results, at the early stage of growth in pepper being a tap rooted plant, four- six day irrigation interval may be sufficient due to lesser transpiration rate, but as the canopy increases, a more frequent irrigation intervals is required to complement moisture requirement for growth and development and replace the lust moisture due to evapotranspiration for optimum growth, development and fruit yield..

References Références Referencias

1. Agele S.O., Adeyemo J.A. and Famuwagun I.B. 2011: Agricultural wastes and mineral fertilizer on soil and plant nutrient status, growth and yield of tomato. *Archives of Agronomy and Soil Science.* 57(1); 91–104 Taylor and Francis
2. Agele, S.O., Agbona, I. A., Famuwagun, I.B. & Ogundare, S.K. 2015. Growth and water-yield functions of dry season fadama-grown pepper under differential irrigation in a rainforest zone of Nigeria. Annual Research & Review in Biology 5(5):419-432.
3. Antony E, Sing and hupe RB, 2004: Impact of drip and surface irrigation on growth, yield and WUE of capsicum (Capsicum annuum L.). Agr Water Manag. 65:121–32.
4. Charles Tortoe*, Papa Toah Akonor and Edna Meriku Essel (2016): Physicochemical and colorimetric properties of green pepper (Capsicum annum L.). Annals of food science and technology 2016.

5. Dalla Costa L. and G. Gianquinto, (2002): Water stress and watertable depth influence yield, water use efficiency, and nitrogen recovery in bell pepper: lysimeter studies. *Australian Journal of Agricultural Research* 53(2) 201 - 210
6. FAO, 2003. *FAOSTAT online database*. Rome, Italy: The Food and Agriculture.
7. Famuwagun I. B. and Agele S.O. 2010: Effect of sowing methods and population densities on root development of cocoa (*Theobroma cacao*) seedlings in the nursery. *International Journal of Agric Research* 6(3); 34-39.
8. Famuwagun I. B, 2016: Cacao Developmental Pattern, Soil Temperature and Moisture Variation as Affected by Shade and Dry Season Drip Irrigation. *International Journal of Plant & Soil Science 12(3): 1-6, 2016, Article no.AJEA.22628* SCIENCEDOMAIN *international.*
9. Hsiao TC, 1993: Growth and productivity of crops in relation to water status. Acta Horticulturae. 335:137–48.
10. Khan MH, Chattha TH, Saleem N, 2005: Influence of different irrigation intervals on growth and yield of bell pepper (Capsicum annuum grossum group). Res J Agr Biol Sci. 1:125–28.
11. Lodhi A.S., A. Kaushal and K. G. Singh, 2014: Impact of Irrigation Regimes on Growth, Yield and Water Use Efficiency of Sweet Pepper. Indian Journal of Science and Technology, Vol 7(6), 790–794, June 2014.
12. Lodhi AS, Kaushal A, Singh KG, 2013: Effect of irrigation regimes and low tunnel heights on microclimatic parameters in the growing of sweet peppers. International Journal of Engineering Science Invention. Vol. 2(7): 20–29.
13. Metin Sezen, Attila Yazar and Salim Ekern 2006: Effect of drip irrigation regimes on yield and quality of field grown bell pepper. Journal of Agricultural Water Management col 81 issues1-2, 2006 pg 115-131.
14. Nwachukwu C.U. and F. N. Mbagwu 2009: Morphological and Leaf Epidermal features of Capsicum annum and Capsicum frutescens (Solanaceae) Journal of American Science, 5(1), 2009, ISSN 1545-1003, http://www.americanscience.org.
15. Ngouajio M, Wang G, Goldy R, 2007: Withholding of drip irrigation between transplanting and flowering increases the yield of field-grown tomato under plastic mulch. Agricultural Water Management. Vol. 87: 285–91.
16. Olotu Yahaya, Femi Alao, Odighi Cletus (2012): Yield-crop water use (cwu) evaluation for pepper production under irrigated cultivation in akure, Nigeria. Global Journal of Science Frontier Research Agriculture & Biology Volume 12 Issue 1 Version 1.0 January 2012.
17. Purseglove, J.W. 1981. Tropical crops.4 vols. Longman Group Ltd., London.
18. Vidyard, R. D and Tripathi S.C 2002. A text Book of Botany. S. Chand and Company Ltd. 7361, Ram Nagar, New Delhi 1054 Pp.

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Livelihood Diversification and Household Well being of Buffer Zone Area of Nepal: A Case of Chitwan National Park

By Keshav Raj Dhakal
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Abstract- This paper aims at analyzing livelihoods of people of buffer zone areas highlighting the case of Chitwan National Park, Nepal. The study has been based on primary data collected through open and close ended questionnaire method. A mixed method research design was employed in this study. Both quantitative and qualitative data were collected at household level. Of the 22 buffer zone users committees in Chitwan National Park, 4 buffer zone users committees were selected from random sampling. From these selected buffer zone user committees, 10% (845 households) of the total households were selected using random sampling. Responses to the close ended questions were analyzed through the SPSS (Statistical Package for the Social Sciences) and responses to the open-ended questions were analyzed inductively. People of this study area primarily rely on agriculture with livestock rearing for their livelihoods. Different varieties of food crops and cash crops were grown in this area. About one third of the respondents were food crop deficient condition. The food deficient respondents had different copping strategies such as selling labour and livestock, borrowing money from others, selling cash crops and other household assets etc.

Keywords: *livelihood, landholding, diversification, buffer zone, non-farm livelihood.*

GJSFR-D Classification: *FOR Code: 300000*

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Keywords: livelihood, landholding, diversification, buffer zone, non-farm livelihood.

I. Introduction

Livelihood is a means of living, skills required, property/assets, and activities (Chambers & Conway, 1992; Carney, 1998). A livelihood comprises the different types of assets, activities and capabilities for means of living. Livelihoods are outcome of how and why people organize to transform the environment to meet their needs through technology, labor, power, knowledge and social relations (Hoeck, 2001). Rural livelihoods comprise one or more often several activities, which variously provide food, cash, and other goods to satisfy a wide variety of human needs (Chambers & Conway, 1992). People's access to different levels and combination of assets has probably the major influence on their choice of livelihood options. The availability of assets, socio-economic and ecological environments and people's choice are the primary determinants for livelihood diversity. Livelihood diversification exist within different geographic areas, across different sectors and over time.

A livelihood approach draws on this improved understanding of poverty, bringing together relevant concepts to allow poverty to be understood more holistically (Farrington et al., 1999). The livelihood approach or framework arose from the broad context of rural development theory (Schuit, 2011) and attempted to go beyond the conventional definitions and approaches to poverty eradication and the integrated rural development (Mbaiwa et al., 2008). Ellis (2000) describes household assets as stocks of capital that can be utilized directly or indirectly, to generate the means of survival of the households. According to Dhakal (2018) livelihood of the people used to depend upon crop farming, livestock farming, fishing, grass and wood cutting and selling, wage and household laboring etc. but the change in socio economic condition influenced by the tourism activities, commercial agriculture, remittance, service sector etc. are the form of livelihood change of adjacent to Chitwan National Park.

The household assets in livelihood approach appear backbone for adaptive and copping strategies from them. People require a range of assets to achieve positive livelihood outcomes. A brief description of the livelihood assets as defined by DFID are natural, physical, human, social and financial capital. In rural areas of developing countries, households combine diverse portfolios of activities in their pursuit of alleviating poverty and improving living standards (Ellis, 2000). Enormous diversities in livelihoods are realized by locality (Bishop 1990, Zoomers 1999, Dahal 2001, Subedi and Pandey 2002, Sulivan et al. 2004) across sectors and households. Livelihood diversification is a process by which rural households construct a diverse portfolio of activities and social support capabilities in their struggle for survival and improvement in their standards of living (Ellis, 2005) and the means of gaining a living Chambers, 1995). The objective of the study was to analyze the diversity of livelihood and household wellbeing of buffer zone area of Chitwan National Park, Nepal.

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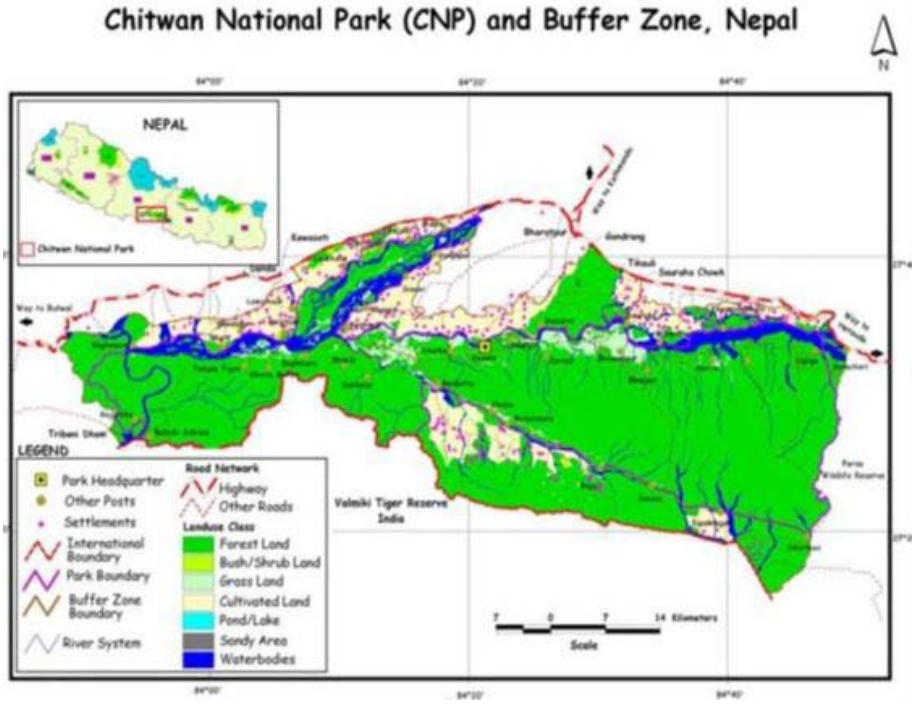
II. Methods and Materials

The Buffer zone area of Chitwan National Park was chosen as the study area. A mixed method research design was employed in this study. Mixed methods research has become increasingly recognized as an approach capable of uniting quantitative and qualitative approaches through the creation of a third paradigm (Johnson et al., 2007). Both quantitative and qualitative data were collected at household level. Of the 22 buffer zone users committees in Chitwan National Park, 4 buffer zone users committees were selected from random sampling. From these selected buffer zone user committees, 10% (845 households) of the total households were selected using random sampling. The lists of households were achieved from the register of respective buffer zone users committee. The household in the buffer zone user committee was considered as sampling frame. Primary data were collected through household survey including open and closed ended questions. This method of data collection is quite popular, particularly in the case of big research studies. Both statistical and non-statistical tools will be applied for data analysis. Responses to the close ended questions were analyzed through the SPSS (Statistical Package for the Social Sciences). Responses to the open-ended questions were analyzed inductively. Along with various diagrams were used as non-statistical tools to draw a clear picture of the study.



III. Result and Discussions

a) *Livelihoods diversification*

Livelihood diversification refers to a key strategy taking place at different levels of the economy, which are usually, but not always directly linked (Start, 2001). Livelihood diversification is one of the most remarkable characteristics of livelihoods. Diversity and diversification in livelihoods is used to include growing, multiplying sources of revenue. Diversity refers to the existence at one time of multiple sources of income (Scoones, 2009); whereas diversification refers to the growth of diversity as the dynamic economic and social process of the farm household (Ellis, 2000).Nepal has an agrarian economy with over 80% of the population in rural areas, the majority adopting subsistence agriculture as themain stay of their livelihoods (CBS, 2012).In the study areas, households depended on diverse sources of activities for generating their income but agriculture was the primary source of income practiced by all interviewed households.

Table 1: Livelihood diversification

S. N.	Livelihood diversification	No. of respondents	Percentage
1.	Agriculture/livestock	338	40.00
2.	Service	137	16.21
3.	Wage Labor	222	26.27
4.	Business	127	15.02
5.	Remittance	85	10.06
6.	Social securities	16	1.89
7.	Others	101	11.95

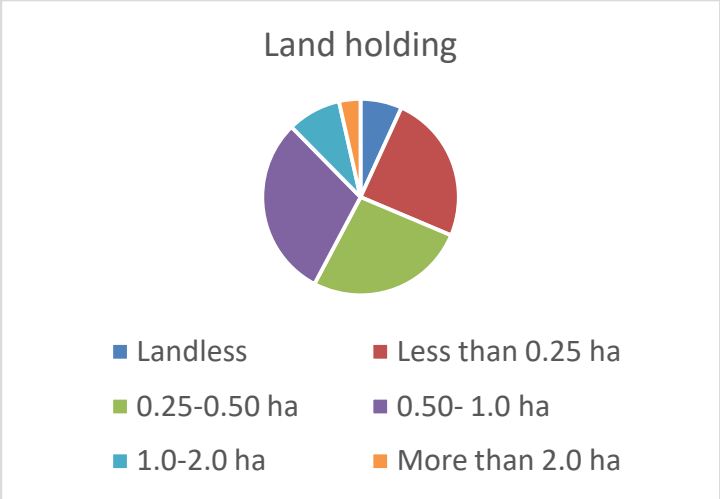
Source: Field survey, 2018

People of this study area primarily rely on agriculture for their livelihoods. Agriculture is a source of livelihood for about 40% of citizens. Rearing livestock is an integral part of agriculture along with crop farming in

this area. Agriculture has strong linkages with the non-farm sector through agro-processing, urban markets and export trade. In sub-Saharan African countries, agriculture as the primary source of income has not secured adequate livelihood for most farming households (Babatunde, 2013). Farm households engage and pursue diverse non-farm livelihood activities to cope with diverse challenges and risks such as drought (Gebru & Beyene, 2012; Alobo, 2015; Kassie & Aye, 2017). Non-farm activities have the potential to help households reduce poverty by offering them with a form of insurance against the threats of farming and minimizing reliance on natural resources. Previous empirical study by (Haggblade, et al., 2010) reports that rural residents across the developing world earn 35–50% of their income from non-farm. In this study 68.77 % of the HHs were dependent on agriculture related occupation, including livestock rearing, while few HHs respondents (15.02 %) were involved in business sectors.

b) Land holding

Land is an important natural capital of the local people as agriculture is the main source of subsistence of the people in study area. Farmland plays a significant role in livelihoods, as it is the source of food for people and livestock, fuel wood, timber and cash income. The landholding size has colossal impact on types of occupation in the villages under study where major sources of household income is from agriculture. Land holding system in any area implies a system according to which land is held by an individual or the actual tiller of the land. Land holding system determines his/her rights and responsibility in connection with his/her holding.



Source: Field survey, 2018

In the study area 95.4 percent of the respondents had their own land. Few people are landless and very few have landholding more than 2 ha. The landless people are 6.86 percent and people more than 2 ha are 3.55 percent. The greatest number of people, 29.94%, have landholding of 0.50 – 1.0 ha while 26.50% of the people have landholding 0.25- 0.5 ha. The study area is mainly dominated by marginal and small farmers.

c) Food crop produced

Involvement in agricultural sector is one of the important strategies for rural people's livelihood. Though people perform a number of activities for their livelihoods, agriculture is the main activity in terms of people's employment as well as contribution on household income. Varieties of crops are grown in this area. Among them rice, maize and wheat are considered as major crops in terms of both area occupied and total production. Cash crops as mustard, lentil and vegetables were the most common type of crops that were grown in the study area. In this area the combination of food crops and cash crops were the most prominent. These are illustrated on table 3 below.

Table 2: Types of food crops produced

S. N.	Food crops	Number of respondents	Percentage
1.	Rice	67	7.92
2.	Wheat	48	5.68
3.	Maize	35	4.14
4.	Rice + Wheat	189	22.36
5.	Wheat + Maize	95	11.24
6.	Rice + Maize	159	18.81
7.	others	252	29.82

Source: Field survey, 2018

d) Livestock products

Livestock rearing is an integral part of the agriculture, and it is one of the sources of the household income in the study area. It is one of the financial assets, which supports livelihoods in many ways supplying

different products such as milk, meat, wool, hides and manure for crop cultivation. Besides, it is used for drought power and as a means of transporting goods. Cattle, buffalo, goat, sheep and chicken are the major types of the livestock reared in this area. The people raise livestock either as stall-feeding or as grazing animals.

Table 3: livestock products

S.N.	Livestock products	No. of respondents	Percentage
1	Milk	99	11.71
2	Meat	45	5.32
3.	Egg	91	10.76
4.	Milk + Meat	120	14.20
5.	Milk + Butter	70	8.28
6.	Milk + Egg	105	12.42
7.	Meat + Egg	89	10.53
8.	Milk + Meat + Butter	78	9.23
9.	Others	103	12.89
10	None	45	5.32

Source: Field survey, 2018

The average livestock unit per household was found to be 1.73 LSU (livestock unit). The most common types of livestock reared were cow, goat, buffalo, ox, sheep and Poultry. 5.32% of the respondents didn't produce any type of livestock products while among those who produced livestock produced; milk was the most common. Other types of livestock products that were produced in the study areas included meat, eggs and butter. These types of livestock products provided households with an alternative source of income for the poor.

e) Status of sufficiency of food crops and coping strategies

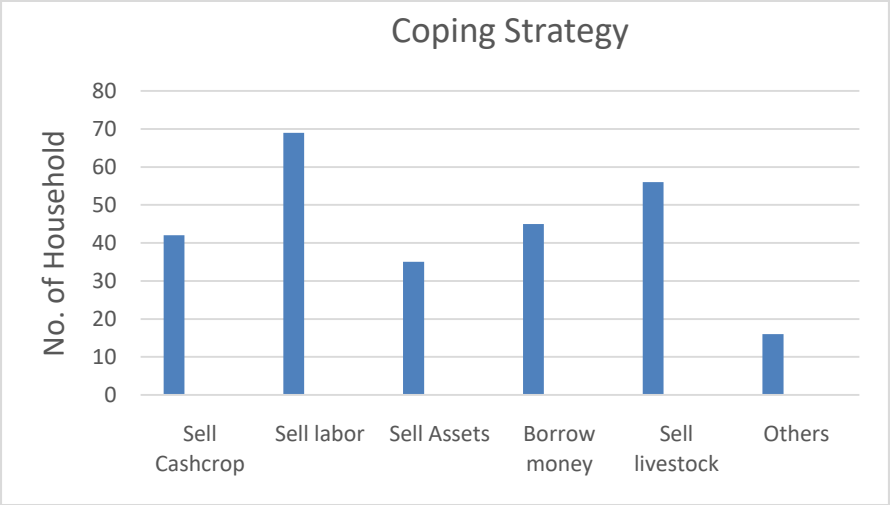
About 31.24% of the respondents were food crop deficient condition. This is understandable due to the fact that very few respondents grow these types of food crops and depend upon buying and bartering to fulfill their needs. It may be due to a number of factors as larger family size, lack of land, shifting pattern from agriculture towards business and services and shifting pattern in crop production from food crops towards cash crops and pulses.

Table 4: Status of sufficiency of food crops

S. N.	Food crops	Number of respondents	Percentage
1.	Sufficient	105	12.42
2.	Balanced	477	56.44
3.	Deficient	263	31.24
4.	Deficit period <3 months	87	10.29
5	Deficit period 3-6 months	105	12.42
6	Deficit period > 6 months	71	8.40

Source: Field survey, 2018

Majority of the respondents 31.24% of the respondents were food crop deficient, 10.29% of them were deficient for a period of 1-3 months while nearly 12.42% were deficient for 3-6 months and 8.40% of the respondents were deficient for a period of more than 6 months up to 1 year.



Source: Field survey, 2018

The respondents who were deficient in food crop, they had different copping strategies to sell food crop for survival. These copping strategies were selling labor (8.16 %), selling livestock (6.62%), borrow money from others (5.32%), selling cash crop (4.97%) and selling other household assets (4.14%) etc.

IV. Conclusion

The diversification of livelihood strategy in the study area was changed from agriculture based to non-agriculture. Land was a major household asset and crop production (maize, mustard, paddy, wheat etc.) was the means of subsistence. However, agriculture

even in the past was not sufficient for them rather they had to dependent other activities besides agriculture. For the period in which agriculture was insufficient, they worked to collect forest resources, off farm labor work and the wage labor in the city. Besides they also worked in the field of different sector for manual work. Now they have no option other than modifying their traditional agriculture towards commercialization of agriculture and adoption of non-agricultural activities. Increasing access in urban employment, expansion of the market for their agriculture are the opportunities created by urbanization. Foreign employments as recently emerged livelihood strategies and due to the proximity to the market the influence of the urbanization is more apparent in the study area. Most of the households follow the multiple occupations besides agriculture and the role of agricultural activities in their life is only substantial. Although a few households sell their crops and vegetable. They are only able to harvest food for some months from their own production. Government of different level also formulated different type of income generation policy and program for the surrounding people. Different types of income generation policy and program makes the better livelihood strategies of people in the study area.

Author Contribution: Keshav Raj Dhakal – Conceptuali zation, methodology, investigation, data analysis, original draft preparation, editing and final paper preparation.

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Conflict of Interest: The author declares no conflict of interest.

References Références Referencias

1. Alobo, L. S. (2015). Rural livelihood diversification in sub-Saharan Africa: a literature review. *J Dev Stud.* 51 (9):1125–1138.
2. Babatunde, R.O. (2013). On-farm and off-farm works: complement and substitute? Evidence from Rural Nigeria. Contributed paper for the 4th International Conference of the African Association of Agricultural Economists, September 22-25, Hammamet, Tunisia. URL: http;//ageconsearch. umn.edu. Accessed on March 10, 2021.
3. Bishop, B. C. (1990), *Karnali under stress: livelihood strategies and seasonal rhythms in a changing Nepal Himalaya.* Illinois: University of Chicago.
4. Carney, D. (Ed.). (1998). *Sustainable rural livelihoods: What contribution can we make?* London: Department of International Development (DFID).
5. CBS. (2012). National Planning and Housing Census 2011 (National Report) National Planning Commission, Kathmandu.
6. Chambers, J.K. (1995). *Sociolinguistic theory*. New York: Blackwell.
7. Chambers, R & Conway, G. (1992).Sustainable rural livelihoods: practical concepts forthe 21st century. (Discussion Paper 296). Brighton: Institute of development studies.
8. Dahal, K. B. (2001), "Struggling with development: a case study of the changing livelihood strategies of the Baramus from western Nepal". Unpublished Master's thesis in Sociology/Anthropology: Tribhuvan University.
9. Dhakal, K.R. (2018). People's perception on tourism related livelihoods: A case study of Patihani. *Pragya Darshan.* 1(2): 128-135.
10. Ellis, F. (2000). *Rural livelihoods and diversity in developing countries.* Oxford: Oxford University Press.
11. Farrington, J., Carney, D., Ashley, C. &Turton, C. (1999). Sustainable livelihoods in practice: early applications of concepts in rural areas. Overseas Development Institute. Natural Resource Perspectives 42: 1-15. URL: http://www.odi.org.uk [accessed Jun 21 2021].
12. Gebru, G.W. & Beyene, F. (2012). Rural household livelihood strategies in drought-prone areas: a case of Gulomekeda District, eastern zone of Tigray National Regional State, Ethiopia. *J. Dev. Agric. Econ.* 4 (6):158–68.
13. Haggblade, S., Hazell, P. & Reardon, T. (2010). The rural non-farm economy: prospects for growth and poverty reduction. *World Dev.* 38(10), 1429–1441.
14. Hoeck, W. van der. (2001), *Water and rural livelihoods*. Retrieved from http://www.ifpri.org/2020/ focus09/ focus09_05.htm.
15. Johnson, R. B., Onwuegbuzie, A. J. & Turner, L. A. (2007). Toward a definition of mixed methods research. *Journal of Mixed Methods Research,* 1(2), 112-133.
16. Kassie, G.W, & Aye, G. (2017). The Nexus between livelihood diversification and farmland management strategies in rural Ethiopia. Cogent Econ Finance. 5(1):1275087. https://www.researchgate.net/publication/327477250_Determinants_of_livelihood_diversification_strategies_in_Eastern_Tigray_Region_of_Ethiopia [accessed Jun 19 2021].
17. Mbaiwa, J.E., Ngwenya, B.N. & Kgathi, D.L. (2008). Contending with unequal and privileged access to

natural resources and land in the Okavango Delta, Botswana. *Singapore Journal of Tropical Geography*, 29: 155–172.

18. Schuit, P. (2011). Livelihood Strategies in the Buffer Zone of La Amistad Biosphere Reserve, Costa Rica. Master's Thesis. Wageningen University, the Netherlands.
19. Scoones, I. (2009). Livelihoods perspectives and rural development. *The Journal of Peasant Studies,* 3691), 171-196.
20. Start, D. (2001). The rise and fall of the rural non-farm economy: Poverty impacts and policy options. *Development Policy Review*, 19, 491–505.
21. Subedi, B. P. and Pandey, R. (2002), Livelihood strategies of Rai communities in Arun valley: continuity and change. In Chaudhary, R. P, Subedi, B. P Vetaas, O. R and Aase, T. H. editors, *Vegetation and society: their interaction in the Himalayas.* Kathmandu: Tribhuvan University, Nepal and University of Bergen, Norway.
22. Sulivan, C. A., Rijal, S. P., Shrestha, M., Khanal, N. and O'regan, D. P. (2004). A*n assessment of the potential impacts of climate-induced deglaciation on communities and their livelihoods in the Hindu Kush-Himalaya.* (DFID KAR Project No. R7980). Wallingford: Center for Ecology and Hydrology.

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Impact of Farm Technologies on Food Security among Smallholder Farmers in Taraba State

By Ojeh, N. Vincent & Bawa, Winnie Irisim

Taraba State University

Abstract- This study examined the role of farm technologies on food security among smallholder farmers in six LGAs in Taraba State. The objectives of the study were to: examine the food security status of smallholder farmers in Taraba State, examine factors affecting the adoption of farm technology and vulnerability to food insecurity by smallholder farmers, determine the level of adoption of farm technology by smallholder farmers and determine the impact of farm technology on household food security in Taraba State. A multistage sampling technique was used to select three farming communities in six Local Government areas, two from the three senatorial districts of the Taraba state. Random sampling was used to select a sample of 400 respondents; the respondents returned 385 questionnaires. Descriptive statistics and inferential statistics were employed for data analysis. The result showedthe farm technologies used by farmers in Taraba state, thus, 50.6% used herbicides/ pesticides while 47.8% used fertilizers as 45.7% used sprayers.The level of farm technology adoption shows that pesticides/herbicides usage is highest with 50.7%, fertilizer usage (47.8%), sprayer (45.7%), improved seeds (43.1%) were the most used.

Keywords: *agriculture, technology adoption, food security, smallholder farmers.*

GJSFR-D Classification: *FOR Code: 070199*

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Keywords: agriculture, technology adoption, food security, smallholder farmers.

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I. Introduction

Nigeria is a blessed country with abundant physical, human and natural resource endowments; however, many of its populace lives below both the outright and relative poverty lines. The public survey conducted between 2003 and 2004 shows that somewhat above half of the populace (51.6 per cent) live under one USA dollar each day, and the relative national poverty incidence was found to be 54.4 per cent (National Bureau of Statistics (NBS), 2005, 2008). Notwithstanding, the most current Human Advancement Report by the United Nations Development Programme (UNDP, 2009) shows that about 64.4 and 83.7 per cent of the populace live beneath $1.25 and $2 every day, individually. This poverty circumstance is more awful in the rural areas where more than 70% of individuals dwell and make money through farming than in the metropolitan regions (UNDP, 2009). More than 86.5 per cent of the rural population is engaged in agriculture (NBS, 2005).

As one of the Sub-Saharan countries in Africa, Nigeria has a notable share of its population, hinging their means of livelihood and survival on agriculture. Therefore, from the same perspective, the past several decades have seen Nigeria's agrarian sector modifying productivity progression through the adoption of diverse new farming technology globally recognised as unparalleled agronomic practices. These practices include the utilisation of soil erosion control structures, improved seeds, pesticides, fertilisers, new farming techniques, among others.

This perpetually leaves farming as a key area fit for influencing most Nigerians differently. In this way, the perseverance of appetite and neediness in Nigeria should be, generally, the disappointment of the farming area to completely affect emphatically on individuals (NBS, 2017)

Notwithstanding the great achievements in the agricultural sector, Nigeria's agricultural performance lately remains deficient and, in reality, undeniably not as much as its potentials. Food demand surpasses the supply, hence prompting huge importations of food, which further erodes the economies foreign exchange. The growing food import over the course of the years brought about heightening foreign exchange expenditures, which might have been invested into different spaces of the economy. Nigeria imported food

items worth ₦3.474 billion as of 1990 to ₦654 billion in 2007, whereas it could only boast of the agricultural export worth of N73.3 million (CBN, 2007); and this trend has not yet changed. According to a CBN report (pmnewsnigeria, 2018), Nigeria's monthly food import bill fell from $665.4million in January 2015 to $160.4million as of October 2018. These noticeable declines were steadily recorded in our monthly food import bill from $665.4million in January 2015 to $160.4million as of October 2018; A cumulative fall of 75.9 per cent and an implied savings of over $21billion on food imports alone over that period. Most evident was the 97.3 per cent cumulative reduction in monthly rice import bills, 99.6 per cent in fish, 81.3 per cent in milk, 63.7 per cent in sugar, and 60.5 per cent in wheat (pmnewsnigeria, 2018).

The expanded under-productivity in the nation could be an after-effect of various components, which might be direct or indirect. With the quick expansion in the human populace in the country, which was 201,252,133 (Worldometer Report, 2019), there is no doubt that resources are becoming scarcer than ever before, and therefore, development strategies should focus on policies that are intended to increase the productivity of scarce resources. Although smallholder farmers dominate agricultural production in Nigeria and individually exert little influence, collectively, they form the foundation upon which the economy rests. About 90 per cent of Nigeria's total food production comes from small farms, and at least 60 per cent of the country's population earns their living from these small farms, with farm sizes generally less than 2 hectares (Dansabo, 2017). According to the CBN, as Ships and Ports (2018) reported, the above percentage of farmers in the country represent about 862,069 farmers cultivating about 835,239 across the country.

Unfortunately, these smallholder farmers are subsistence farmers and use crude and traditional production implements and techniques resulting in the poor performance of the sector. Therefore, an effective economic development strategy will depend critically on promoting productivity and output growth, particularly among small-scale producers since they make up the bulk of the nation's agriculture. In order to boost the agricultural production base of the country, several policies have been put in place and these in a broad sense; include(Oluwatayo as cited in Dansabo, 2017): the accomplishment of independence in essential food supply and the attainment of food security; expanded production of agricultural raw materials for enterprises; expanded production and processing of export crops, utilising improved production and processing technologies; generating gainful employment; rational utilisation of agricultural resources, improved protection of agricultural land resources from drought, desert encroachment, soil erosion and flood, furthermore, the overall conservation of the environment for the sustainability of agricultural production; Advancement of the expanded use of current innovation to agricultural production and an improvement in the quality of life of rural dwellers (Olowa and Olowa, 2015).

Agricultural productivity in Sub-Saharan Africa remains low, inadequate and considerably behind other continents and regions in the world (Alliance for a Green Revolution in Africa, AGRA, 2013). The agricultural sector, which is known as smallholder mixed farming, is dominated by primary production. According to Food and Agricultural Organization (FAO 2009), the sector has not received sufficient support from sub-Saharan governments. Whilst many agricultural development initiatives in Africa are now supporting the use of modern and appropriate technologies to enhance productivity (AGRA, 2013), farmers continue to be disadvantaged due to failure to adopt such technologies that would guarantee sustainable land use and improved productivity.

According to FAO's (2005) definition and concepts, food securityis achieved when individuals have the food they need to live their lives: it depends on sufficient, adequate food being available; people having access to it; food being well utilised; and on reliable availability and access (Wiggins and Keats, 2013). The Famine Early Warning Systems Network (FEWS NET, 2019) reported that Herders/farmers conflicts ravaging the country, especially the north-central states, parts of southeast and southwest and the armed banditry affecting households in Zamfara and Katsina states had threatened agricultural productivity in these parts of the country. This, according to FEWS NET, has resulted in under nutrition and food insecurity in these parts and the country as a whole. The report of the Global Hunger Index (GHI) for 2018 shows that hunger varies enormously by region. The 2018 GHI scores of SouthAsia and Africa (south of the Sahara), at 30.5 and 29.4, respectively, reflect seriouslevels of hunger. These scores stand in stark contrast to those of East and Southeast Asia, the Near East and North Africa, Latin America and the Caribbean, and Eastern Europe andthe Commonwealth of Independent States, where scores range from7.3 to 13.2, indicating low or moderate hunger levels (von Grebmer, Bernstein, Patterson, Sonntag, Klaus, Fahlbusch, Towey, Foley, Gitter, Ekstrom, and Fritschel, 2018).

Families spend up to seventy per cent of their income on food, and yet nearly fifty per cent of the children under five are malnourished (Ibok, 2012). The present status of hungry people in Nigeria stands at 33% of the country's population of 201,252,133, equivalent to 66.4 million people (von Grebmer et al., 2018; Worldometer.com, 2019). These are matters of grave concern generally in light of the fact that Nigeria was independent in food production and was indeed a net exporter of food to different regions of the African continent during the 1950s and 1960s.Things changed

dramatically for the worse following the global economic crises that hit the developing countries beginning from the 1970s. The discovery of raw crude and rising revenue from the country's oil and gas sector encouraged official neglect of the agricultural sector and turned Nigeria into a net importer of food (Ibok, 2012).

Loevinsohn, Sumberg, and Diagne (2012) see technology as the means and methods of producing goods and services, including methods of organisation as well as physical technique. According to Loevinsohn et al. (2013), new technology is new to a particular place or group of farmers or represents a new use of technology that is already in use within a particular place or amongst a group of farmers (Mwangi and Kariuki, 2015). Technology/innovation is the information/ knowledge that allows some tasks to be executed more easily without any problem, and some services to be rendered or the manufacture of a product with less stress (Lavison, 2013). Technological innovation itself is pointed toward advancing a given circumstance or changing the state of affairs to a more attractive level. It helps the candidate to tackle a job simpler than he would have without the technology; consequently, it assists in saving time and labour (Bonabana-Wabbi, 2002).

The failure by farmers to adopt modern and appropriate technology has previously been blamed on farm location, land tenure security and other personal related factors such as age, gender (Nyariki, 2011), lack of incentives (Masano and Miles, 2004), limited ducation, household income levels, socio-economic status (Adekoya and Babaleye, 2009; Ali, 2014), simplicity and usefulness of the technology (McDonald, Heanne, Pierce, and Horan, 2015). Looking at the present rate of agricultural development and empirical pieces of evidence from the literature, the lacklustre approach to agricultural development in Nigeria, the attainment of Agenda 2030 (Sustainable Development Goals, SDGs) will be a wild goose chase.

Food is a basic necessity of life. Its importance is seen in the fact that it is a basic means of sustenance and adequate food intake in terms of quality and quantity; it is key for a healthy and productive life. The importance of food is also shown in the fact that it accounts for a substantial part of a typical Nigerian household budget (Omonona and Agori, 2007). Food security has always been at the spearhead of countries' agricultural advancement policies because it clearly indicates the population's standard of living, especially in countries where agriculture is the predominant factor of people's livelihood.

The problem of food insecurity is exacerbated by low production and crop loss mainly caused by low technological input, poor management practices, low and irregular rainfall, among others. Agricultural production is predominantly dependent on farm inputs in terms of improved seeds, modern farm implements like tractors, planters, harrowers, harvesters, etc. This has made the country's agricultural-based economy extremely fragile and vulnerable, which results in partial or total crop failure and subsequent food shortages and famines. This implies that, at present, the food security status of smallholder farmers in Nigeria is threatened. This is no doubt occasioned by certain factors such as illiteracy, poverty/lack of funds which has impeded the adoption of farm technology, making smallholder farmers vulnerable to food insecurity.

In Zimbabwe, Pindiriri (2018) observed that there is increased adoption among smallholders exposed to farm technologies. Langat et al. (2013) reported that the challenges of agricultural technology adoption in Kenya is being solved through gender-targeted programmes, off-farm employment, household size, education level, age, land size and extension services. Enjoy et al., as cited in Jha et al. (2019), observed that before an agricultural technology is introduced, promoted, and implemented, its sustainability for the local region must be investigated and include the perceptions of the farmers. This implies that the perception of local farmers goes a long way in determining technology adoption.

Previous studies in Nigeria dealt with agricultural technology adoption (Chukwuone, Agwu &Ozor, 2006) carried out in the six geopolitical zones-specifically, Katsina, Bauchi, Kogi, Ondo, Rivers, and Enugu states, as well as the role of agricultural technology in poverty reduction among crop farmers in Ohaji Area of Imo State (Nnadi, Chikaire, Nnadi, Utazi, Echetama & Okafor 2012). Studies in Taraba have dealt with the level of awareness of climate change impacts and adaptation strategies among women in Ardo-Kola (Philip, Ojeh and Tukura, 2018), the response of household food security to climate change extreme events and socio-economic characteristics of the household (Ike and Opata, 2017). Little has been done to analyse the impacts of farm technology on food security among smallholder farmers in Taraba State; it is invaluable to analyze if there has been an increase in food production, availability, and subsequently food security among smallholder farmers in Taraba State; and if the said increase is as a result of farm technologies. It is against this backdrop that this study analyzed technology adoption and food security among smallholder farmers in Taraba State.

II. Aim and Objectives

The aim of this study is the analysis of farm technologies on food security among smallholder farmers in Taraba State.

The specific objectives include to:

1. Examine the food security status of smallholder farmers in Taraba State;

2. Examine factors affecting the adoption of farm technology and vulnerability to food insecurity by smallholder farmers in Taraba State;
3. Determine the level of adoption of farm technology by smallholder farmers in Taraba State; and
4. Determine the impact of farm technology on household food security in Taraba State.

In order to ascertain the level of relationship between the adoption of technology and food security, two hypotheses were stated:

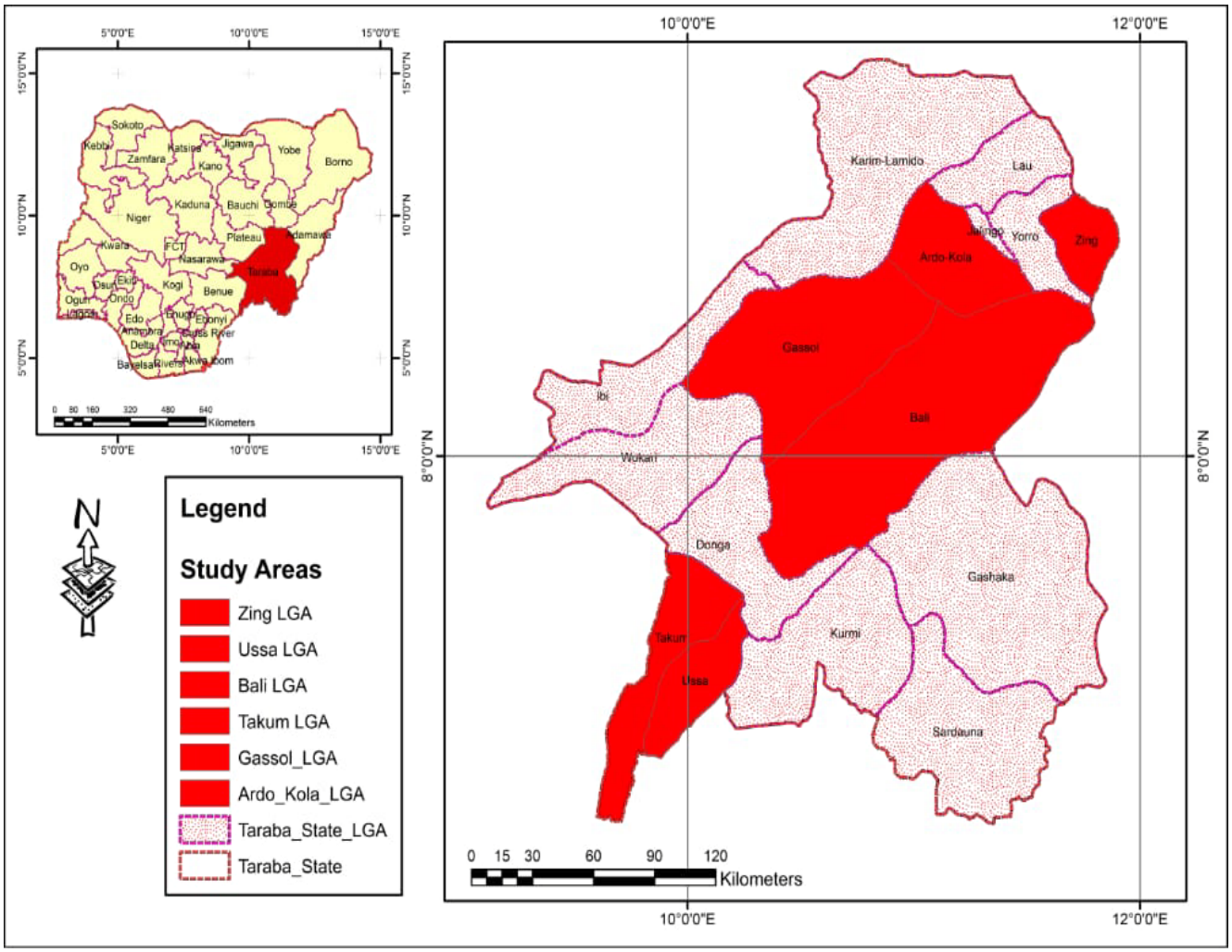
H_{o1}= There is no significant relationship between the level of farm technology adoption and smallholder farmers' food security in Taraba State.

H_{o2}= There is no significant relationship between the factors affecting the adoption of farm technology and vulnerability to food insecurity by smallholder farmers in Taraba State.

III. Materials and Methods

a) Study Area

- *Location:* Taraba state is located in the Northeastern part of Nigeria. It lies between latitude 6°25` and 9°30`North and between longitude 9°30` and 11°45` East of the Greenwich Meridian (Fig. 1). The State shares boundaries with Bauchi and Gombe States in the North, Adamawa State in the East and the Cameroon Republic in the South. The state is bounded along its western side by Plateau, Nassarawa and Benue States. The state has a land area of 54 428km^2. The 2019 projected population of Taraba was about 3,345,666 at +2.94% per year according to the 2006 census (NPC, 2011). Taraba has 16 Local Government Areas with Jalingo as the State capital (Oruonye and Abbas, 2011).



Source: Adopted from Taraba State Map, Ministry of Land and Survey

Figure 1: Taraba State showing study areas

- *Climate:* Taraba has a tropical savanna climate well marked by wet and dry seasons. Constant high temperatures characterise tropical climates (at sea level and low elevations); all 12 months of the year have average temperatures of 18°C or higher. According to Wladimir Koppen and Rudolf Geiger's

climate classification, or as it is sometimes called the Koppen-Geiger climate classification system, Taraba falls under the *Aw*: tropical savanna climate with non-seasonal or dry-winter characteristics. *Aw* climates have an articulated dry season, with the driest month having precipitation under 60mm (2.36 inches) of precipitation (Wikipedia, 2019). The wet season lasts, on average, from April to October, with mean annual rainfall that varies between 1058mm in the North around Jalingo and Zing to over 1300mm in the South around Serti and Takum. The wettest months occur in August and September, while the dry season is experienced from November to March; the driest months are December and January, with relative humidity dropping to about 15 per cent. The mean annual temperature around Jalingo is about 28°C with maximum temperatures varying between 30°C and 39.4°C, and minimum temperatures range between 15°C to 23°C. The Mambilla plateau has climatic characteristics typical of a temperate climate (Oruonye and Abbas, 2011).

- *Socio-economic Activities:* The people of Taraba are mainly farmers, fishers and traders. Crops grown in Taraba include maise, groundnut, yam, millet, beans, rice, fruits and vegetables. Therefore, the major occupation of the people of Taraba State is Agriculture. Cash crops produced in the state include coffee, tea, groundnuts and cotton. Crops such as maise, rice, sorghum, millet, cassava, and yam are also produced in commercial quantity. However, because of the growth in the numbers of civil servants, public officials, educational institutions, and Federal Government establishments, establishments propelled the growth of the commercial and service section of the economy (Oruonye, 2012). Therefore, a significant portion of the population is engaged in the civil service (local, state and federal government). Others include; shop-keepers, service providers like barbing saloons, hairdressers, restaurants, hotels, GSM and recharge card business, transportation, business centres, fruits and vegetable trade and petroleum products businesses. Additionally, because of the agrarian nature of the state and the increasing rate of urbanisation, a significant part of the population is engaged in produce and livestock trades to cope with the demand of food and meat product of the populace (Oruonye, 2012).

b) *Methodology*

- *Research Design:* The study adopteda descriptive survey research design. The survey research studied samples chosen from the population to discover the relative incidence, distribution, and inter-relations of sociological and psychological variables. Survey research is interested in the accurate assessment of the characteristics of whole populations of people. The study adopted the survey design because it more than merely uncoversdata; it interprets, synthesizes, and integrates these data and point to implications and inter-relationship. It offers ample opportunity for the investigator to display ingenuity and scholarliness in his/her interpretation of the data and understanding of their relationship, their apparent antecedents, and especially their implication.

- *Population of the Study:* The population comprises all farmers in Taraba State. For the purpose of this research, only registered farmers in six (6) Local Government areas were selected for the study. The researcher selected two Local Government areas, each from the state's northern, central and southern zones. The basis for the selection of farmers in those Local Governments was due to the available and up-to-date data of farmers from the Value Chain Development Programme (VCDP, an International Fund for Agricultural Development IFAD, intervention programme), Federal Ministry of Agriculture and Rural Development (FMARD), and Taraba State Ministry of Agriculture (TSMA). There are approximately 78,688 registered smallholder farmers (TSMA/FMARD, 2019).

- *Sample Size and Sampling Technique:* A multistage sampling technique was used to select the respondents for the study. The respondents were 384 farmers with smallholdings. Taraba state consists of three senatorial zones. These are the Taraba North (with six LGAs: Jalingo, Zing, Yorro, Ardo-Kola, Karim-Lamido and Lau), Taraba Central (with five LGAs: Gassol, Bali, Kurmi, Gashaka and Sardauna) and the Taraba South (with five LGAs: Wukari, Takum, Ussa, Donga and Ibi). The three zones were used for the study. For the purpose of this study, smallholder farmers refer to farmers who rely predominantly on family-provided labour, which is made up of at least four persons – the farmer, his wife and two children. In addition, they are resource-poor in terms of farming and financial inputs with farms sizes of about two hectares, which are predominantly run for subsistence with the aid of hoes, cutlasses and other local implements.

First, two LGAs were selected, using random sampling from each zone, making a total of six LGAs based on the availability of data on registered farmers and the predominance of farming activities in these areas. Secondly, three (3) farming communities were randomly selected, each from Ardo-Kola, Zing, Bali, Ussa and Takum LGAs, while four (4) communities were selected from Gassol to give a total of sixteen (16) communities. Since it would not be convenient for the researcher to study the entire population, the sample

size was determined using the Raosoft method of sample size calculation (Raosoft ©).

The Local Governments selected for the study include Ardo-Kola and Zing (North), Bali and Gassol(Central) and,Takum and Ussa (South); they were selected purposively based on available farmers' data. The available data of farmers in the selected Local Governments and sample size is shown below.

Table 1: Population sample

Zones	Local Government Area	Farmers' Population	Sample Size
North	Zing	19,216	70
	Ardo-Kola	15, 222	66
Central	Bali	18,683	66
	Gassol	19,033	66
South	Takum	15,374	66
	Ussa	11,902	66
Total		99,430	400

Finally, in each community, twenty-four (24) respondents (smallholder farmers) were randomly selected from each of the sixteen (16) communities with the help of extension agents and research assistants in the area and the farmers' cooperatives in each of the communities, making three hundred and eighty-four (384) respondents. This is the sample size for this study. Three (3) extension agents were used for the study. They provided the necessary information on farming communities in the local governments. Two (2) research assistants were recruited to help in the distribution and retrieval of the questionnaires as well as coding of the data.

- *Instrument for Data Collection:* Data for this study was obtained from primary and secondary sources. The research questionnaire was used for data collection, whereas the secondary source comprises data from TADP, IFAD, FMARD and TSMA. Data was collected using a set of structured questionnaires. The questionnaires, four hundred (400) was administered to respondents eliciting information on their demographic and socio-economic characteristics, level of adoption of farm technology, the impact of farm technology on household food security, the food security status of smallholder farmers and the factors affecting the adoption of farm technology and vulnerability to food insecurity by smallholder farmers. The study wanted to administer three hundred and eighty-four (384) respondents, but in order to take care of respondents misplacing or not filling out the questionnaires correctly, the error margin was reduced to 4.88% as against 5%, and the number of questionnaires was increased to four hundred (400); which was the amount that was administered to the respondents in the study area. Three hundred and eighty-five (385) questionnaires were returned in all.
- *Data Analysis:* The descriptive statistics involving the use of frequency count, percentage (%), the mean and standard deviation were used. The choice was premeditated on the ease in the interpretation of results obtained. In the presentation, analysis and interpretation of data, tables were used from which inferences were drawn. Most importantly, the analysis was carried out in line with the objectives of the study, as earlier on stated in chapter one. Correlation analysis was carried out to test the null hypotheses: H_{o1} there is no correlation between the level of farm technology adoption and smallholder farmers food security in Taraba State and H_{o2} there is no correlation between the factors affecting the adoption of farm technologies and vulnerability to food insecurity by smallholder farmers in Taraba State.

IV. Study Result

a) Demographic Characteristics of the Respondents

This section presents the demographic characteristics of the food security status of the respondents.

Table 4. 1: Demographic Characteristics

Item	Frequency	Percentage %
Gender		
Male	209	54.3
Female	176	45.7
Age		
26 – 35	76	19.7
36 – 45	179	46.5
46 – 55	104	27
56>	26	6.8
Marital Status		
Single	133	34.5
Married	252	65.5
Educational Level		
No Formal Edu.	67	17.4
Adult Education	-	-
Primary	93	24.2
Secondary	116	30.1
Tertiary	109	28.3
Household Size		
1 – 3	122	31.7
4 – 6	179	46.5
7 >	84	21.8
Farming Experience		
1 – 10	119	30.9
11 – 20	163	42.3
21 >	103	26.8
TOTAL	385	100

Source: Field survey, 2020

Table 4.1 shows that 209 respondents representing 54.3%, are males while 176 respondents represented by 45.7% are females. The age distribution of the respondents shows that those within the age bracket of 36 – 45 years represent 46.5%, followed by those in the age bracket of 46 – 55 years represented by 27%. Those in the age bracket of 26 – 35 and 56 above age bracket are represented by 19.7% and 6.8%, respectively. The marital status of the respondents shows that 252 respondents representing 65.5%, are married, while 133 respondents representing 34.5%, are single. The table also shows that most of the respondents have formal education. The majority of the respondents, represented by 116 (30.1%), have attained a secondary level of education. Those with a tertiary and primary level of education represented 28.3% and 24.2%, respectively. However, 67 respondents representing 17.4%, had no formal education. The household size of the respondents shows that 179 respondents' household size is 4 – 6. Those with a household size of 1 – 3 represented 31.7% of the sampled population. Eighty-four (84) respondents representing 21.8%, have household size above seven (7). The farming experience of the respondents shows that 163 respondents representing 42.3%, have 11 – 20 years of farming experience, 119 representing 30.9% have 1 – 10 years farming experience. Those with over twenty (20) years of farming experience represent 26.8% of the sampled population.

b) Food Security Status of Smallholder Farmers

Table 4. 2: Smallholders food security

Statement	VHE (%)	HE (%)	L.E. (%)	VLE (%)
In the past four weeks, did you worry that your household would not have enough food?	175 (45.5)	53 (13.8)	103 (26.7)	54 (14)
In the past four weeks, were you or any household member not able to eat the type of food you preferred due to lack of resources?	183 (47.5)	72 (18.7)	38 (9.9)	92 (23.9)
In the past four weeks, did you or any household member eat a limited variety of food due to a lack of resources?	141 (36.6)	153 (39.7)	51 (13.3)	40 (10.4)
In the past four weeks, did you or any household member eat some food that you really did not want to eat due to a lack of resources to obtain other types of food?	191 (49.6)	122 (31.7)	46 (11.9)	26 (6.8)
In the past four weeks, did you or any household member eat a smaller portion of a meal than you felt you needed because there was not enough food?	163 (42.3)	107 (27.8)	82 (21.3)	33 (8.6)
In the past four weeks, did you or any other household member eat fewer meals in a day because there was not enough food?	109 (28.3)	48 (12.5)	144 (37.4)	84 (21.8)
In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food?	215 (55.8)	42 (10.9)	77 (20)	51 (13.3)

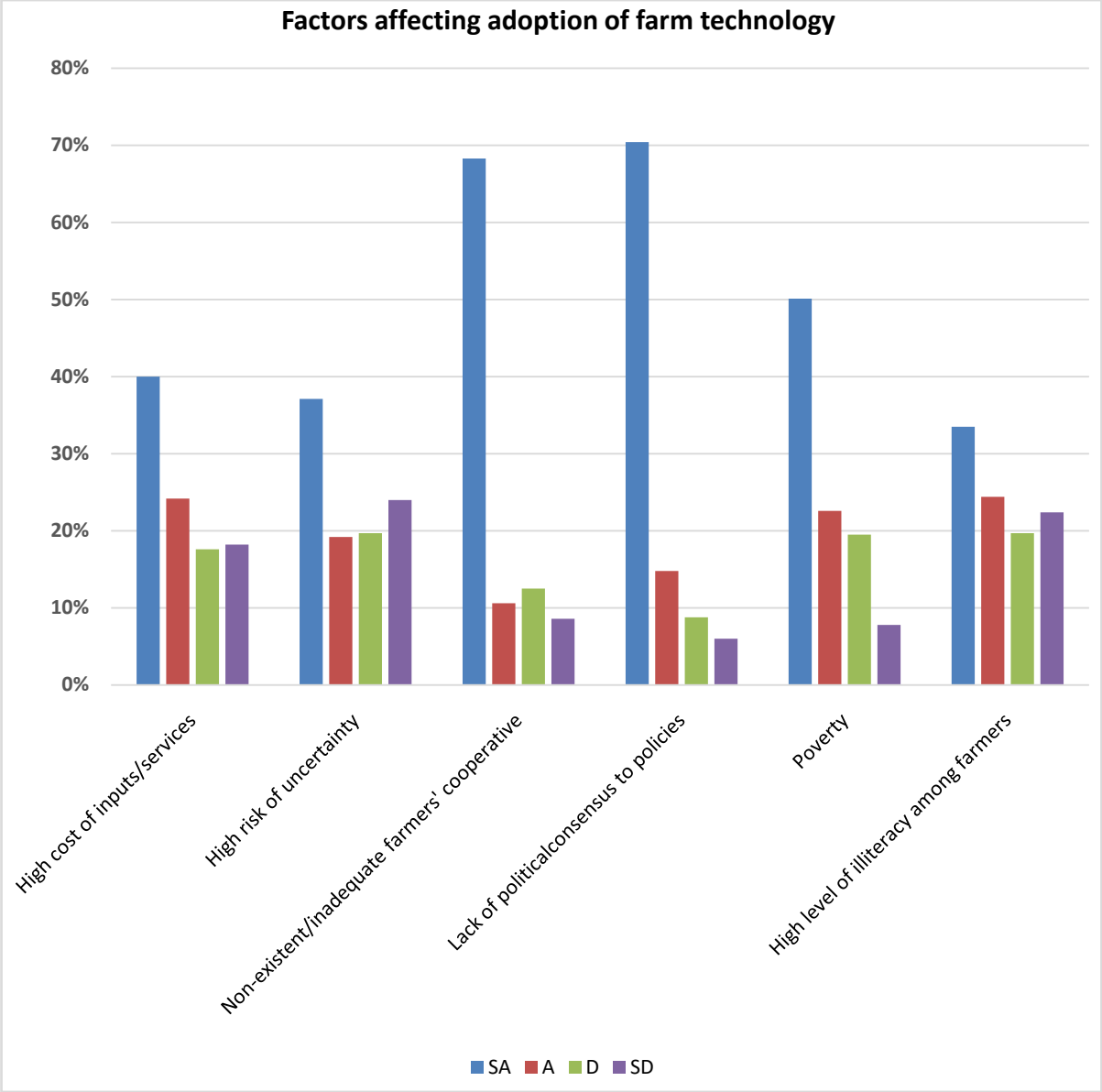
Source: Field survey, 2020

Key: VHE=Very High Extent, HE=High Extent, LE=Low Extent, VLE=Very Low Extent

The result presented in Table 4.2 shows the food security status of smallholder farmers in the study area. The table shows that 55.8% of the study sample went to bed hungry due to the household's inadequate food supply, while 13.3% went to bed on a full stomach. Also, 47.5% of the study sample were not able to acquire and eat the type of food they preferred due to lack of resources, and 9.9% had no challenge acquiring and eating what they preferred at the time they wanted it. Meanwhile, 45.5% of the respondents worry about food not being enough within their households, while 14% are less worried about enough food within their household. This shows that smallholder farmers experience food insecurity challenges, as the majority of them are yet to adopt the use of farm technology in the study area. This could be attributed to the lack of political will to commitment on the side of the government, farming system, poverty, illiteracy, family size and the rurality of the communities under study. The findings of the study are in line with the result of Osabohien, Osabuohien, and Urhie (2017) in which was found that there is a high level of food insecurity as a result of insufficient attention on food production occasioned by the pervasive influence of oil that is the major export product in Nigeria. Similarly, the result is also in consonance with Ike and Opata (2017) findings, which reported that 92% of respondents in their study were food insecure in Taraba State. The finding also conforms to the finding of Fakayode et al. (2009), in which it was reported that only 12% of their study samples were food secured as against 43.6% who were food insecure with moderate hunger.

c) Factors Affecting Adoption of Farm Technology

This section presents result on factors affecting farm technology adoption and vulnerability to food insecurity.



Source: Field survey, 2020

Key: SA=Strongly Agree, A=Agree, D=Disagree, SD=Strongly Disagree

Figure 2: Factors affecting adoption of farm technology

The result presented in Figure 2 shows factors impeding the adoption of farm technology. The result revealed that lack of political will to commitment on the side of government, non-existence/inadequate cooperative organisations, poverty, high costs of agricultural inputs and services, risk of uncertainty in agriculture, and high level of illiteracy among farmers with percentages of 70.4, 68.3, 50.1, 40, 37.1 and 33.5 respectively are some of the stonewalls met by smallholder farmers. This implies that the factors militating against smallholders' adoption of farm technology include costs, risks, inadequate cooperative organisations, lack of political will to commitment on the side of government, poverty, and illiteracy. The result corroborates the finding of Godffrey, Halimu, and Titus (2016) that group involvement and social support are the two important components that significantly influenced the adoption of appropriate agricultural production technologies among farmers in Kenya. This shows that with adequate cooperative groups, the adoption of agricultural technologies will be easy. Similarly, the findings reflect the result of Bethel (2015), where it was reported that the major constraints to the use of agricultural technology were the high cost of inputs, availability of inputs, lack of technical know-how, and poverty among farmers.

Table 4. 3: Factors Affecting Technology Adoption Correlation Summary

Variable	N	Mean	SD	R	Sig	P
Age	385	3.16	1.11	727	.000	Significant P<0.05
Technology Adoption	385	2.92	1.10			

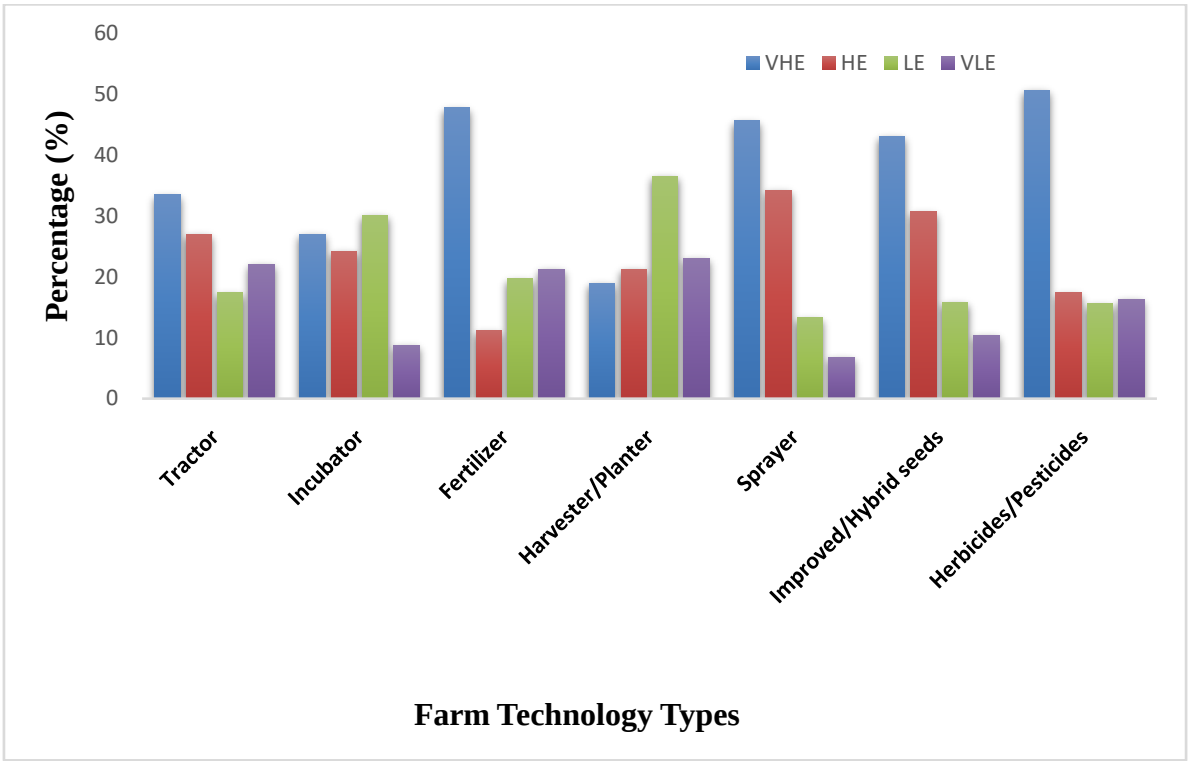
The correlation result presented in Table 4.3 shows that there is a significant correlation between age and education and farm technology adoption among smallholder farmers in Taraba State.

d) Level of Farm Technology Adoption

The section presents results of the level of farm technology adaption.

Table 4.4: Level of technology usage

Technology type	VHE (%)	HE (%)	L.E. (%)	VLE (%)	Mean	S.D.
Tractor	129 (33.5)	104 (27)	67 (17.4)	85 (22.1)	2.71	1.16
Incubator	104 (27)	93 (24.2)	116 (30.1)	72 (18.7)	2.64	.51
Fertiliser	184 (47.8)	43 (11.2)	76 (19.7)	82 (21.3)	3.11	.41
Harvester/planter	73 (19)	82 (21.3)	141 (36.6)	89 (23.1)	2.39	1.23
Sprayer	176 (45.7)	132 (34.2)	51 (13.3)	26 (6.8)	3.22	.95
Improved/Hybrid seeds	166 (43.1)	118 (30.7)	61 (15.8)	40 (10.4)	3.02	.96
Herbicide/Pesticides	195 (50.7)	67 (17.4)	60 (15.6)	63 (16.3)	3.13	.40



Source: Field survey, 2020

Key: VHE=Very High Extent, HE=High Extent, LE=Low Extent, VLE=Very Low Extent

Figure 3: Level of Farm Technology Adoption

Table 4.4 shows that most respondents adopted herbicides/pesticides (50.7%), fertilizer (47.8%), sprayer (45.7%), improved/hybrid seeds (43.1%) and tractor (33.5%).The adoption of herbicides/pesticides, fertiliser, sprayer and improved/hybrid seeds could be attributed to availability, accessibility and affordability.

The result shows that incubator (27%) and harvester/planter (19%) have a low level of adoption among smallholder farmers in the study area. As indicated in the table above, the technologies that were less adopted could be attributed to their availability and affordability. The table shows that harvester/planter (19%) is not a farm technology adopted by many smallholder farmers in the study area. Most of the smallholder farmers live in rural areas with little or no access to or knowledge of these technologies, thus the low level of adoption.

Table 4.5: Chi-square (X^2) Result for Level of Farm Technology Adoption

Chi-Square Tests

	Value	df	Asymptotic significance (2-sided)
Pearson Chi-Square	679.268[a]	9	.000
Likelihood Ratio	708.177	9	.000
Linear-by-Linear Association	348.341	1	.000
N of Valid Cases	385		

a. 0 cells (0.0%) have an expected count less than 5. The minimum expected count is 6.70.

The result presented in Table 4.5 shows the chi-square (X^2) result for the level of farm technology adoption. The result shows a significant ($p<0.5$) level of farm technology adoption among smallholder farmers in Taraba State. This thus indicates that the level of farm technology adoption among smallholder farmers in Taraba State is moderate.

e) Impact of Technology Adoption on Smallholder Farmers

This section presents results on the impact of farm technology on household food security.

Table 4.6: Impact of technology adoption on smallholder farmers

Statement	VHE (%)	HE (%)	L.E. (%)	VLE (%)	Mean	S.D.
There is an increase in crop yield due to technology adoption	143 (37.1)	151 (39.2)	51 (13.3)	40 (10.4)	3.04	.96
Smallholder farmers experience improves cropping system due to technology adoption	181 (47)	122 (31.7)	54 (14)	28 (7.3)	3.21	.95
Adoption of farm technology increases farm input among smallholder farmers	158 (41)	117 (30.4)	75 (19.5)	35 (9.1)	3.02	1.0
Adoption of farm technology improves storage system devoid of pest infestation	104 (27)	88 (22.9)	116 (30.1)	77 (20)	2.64	1.11
Adoption of farm technology makes farm cultivation among smallholder farmers fast, efficient and easy	195 (50.7)	62 (16.1)	60 (15.6)	68 (17.6)	3.13	1.14

Source: Field survey, 2020

Key: VHE=Very High Extent, HE=High Extent, LE=Low Extent, VLE=Very Low Extent

The result presented in Table 4.6 above shows that farmers that adopted one form of farm technology or the other revealed faster farm cultivation, improved cropping system, increased farm input, increased crop yield, and improved storage system with percentages of 50.7, 47, 41, 37.1, and 27 respectively. This implies that technology adoption positively impacts smallholder farmers in the study area, as it enhances farm input, output, and storage. The finding is in line with the result of Bethel (2015) in which was found that agricultural technology had a positive effect on farm output for farmers that used it in Bayelsa State, Nigeria. The finding also reflects the result of Muzari et al. (2017), where it was found that the use of conservation agriculture and irrigation technology resulted in significantly higher maise yield among smallholder farmers among households in Ward 15 of Makonde District in Mashona land West Province in North Central Zimbabwe.

Table 4.7: Chi-square Test Result on Impact of technology adoption

Chi-Square Tests

	Value	df	Asymptotic significance (2-sided)
Pearson Chi-Square	357.153[a]	9	.000
Likelihood Ratio	492.941	9	.000
Linear-by-Linear Association	208.605	1	.000
N of Valid Cases	385		

a. 1 cells (6.3%) have an expected count less than 5. The minimum expected count is 4.59.

The result presented in Table 4.7 shows the chi-square (X^2) test result for the impact of farm technology adoption on smallholder farmers. The result indicates that farm technology adoption has a significant ($p<0.5$) impact on smallholder farmers' household food security in Taraba State. This means that farm technology adoption impacts smallholder farmers' food security status in Taraba State.

f) Reasons for Technology Adoption

Table 4.8 reveals the reasons for the adoption of the various technologies by the respondents. Respondents who utilised tractors recorded the highest percentage of 59.2, which implies that tractor usage is based on its availability and simplicity as well as effectiveness. Herbicide/pesticide usage recorded a percentage of 50.1, which implies that the choice of herbicides/pesticide is based on availability, affordability and simplicity of usage. Furthermore, the usage of sprayer and fertiliser recorded percentages of 48.3 and 46.1, respectively, implying that availability, affordability and simplicity were the reasons for adopting sprayers and fertilisers.

Table 4. 8: Reasons for the choice of technology adopted

Technology Type	Availability (%)	Affordability (%)	Simplicity (%)	Effectiveness (%)	Mean	S.D.
Tractor	222 (59.2)	30 (8)	72 (19.2)	51 (13.6)	3.1	.61
Incubator	139 (100)	-	-	-	2.6	.22
Fertiliser	173 (46.1)	97 (25.9)	72 (19.2)	33 (8.8)	2.7	.45
Harvester/planter	84 (40.5)		44 (21.3)	79 (38.2)	2.5	.63
Sprayer	181 (48.3)	117 (31.2)	54 (14.4)	23 (6.1)	3.1	.46
Improved/hybrid seeds	91 (42.1)	30 (13.9)	35 (16.2)	60 (27.8)	2.8	.69
Herbicides/Pesticides	193 (50.1)	107 (27.8)	54 (14)	31 (8.1)	3.2	.64

Source: Field survey, 2020

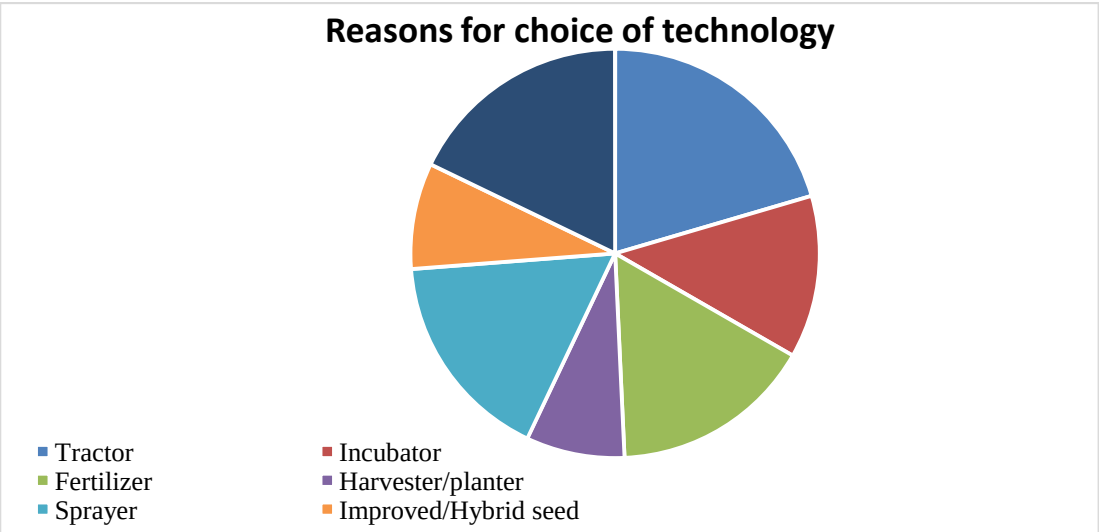


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Fig: XXXX

V. Summary and Conclusion

The study analysed the impact of farm technologies on food security among smallholder farmers in Taraba State. As one of the Sub-Saharan countries in Africa, Nigeria has a substantial share of its population, hinging their means of livelihood and survival on agriculture. Therefore, from the same perspective, the past several decades have seen Nigeria's agrarian sector modifying productivity progression by adopting diverse new farming technology globally recognised as unparalleled agronomic practices.

Food insecurity has remained a fundamental challenge in Nigeria. Food security has always been at the spearhead of countries' agricultural advancement policies because it clearly indicates the population's standard of living, especially in countries where agriculture is the predominant factor of people's livelihood. Food insecurity is exacerbated by low production and crop loss mainly caused by low technological input, poor management practices, low and irregular rainfall, among others. Agricultural production is predominantly dependent on farm inputs in terms of improved seeds, modern farm implements such as tractors, planters, harrowers, harvesters, etc.
Findings revealed that most of the respondents produced crops such as maise, cassava, fruits, white-seed melon, rice, beans and vegetables, among other crops. The types of technology used by farmers in the study area include fertiliser, herbicides/pesticides, improved seeds, and tractor. The smallholder farmers adopted herbicides/pesticides, fertiliser usage, sprayer, improved seeds and tractors. The study found that few farmers only adopt irrigation in the study area. Farmers that adopted one form of farm technology or the other experienced faster farm cultivation, improved cropping system, increased farm input, increased crop yield, and improved storage system. The result revealed that the food security status of smallholder farmers in the study area is moderate (44%). This shows that the smallholder farmers experience food security challenges. The study found that the high costs of agricultural inputs and services, risk of uncertainty in agriculture, nonexistence/inadequate cooperative organisations, lack of political consensus to commitment, poverty and illiteracy were the most prevailing factors militating against technology adoption among smallholder farmers.

The adoption of farm technology will go a long way in enhancing their farm inputs and food security status. The majority of the farmers in Taraba state produce crops such as maise, cassava, fruits, white-seed melon, rice, beans and vegetables, among other crops. The types of technology used by farmers include fertiliser, herbicides/pesticides, sprayers, improved seeds, and tractors. The adopted farm technologies include fertiliser, herbicides/pesticides, sprayers, improved seeds and tractors. Irrigation is not much adopted in the study area. The farmers that adopted one form of farm technology or the other faster farm cultivation improved cropping system, increased farm input, increased crop yield, and improved storage system. The status of smallholder farmers' food security in the state is moderate. This shows that smallholder farmers experience food security challenges. Lack of political consensus to commitment on the side of government, nonexistence/inadequate cooperative organisations, poverty, high costs of agricultural inputs and services, risk of uncertainty in agriculture, and illiteracy were the most prevailing factors militating against technology adoption among smallholder farmers.

VI. Recommendations

Based on the findings of the study, the following recommendations are put forward:

1. Small holder farmers should be enlightened about the various types of farm technologies and the benefits derivable from their usage.
2. The government, NGOs and other stakeholders should make these farm technologies accessible and affordable to smallholder farmers who may be interested in adopting them.
3. The federal, state and local governments should invest in agriculture and make it attractive and profitable so that smallholder farmers can increase their production capacity and earnings, thereby increasing their socioeconomic status.
4. Grants and loans should be given to smallholder farmers to enable them to produce more food to curb food insecurity.

References Références Referencias

1. Adekoya, A.E., and Babaleye, T. (2009). Consistency of technology adoption among farmers in Northern Nigeria. *Journal of Food, Agriculture & Environment,* 7(3), 457-460.
2. Adetola, A. (2009). Factors Influencing Irrigation Technology Adoption and its Impact on Household Poverty in Ghana. *Journal of Agriculture and Rural Development in the Tropics and Subtropics,* 109(1), 51–63.
3. AGRA (2013). *African Agriculture Status Reports: Focus on Staple Crops*. Nairobi, Kenya.
4. Ajibola, O. (2000). Institutional analysis of the national food storage programme (Development Policy Centre, (Nigeria). *Research Report*, No. 23). Ibadan: Development Policy Centre.
5. Ali, J. (2014). Adoption of Innovative Agricultural Practices across the Vegetable Supply Chain. *International Journal of Vegetable Science*. DOI: 10.1080/ 19315260.2014.916773.

6. Bethel, O. (2015). Effects of Agricultural Technologies on Cassava Production by Smallholder Farmers in Bayelsa State, Nigeria. *Unpublished M.Sc. Dissertation*, University of Nigeria, Nsukka.
7. Bonabana-Wabbi, J. (2002). Assessing Factors Affecting Adoption of Agricultural Technologies: The Case of Integrated Pest Management (IPM) in Kumi District. *M.Sc. Thesis*, Eastern Uganda.
8. CBN Annual Report and Statements of Accounts/ Statistical Bulletin (2007).
9. Central Bank of Nigeria Annual Report—2018.
10. Chukwuone, N. A., Agwu, A. E., and Ozor, N. (2006). Constraints and Strategies Towards Effective Cost-sharing of Agricultural Technology Delivery in Nigeria: Perception of Farmers and Agricultural Extension Personnel. *Journal of International Agricultural and Extension Education*, 13(1), 29-40.
11. Dansabo, M.T. (2017). Potentials of Economic Diversification in Nigeria: A Study of Irrigation with Middle Rima Valley Irrigation Scheme with Goronyo Dam. *Research Journal of Sociology*, 5(8). 2 – 18.
12. Fakayode, S.B., Rahji, M.A.Y., Oni, O.A., and Adeyemi, M.O. (2009). An Assessment of Food Security Situations of Farm Households in Nigeria: A USDA Approach. *The Social Sciences*, 4, 24-29.
13. FAO (Food and Agriculture Organisation) (2005). *Mobilising resources to halve world hunger. Paper prepared for 2005 World Summit*. Rome, Italy: FAO.
14. FAO (Food and Agriculture Organisation) (2009). *Food Security and Agricultural mitigation in developing countries: Options for capturing synergies*. Rome, Italy.
15. FEWS NET (2019). Nigeria food security outlook update. www.fews.net/nigeria. Retrieved on July 21, 2019.
16. Godffrey, N.N., Halimu, S.S., and Titus, T.K. (2016). Influence of Social Capital on Adoption of Agricultural Production Technologies among Beneficiaries of African Institute for Capacity Development Training Programmes in Kenya. *International Journal of Social Science and Technology,* 1(1), 1-21.
17. Global Hunger Index GHI (2018). The Inequalities of Hunger. International Food Policy Research Institute (IFPRI), Bonn pp 1-46
18. Ibok, I.N. (2012). Socio-economic and demographic determinants of health insurance consumption. *Canada Social Science*, 8(5), 58-64. DOI: Available from: http://www.cscanada.net/index.php/css/article /view/j.css.1923669720120805.1836
19. Ike, C.U., and Opata, P.I. (2017). Household Food Security Response to Climate Change Extreme Events in Taraba State, Nigeria. *Journal of Economics and Sustainable Development,* 8(22), 23-30.
20. Jha, S., Kaechele, H., Sieber, S. (2019). Factors Influencing the Adoption of Water Conservation Technologies by Smallholder Farmer Households in Tanzania. *Water*, 11(12): 2640. https://doi.org/ 10.3390/w11122640.
21. Langat, B.K., Ngero, V.K., Nyangweso, P.M., Mutwol, M.J., Kipsat, M.J., Gohole, L. and Yaninek, S. (2013). Drivers of technology adoption in a subsistence economy: The case of tissue culture banana in Western Kenya. Invited Paper presented at the *4th International Conference of the Africa Association of Agricultural Economists*, September 22-25, 2013, Hammamet, Tunisia.
22. Lavison, R. (2013). Factors Influencing the Adoption of Organic Fertilizers in Vegetable Production in Accra, *M.Sc. Thesis*, Accra Ghana.
23. Loevinsohn, M., Sumberg, J., and Diagne, A. (2012). *Under what circumstances and conditions does adoption of technology result in increased agricultural productivity? Protocol*. London: EPPI Centre, Social Science Research Unit, Institute of Education, University of London.
24. Loevinsohn M, Sumberg J, Diagne A, Whitfield S (2013). *Under what circumstances and conditions does adoption of technology result in increased agricultural productivity? A Systematic Review*. Department for International Development, Institute of Development Studies, Brighton, UK and The Africa Rice Centre, Cotonou, Benin, pp 1-38.
25. Masano, C. M., and Miles, C. A. (2004). Factors influencing farmers' adoption of Kalima bean variety in Malawi. *Journal of Sustainable Agriculture,* 24(2), 117-129.
26. McDonald, R., Heanne, K., Pierce, K., and Horan, B. (2015). Factors influencing new entrant dairy farmers' decision-making process and technology adoption. *The Journal of Agricultural Education and Extension,* 1, 1-15.
27. Muzari, W., Kupika, O., Danha, C., and Mapingure, C. (2017). The impacts of agricultural technology use on productivity and food security among smallholder farmers in Zimbabwe: The case of Makonde district. *Journal of Agricultural Extension and Rural Development,* 5(10), 225-231.
28. Mwangi, M., and Kariuki, S. (2015). Factors Determining Adoption of New Agricultural muhamm Technology by Smallholder Farmers in Developing Countries. *Journal of Economics and Sustainable Development,* 6(5), 208-213.
29. NBS (National Bureau of Statistics). (2005), *Poverty Profile for Nigeria, National Bureau of Statistics, Lagos*. Available at: http:// www.nigerianstat.gov.ng/ Connections/poverty/ POVPreliminary.pdf.
30. NBS (National Bureau of Statistics). (2008) Nigeria-General Household Survey, Fourth Round https://www.nigerianstat.gov.ng/nada/index.php/catalog/19/related_materials.

31. NBS (National Bureau of Statistics). (2017). *Multiple Indicator Cluster Survey 2016–17, Survey Findings Report.* Abuja, Nigeria.
32. Nnadi, F. N., Chikaire, J., Nnadi, C.D., Utazi, C.O., Echetama, J.A., and Okafor, O.E.(2012). Role of Agricultural Technology in Poverty Reduction among Crop Farmers in Ohaji Area of Imo State, *Nigeria Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS),* 3(5), 754-760.
33. NPC (National Population Commission) (2011). *The Nigeria Population Census, 2006*. "Retrieved from http://www.population.gov.ng/index.php?option=com_content&view= artide&id=89.
34. Nyariki, D.M. (2011). Farm Size, Modern Technology Adoption, and Efficiency of Small Holdings in Developing Countries: Evidence from Kenya, Journal of Developing Areas, Tennessee State University, *College of Business*, 45(1), 35-52, July-Dec.
35. Olowa W & Olowa A.O. (2015). Factors Affecting Entrepreneurship Development in Agribusiness Enterprises in Lagos state, Nigeria. *Global Journal of Management and Business*, Vol 15, No 7-B (2015)ISSN 2249-4588. Available at: <https://www.journalofbusiness.org/index.php/GJMBR/article/view/1804>
36. Omonona, B.T., and Agori, G.A. (2007). An analysis of food security situation among Nigerian urban households: evidence from Lagos State, Nigeria. *J Cent EurAgric,* 8, 397-406.
37. Oruonye, E.D. (2012). Socio-Economic Impact Assessment of Flash Flood in Jalingo Metropolis, Taraba State, Nigeria.
38. Oruonye, E.D., and Abbas, B. (2011). *The Geography of Taraba State, Nigeria*. Germany: LAP Publishing Company.
39. Osabohien, R., Osabuohien, E., and Urhie, E. (2017). Food Security, Institutional Framework and Technology: Examining the Nexus in Nigeria Using ARDL Approach. *Current Nutrition & Food Science,* 13, 1-10.
40. Philip, A.H., Ojeh, V.N., and Tukura, E.D. (2018). Awareness of climate change impacts and adaptation strategies among women in Ardo-Kola, North-East Nigeria. *Climate Change*, 4(14), 95-111.
41. Pindiriri, C. (2018). *Breaking the Traditional Trap: Assessing Drivers of Modern Technology Adoption by Smallholder Farmers in Hurungwe District, Zimbabwe*. Monographs: Applied Economics, AgEcon Search, number 302435, October. DOI: 10.22004/ag.econ.302435.
42. Pmnewsnigeria. (2018). *Nigeria has achieved food import reduction, saved 21bn in 34 months*. https://www.pmnewsnigeria.com/2018/12/03/nigeria-has-achieved-food-import-reduction-saved-21bn-in-34-months-emefiele/
43. Raosoft (2004) Raosoft Sample Size Calculator. Raosoft, Inc., Seattle. http://www.raosoft.com/samplesize.html
44. Taraba State Ministry of Agriculture (TSMA), (2019). Department of Agricultural Service, Taraba State Ministry of Agriculture.
45. United Nations Development Program. (2009). Human Development Report 2009, http://hdr.undp.org/en/statistics.
46. Von Grebmer, K., Bernstein, J., Patterson, F., Sonntag, A., Klaus, L. M., Fahlbusch, J., Towey, O., Foley, C., Gitter, S., Ekstrom, K., and Fritschel, H. (2018). *World Hunger Index: forced migration and hunger*. Dublin: Bonn.
47. Wiggins, S., and Keats, S. (2013). *Smallholder agriculture's contribution to better nutrition*. Overseas Development Institute. Report commissioned by the Hunger Alliance.
48. Wikipedia. (2019) Koppen Climate Classification-Retrieved from https://en.m.wikipedia.org/wiki/Koppen-climate-classification Accessed August 19th, 2019.
49. Worldometer Report (2019). Nigeria Population. Accessed at https://www.worldometers.info/world-population/nigeria-population/

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Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

Format Structure

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, “What words would a source have to include to be truly valuable in a research paper?” Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

Tips for Writing a Good Quality Science Frontier Research Paper

Techniques for writing a good quality Science Frontier Research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of science frontier then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

The Administration Rules

Administration Rules to Be Strictly Followed before Submitting Your Research Paper to Global Journals Inc.

Please read the following rules and regulations carefully before submitting your research paper to Global Journals Inc. to avoid rejection.

Segment draft and final research paper: You have to strictly follow the template of a research paper, failing which your paper may get rejected. You are expected to write each part of the paper wholly on your own. The peer reviewers need to identify your own perspective of the concepts in your own terms. Please do not extract straight from any other source, and do not rephrase someone else's analysis. Do not allow anyone else to proofread your manuscript.

Written material: You may discuss this with your guides and key sources. Do not copy anyone else's paper, even if this is only imitation, otherwise it will be rejected on the grounds of plagiarism, which is illegal. Various methods to avoid plagiarism are strictly applied by us to every paper, and, if found guilty, you may be blacklisted, which could affect your career adversely. To guard yourself and others from possible illegal use, please do not permit anyone to use or even read your paper and file.

Criterion for Grading a Research Paper (Compilation) by Global Journals

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals.

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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