International Journal of Agriculture Innovations and Research
Volume 8, Issue 6, ISSN (Online) 2319-1473
Manuscript Processing Details (dd/mm/yyyy):
Received: 17/04/2020 | Accepted on: 08/05/2020 | Published: 22/05/2020

Vegetable Production Trend and Constraints on Vegetable Farmers: A Case of Ditladi and Gulushabe Clusters in the Northern Region of Botswana, Part 1

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Abstract **– The article presents results of a survey conducted in the northern part of Botswana. The study was designed to assess the quantity of vegetable produced, production trend and constraints faced by farmers. The survey was done at Ditladi and Gulushabe in the farmer's fields in May 2019 using a pre-tested survey questionnaire. Farmers were interviewed individually in their farms. Vegetable production and importation data was sourced from Horticultural sector and department of agricultural business promotion. Farmers (41.18%) perceived an upward production trend but data from agricultural offices indicate that production is fluctuating while generally low in all crops except cabbage. Farmers are faced with constraints such as gullies that limit the cultivable area, lack of implements, and lack of transport. The small size of fields is a bottleneck to most farmers. Prevalence of crop pests and diseases results in heavy application of synthetic chemicals. Cropping plan is neglected by more than half of the farmers interviewed. Farmers do not utilize available programs and financiers satisfactorily. They interact with government extension agents mostly on quarterly basis and are aware of climate change at the same time experiencing its consequences. There is a need for a joint effort for on-farm trials and information dissemination by the relevant stakeholders.**

Keywords **– Vegetable Trend, Constraints, Farmers, Production, Extension Agents, Climate Change.**

I. INTRODUCTION

In most of African countries, agriculture stand as a source of livelihood, which provide employment opportunities particularly in rural areas. In Botswana agricultural sector's performance is in downfall trend, unstable and its income has collapsed (Mbulawa, 2017). However, beef industry has been outstanding in Botswana, contributing significantly a large stake of agriculture's contribution to GDP (UNDP, 2012; African Development Bank, 2014), but it has been under immense threat due to consistent out breaks of animal diseases such as foot and mouth. This disease has been a stumbling block for local and export beef markets. Although beef industry is thriving well in Botswana, crop sector remains an important livelihood activity as many households have lands to cultivate crops (Botswana Country Report, 2005). Botswana, government has been supportive by introducing programmes tailored for farmers (producers) such as, Financial Assistance Policy (FAP), Citizen Entrepreneurial Development Agency (CEDA),National Master Plan for Arable Agriculture and Dairy Development (NAMPAADD) for the success of the agricultural sector (Seleka, 2005) and the recent one being Integrated Support Program for Arable Agricultural Development (ISPAAD). Though the government has been making concerted efforts to support farmers, the crop sector still performs below expectations due to high crop failure emanating from frequent droughts. Thus, diversification in agricultural sector as per the national development plan 10, strengthened initiatives such as irrigated farming (vegetable/ horticulture), promoted by the Ministry of Agricultural Development and Food Security (MoA). For irrigation sector to thrive, it has to overcome constraints such as market competitions (Baliyan and Kgathi, 2009), crop pests, crop diseases, shortage of basic inputs (Madisa *et al.*, 2012). Hess and Molatakgosi (2009), indicated that many vegetable

farmers suffer from lack of irrigation management experiences, this is a bottleneck in crop cultivation. Notwithstanding that, adhering to good agronomic practices needed by each crop also play a role in improving crop production (Bosekeng and Coetzer, 2015; Karaye *et al.*, 2017; Moswetsi *et al.*, 2017).

In the Northern part of Botswana, the farming communities of Ditladi and Gulushabe which are situated along Shashe River have been identified as potential are as for horticultural production. The ultimate aim of demarcating these areas was to intensify vegetable production in order to improve food security and reduce the importation rate of vegetables. In addition to the government programmes, Ditladi and Gulushabe clusters were assisted with infrastructure (electricity reticulation) around 2009 in order to smoothen production activities. Furthermore, the government assigned horticultural specialists for technical advices in these clusters. The government also implement a protectionist economy where import restriction is revoked whenever there is sufficient production locally. In spite of tremendous effort to support Ditladi and Gulushabe clusters, vegetable production trend is still not showing increasing signs rather, it remains either declining or fluctuating, which is a concern prompting massive importation of vegetables. Again in trying to reduce the constant importation of vegetables, four vegetables namely; cabbage, tomato, onion and Irish potato, were and are still promoted intensively since they are the most imported vegetables, yet the common ones in daily meal. Conversely, quantities of vegetable importation is still prevailing (MoA, 2018) in order to compensate the shortage of vegetables in the local markets.

Therefore, a survey was carried out in Ditladi and Gulushabe agricultural clusters aiming to 1) assess the vegetable production trend of the area; 2) identify production constraints that affect the producers.

II. MATERIALS AND METHODS

2.1. *Site Description*

The study was undertaken along Shashe River in Ditladi and Gulushabe clusters. Shashe River is not a perennial river, though it is a back bone of all vegetable producers along it. Farmers designated well points in this river where they can draw up water for irrigation. Ditladi clusteris in the North East District, situated on the eastern side of the river and Gulushabe cluster in the Central District, situated on the southern side of the same river.

2.2. *Study Design*

A full structured questionnaire aimed at assessing the production trend as well as constraints faced by vegetable farmers was designed in February and March 2019. The questionnaire was pre-tested with the farmers in Shashe Bridge, a farming community in the western side of Ditladi and Gulushabe clusters. After the pre-test survey, the questionnaire was refined and appropriate corrections were effected to avoid biasness and maintain confidentiality of respondents. The final approved questionnaire was used to interview thirty-four (34) horticultural farmers randomly selected in May 2019. Though the questionnaire was in English, Setswana (local language) was used for those who were not conversant with English. Farmers were interviewed individually in their farms and where the producers were not available, farm managers who had detailed knowledge on farm management practices were engaged. If farm managers failed to provide information on some questions, a call back was done to the farm owners for clarity. The design of the questionnaire was spearheaded by the Department of Agricultural Research, Statistics and Policy Development (DARSPD), in collaboration with the

Department of Agricultural Business Promotion (DABP), Department of Agricultural Research (DAR), and Department of Crop Production (DCP) in the North East District. The officers from these departments assisted in the administration of the questionnaire. The data on production trend was derived from horticultural projects inventories of the two horticultural offices (North East District and Central District) which are overseeing the area of study.

2.3. *Data Analysis*

Data was coded and captured in Excel for descriptive analysis and presented in tabular and graphic forms.

III. Results and Discussion

3.1. *Production Trend Perceived by Farmers*

Farmer's observations varied regarding the production trend (Figure 1). A high percentage (41.18%) of them pronounced an increase trend as opposed to 29.41% who observed a decline in production. An increase trend in vegetable production was also reported by Madisa *et al*. (2012). On the other hand, 17.65% of farmers reported a fluctuating trend. This is corroborated by Batlang *et al*. (2014) who stated that despite the efforts of Botswana government in coming up with strategies in mitigating constraints in crop production, yields are still reported to be fluctuating. Some farmers (5.88%) acknowledged a constant trend and others (5.88%) were silent with their observation. More than 60% of farmers produce tomato, cabbage, onion, beetroot, carrots, butternut, water melon, rape, spinach and green mealies. Among the panoply of crops cultivated, majority of farmers (85.29%) coincidentally produce cabbage and green mealies. Comparably, more farmers are of the view that green mealies production increased more than cabbage whereas those that stated that production of these two crops was constant, were below 15%, and those that highlighted that it is fluctuating were below 20%. Irish potato, Ethiopian mustard, eggplant, okra, herbs, choumolier, chunga, covo and green pepper were produced by lower number of farmers. Moreover, production of Irish potato, eggplant and choumolier were said to be drastically declining, hence, triggers increased importation of vegetables (MoA, 2018). Though herbs, covo and green pepper are produced by less than 12% of farmers, these crops are gaining an increase in production.

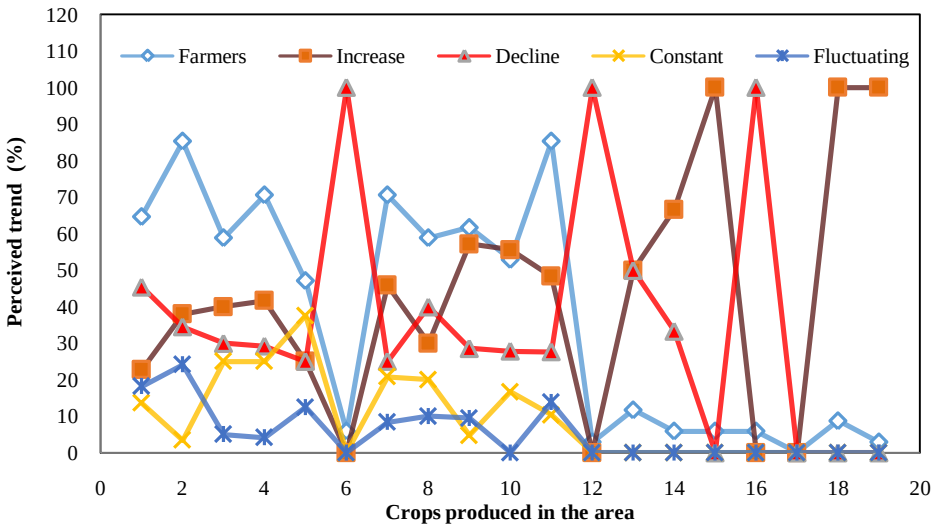

Fig. 1. Crop production trend perceived by farmers (1 = Tomato, 2 = Cabbage, 3 = Onion, 4 = Beetroot, 5 = Carrots, 6 = Irish potato, 7 = Butternuts, 8 = Watermelon, 9 = Rape, 10 = Spinach, 11 = Green mealies, 12 = Ethiopian mustard, 13 = Eggplant, 14 = Okra, 15 = Herbs, 16 = Choumolier, 17 = Chunga, 18 = Covo and 19 = Green pepper).

3.2. *Production (Data) Trend from Agricultural Offices*

Data in Figure 2 shows that only cabbage production sharply increased as early as 2013/14 season passing the 200 tonnage (tons) mark. Cabbage excelled other crops and recorded more than 1200 tons in 2017/18 while the rest of crops recorded less than 200 tons in the same season. This might be linked to numbers of farmers as shown earlier on in this section (3.1), that this crop is favoured by high percentages of producers. Other than that, a head of cabbage often has more mass than other vegetables, hence, the required amount needed from each crop ought to be determined and be used for comparison in the future. Beetroot also showed an increasing trend in 2016/17 though it recorded maximum production of 224.71 tons. From 2012 until 2018, all crops showed a fluctuating trend except cabbage. After 2015/16 season, farmers managed to exceed 100 tons on tomato, beetroot and rape. Among vegetable crops (Cabbage, tomato, onion and Irish potato) that are promoted in order to reduce their importations, only cabbage has been successfully produced. However, cabbage like other crops, still do not meet the market demand, indicating that production is low, hence compensated by importations (Table 1), and this confirms the insufficiency produced from Ditladi and Gulushabe.

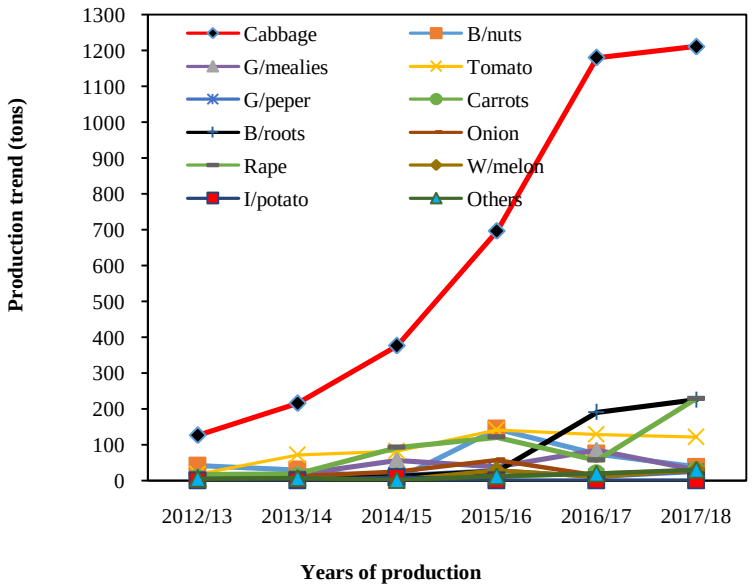

Fig. 2. Vegetable production trend of Ditladi and Gulushabe clusters. G/mealies = Green mealies, G/peper = Green pepper, B/root = Beetroot, I/potato = Irish potato, B/nuts = Butternuts and W/melon = Watermelon (Others = Lettice, Spinach, Okra, Choumolier, Tunnip, Eggplant, Chunga, Cauliflower, Sugarloaf, Garden peas and Covo). Data sourced from horticultural projects inventory of North East District and Central District agricultural offices. NB: data of 2012/13 and 2013/14 of Central District was missing.

Table 1. Quantity of imported vegetables in North East District.

Crop	Years				
	2011/ 12	**2012/ 13**	**2013/ 14**	**2014/ 15**	**2015/ 16**
1	208.90	164.06	559.87	526.50	150.18
2	142.33	184.70	116.71	150.04	109.85
3	368.24	168.97	172.32	155.90	158.73
4	26.82	21.32	14.59	266.44	38.01
5	55.17	40.92	44.28	28.91	16.44

Crop	Years				
	2011/ 12	2012/ 13	2013/ 14	2014/ 15	2015/ 16
6	942.30	522.70	479.00	305.61	546.37

NB; Values given are in tonnage. Crop 1 = Cabbage, 2 = Tomato, 3 = Onion, 4 = Beetroot, 5 = Butternut and 6 = Irish potato.

Data Source: Department of Agricultural Business Promotion (North East District– Botswana)

3.3. *Gender of Farmers*

The study results indicate that there are more male (82%) than female (18%) farmers in vegetable production. Previous works in Botswana by Madisa *et al*. (2010) also shows that participation of male in horticulture exceed the female participation. This variation is due to the fact that horticulture is regarded as a business entity and in business, the scarcity of women therein is of concern. Generally, in Botswana, men are expected to provide for the family while women remain at home taking care of household chores. These differences between male and female in farming were also highlighted by Nankya *et al*. (2019), who stated that culturally, women get involved more in domestic activities. The same trend was noted by Olawepo (2010), who pointed out that farming was predominantly done by men while women were responsible for harvesting, processing and marketing of the produce.

3.4. *Age of Farmers*

Table 2 shows farmer's age which was designated into three categories; <35 (Youth), 36 – 59 (Adults) and >60 considered elderly). From this study, it is evident that adults were prominent, seconded by the elderly and the youth taking the least stake of percentages.

Table 2. Age of farmers.

Age	Frequency	Percentage
<35	7	20.59
36 – 59	17	50.00
>60	10	29.41
Totals	34	100

These findings are in line with report of Statistics Botswana (2018), which indicated that engagement of youth in agriculture is still low. This is due to the fact that majority of youth aspire to migrate to urban dwellings in search of white collar jobs and are also more interested in millennium age resources that are common in the cities than in the rural farming communities. Hence, those that are advanced in age are more visible in farming and this reduces transfer of agricultural knowledge from the old to the young generation. Thus, age might be a limiting factor in agricultural production. Tauer and Lordkipanidze (2000), pointed out that productivity of farmers increases and decreases with age. This is in the same line with (Tauer, 1982), who stated that between the ages of 29 and 40, peak efficiency is reached by farmers and substantially decreases after the age of 40. When studying the efficiency of family dairy farm over its life cycle, Tauer (1982) observed that productivity was in relation to farmer's age and stated that numbers of animal herds increased when farmers were at 50 years and then herds declined as farmers are reaching 65 years of age. Subsequently, Saiyut *et al*. (2019) noted that farmers aged 60 years and above in Thailand, increased in the technical inefficiency. On the other hand, Corner-

Thomas *et al*. (2015), observed that utilization of farm tools varied according to farmer's age. Although those being stricken in years seems to be compromising production, their tremendous experience ought not to be ignored.

3.5. *Education Level of Farmers*

Majority of farmers (35%) attained senior school studies, followed by junior secondary school leavers by 23%, then tertiary accounting for 21%, thereafter primary with 18% and lastly informal education (3%). Generally, majority of farmers had surpassed elementary education and this is advantageous in compressing advanced dynamic and appropriate farming information, technologies as well as collaborations with the international partners. Moreover, educated farmers can comprehend sophisticated dynamics of farming better than the less educated people, hence reducing dependency on extension officers. In support, Afari (2001) pointed out that academically superior farmers are likely to adopt new technologies earlier in comparison to those with low education levels. Kabiru and Arshad (2019), stated that education significantly influence agricultural productivity and they suggested that government should provide more schools in the rural areas to boost productivity in agriculture. Furthermore, Mburu *et al*. (2014), pointed out that the efficiency level of farmers depends on the number of years they had in formal education.

3.6. *Number of Years in Farming*

Majority of farmers interviewed had more than 15 years in farming (Figure 3). This might be beneficial as these farmers have acquainted themselves more with the area compared to those that have less than 15 years in the area.

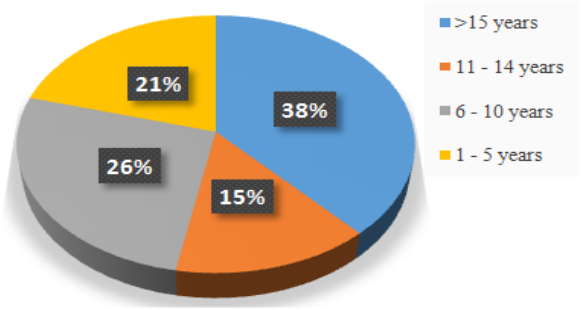

Fig. 3. Number of years in farming.

Farmers with more years in the area tend to be more knowledgeable about the challenges and developments (be either men made or natural calamities) prevailing in the area and have as curtained local adaptation measures practiced. The second group of farmers were those with 6 to 10 years in farming, then those with 1 to 5 years and the least being farmers with 11 to 14 years in farming.

There is an observation (by the researcher), that farmers in Ditladi and Gulushabe started farming at adult stage, to some extent, pensioners (elderly). Thereto do not have adequate time in farming and often passes field to others without succession plan. Although farm owners may opt to exit farming, handing over is only on farm physical assets to the successors, neglecting intangible assets such as managerial skills and farm-specific knowledge (Uchiyama *et al*., 2008). This might contribute negatively to the level of production particularly when farmers who take over are not enlightened on farming. When farm successors are not acquainted with day to day farming challenges, usually it takes years to break even in production.

3.7. *Field Ownership*

The results indicate that 82.35% of farmers use their own fields, and 17.65% had leased the fields. Farmers that uses their own fields often develop them and take cautions in conserving natural resources such as soil and also can have long plans for their production. The land lessee often spends more on farm rentals. This concur with Ayamga and Dzanku (2013), who stated that complimentary inputs needed on seasonal conditions are often done without considering the land rights, but when it comes to investing in long-term soil improvements and irrigation which are expensive and their benefits being enjoyed over extended period of time, re-considering land rights will be compulsory. Similarly, Rai *et al*. (2019) pointed out that landowners enjoy lower expenditures and are acquainted with raises in yielding capacity.

3.8. *Field Size, Development and Utilization*

Current study indicates that more farmers cultivate small sized lands of 1 - 5 hectares (ha), followed by those cultivating 6 - 10 ha, then those cultivating farm sizes ranging from 11 to 20 ha and lastly those with more than 20 ha (Table 3). In each category (size of area allocated), more than 75% of farmers have developed their fields satisfactorily (76 to 100%).

Table 3. Area allocated to farmers and the extent to which is developed.

Area Allocated (ha)	**Number of farmers allocated**	**% of area developed by farmers**			
		<25%	**26-50%**	**51-75%**	**76-100%**
1-5	21	-	1	2	18
6-10	8	-	-	2	6
11-20	3	-	-	-	3
>20	2	-	-	1	1
Totals	34	0	1	5	28

Many farmers in Ditladi and Gulushabe were allocated a hectare size field for production. Farmers that secured the land exceeding 1 ha, managed by leasing other hectares from farmers who are out of production. Notwithstanding that an extra portion can be added provided that the initial allocated area is fully developed and or there is unallocated land nearby. Concerning the undeveloped portions of fields, 50% of farmers cited gullies as limiting factor and this is in agreement with the findings of Bosekeng *et al*. (2020) who stated that the farming areas in the Northern part of the country has gullies that reduce the cultivable area. The second most hindering issue highlighted by 33.33% of farmers, was lack of finance. While 16.67% of farmers opted to leave certain portion of the land undeveloped for future purpose. Table 4, shows that more farmers utilize 76 to 100% of the cultivable land, while those utilizing 26 to 50% of the land are at par with those that are utilizing 51 to 75% of the land. Nankya *et al*. (2019) highlighted that more land utilized means more production. Though majority of farmers utilize more than 76% of their land, factors such as, lack of machineries/labour, poor soils were the reasons for not fully utilizing the land. Our results complement those of Madisa *et al*. (2010) when assessing production constraints, crop and pest management in Peri-Urban vegetable farms in Botswana, however gullies were not indicated as an impediment in their study.

Table 4. Area allocated and utilization.

Area Allocated (ha)	Number of farmers allocated	% of area utilized by farmers			
		<25%	26-50%	51-75%	76-100%
1-5	21	1	5	4	11
6-10	8	-	1	2	5
11-20	3	-	1	-	2
>20	2	1	-	1	-
Totals	34	2	7	7	18

3.9. *Number of Farm Workers*

Agriculture is a back bone of employment for many people in African countries (Davis *et al.*, 2017). These sector depend on labour intensity (*LI*) than labour productivity (Nolte and Ostermeier, 2017), where by labour intensity is the amount of labour force needed to cultivate one hectare of specific crop and is represented as;

$$LI = \frac{\text{Number of farm workers on the farm}}{\text{Area in production (hectare)}}$$

However, in a large scale, labour intensity is estimated per crop. In small scale farming, number of workers should range between 1.13 and 3.77 labours per hectare (FAO), cited by Nolte and Ostermeier (2017). Thus, when taking into consideration the common description that small scale farmers are those that use up to two hectares, thus, from the current study only those cultivating 0.5 ha managed to exceed maximum expected number of workers per hectare (Table 5). The rest of farms endure work force constraints and this has an effect on production. From this study, for large scale farming it would be not easy to reach an ideal labour intensity since farmers are not crop specific per hectare (e.g. put more than three crops per hectare).

Table 5. The area cultivated, number of farm workers and labour intensity of the interviewed farmers.

Area in use	Number of workers	Labour Intensity
0.5 ha X 1	2	4.00
1 ha X 10	20	2.00
1.5 ha X 3	3	0.67
2 ha X 4	8	1.00
3 ha X 2	8	1.33
3.5 ha X 1	4	1.14
4 ha X 1	2	0.50
5 ha X 2	4	0.40
6 ha X 5	64	2.13
6.13 X 1	4	0.65
7 ha X 1	2	0.29

Area in use	Number of workers	Labour Intensity
11 ha X 1	10	0.91
15 ha X 1	5	0.33
18 ha X 1	110	6.11

Though reasons regarding the number of workers employed were not sought for, it is observed that those with more workers practice protected cultivation (Tunnels and shade net) which is often intensive. Additionally, the farmer with the highest number of workers had previously worked with large scale vegetable producers and this might have assisted in acknowledging the importance of number of farm workers. This can then suggest that farmers or agricultural scholars ought to be attached to prominent and advanced farmers before endeavoring in farming so that they be enlightened.

3.10. *Type of Irrigation Used and the Efficient Irrigation System*

Figure 4 indicates irrigation systems used by farmers and the one that they see as being efficient. Evidently, sprinkler system was more preferred than the rest of irrigation systems, followed by drip then spray tube, furrow and horse system. Earlier work by Hess and Molatakgosi (2009) indicated that farmers around this area were confined to hand irrigation, followed by sprinkler irrigation and drip being the least.

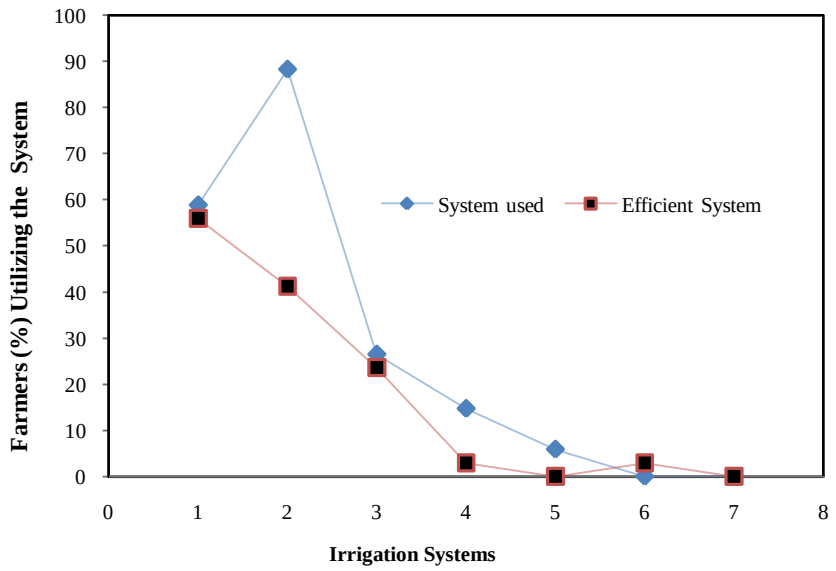

Fig. 4. Percentage of farmers utilizing irrigation system and the efficient irrigation system according to farmers (1 = Drip; 2 = sprinkler; 3 = spray tube; 4 = furrow; 5 = horse pipe, 6 = center pivot and 7 = Micro-jets).

None of the farmers in this study used center pivot nor micro-jets. Although sprinkler is dominating, one would have weighed drip irrigation more for its primary benefit of saving water since the study area is situated in a semi desert country. Moreover, even if conclusions are not yet reached, the on-going research on irrigation systems in Botswana indicate that the most promising system is drip irrigation in Ngamiland District (MoA, 2009). Saving irrigating water is of paramount as studies revealed that in this country evapo-transpiration rate is much higher than precipitation (Pule-Meulenberg and Emongor, 2005). When sharing the same sentiments, Mburu and Massimo (2005) pointed out that Botswana is water deficient and the possibilities of finding more water is diminishing. Majority (20%) of those that are using sprinkler stated that sprinkler saves water, while

13.33% of farmers highlighted that it saves time, easy to connect and then 10% of farmers indicated that it coversa large area. Other farmers (6.67%) highlighted that sprinkler is more durable. Others pointed out that they use it because of lack of funds to buy the desired system and others said it cools the plants. Certain percentage (3.33%) indicated that sprinkler produce quality crops, wash away aphides and easy to control weeds. Among the farmers that use drip irrigation system, 60 % of them stated that drip system saves water and 35% of them pointed out that with drip system weeds are controlled easily while 30% said the system saves time and easy to connect. In addition, 10% of farmers using drip believe that is cheaper and excellent in reducing labour, whereas 5% of farmers said it saves fuel, is efficient and durable. As for the usage of spray tube, more farmers (55.56%) indicated that it saves time and easy to use, followed by those (22.22%) that pointed out that it saves water and 11.11% of farmers found the system to be fuel economic, with minimum labour for weeding, not compacting the soil as well as cooling the plants. Nhundu *et al*. (2015) stated that even if irrigation technology is appropriate to the ecological zone and is economically advantageous, it will not have impact on production and income if it is not adopted by significant proportion of farmers. Other than that, the intensity of irrigation technology is affected by yields recorded, land holding, education and the place of the farmer (Pokhrel *et al.*, 2018).

This study also revealed that 5.88% of farmers connected water meters for recording the amount of water used during production, and 94.12% use water which is not metered. This clearly indicate that usage of water is not restricted or monitored. Correspondingly, leaching occurs with the excess water and if overhead irrigation systems are used as it is the case with this study as shown earlier on this section, thereto plant pathogens which are prone to prolonged wetness on the plants are not exception. Moreover, where there is a magnitude of leaching, fertilizers applied would be lost, hence, lower production. Conversely, under irrigation might be prevailing also and its consequences such as imbalance translocation of minerals, curling of plant leaves in preserving little moisture absorbed, poor photosynthesis and ultimately poor yields might account for low production in the area of this study. Other than agronomic consequences, this might mean that farmers are not adhering to the amount of water apportioned to them as per water rights by Water Utilities Cooperation. This finding are in the same line with those of Hess and Molatakgosi (2009), who concluded that without measured water, farmers either over irrigate or under irrigate.

3.11. *Implements*

Lack of implements can delay land preparations, resultantly delayed sowing. The finding shows that 67.65% of farmers do not have farm implements. The remaining 32.35% of farmers own implements. Notably, 80% of farmer sowned tractors and harrows, followed by those that owned ploughs (60%), then 20% owned cultivators and 10% of farmers possess ridgers or rotovators. Implements ownership seems to be associated with the size of the land and farmers' age. All the farmers that owned bigger fields (20 ha) had implements, while only 23.81% of farmers owning small sized fields (1-5 ha) have implements. As for the age of farmers, many elderly farmers (70%) owned implements, followed by adults (17.65%) and lastly youth (14.29%). Thus, this might be associated with retirement's packages of the elderly as well as pressure to cover large area in lesser time for those owning larger fields. This is in support of the study of Ghosh (2010) who alluded that availability of farm machinery is determined by factors such as farm size, access to institutional credit and experience of the farmer. When sharing the same sentiment, Mottaleb *et al*. (2016), pointed out that ownership of machinery is positively

associated with chances a producer has to the sources of funds.

3.12. *Production Methods*

It is noted from farmer's response that 84.85% of them use both seedlings and direct seeding in production, whilst 9.09% of them leverage on direct seeding only and 6.06% solely use transplants. Majority of farmers manage to raise transplants in their farms while 5.88% of farmers' source transplants from the local markets or outside the country. This is commendable as it shows that farmers adopted transplanting technology. The study also reveals that 79.41% of farmers depend on hybrid seeds. This might mean more produce of excellent quality as hybrid seeds are known to be producing vigorous crops with competitive yield (Thakur *et al*., 2016). But this does not tally with the results of this study, perhaps for cabbage.

3.13. *Frequency of Soil Tests and the Type of Fertilizer used*

It is evident from this finding that a blanket application of fertilizers is a phenomenon practice as large stake of farmers do not do soil analysis (Figure 5) or have done it once at the commencement of farming which is usually a compulsory as a component of characterizing farm soils before initial cultivation. This tendency of not analysing the soil is contrary to Sullivan *et al*. (2017) who highlighted that every 3 to 5 years under most conditions, a complete pre-plant soil test should be sufficient in determining quantity of nutrients required. Preferably, nutrients deficiencies can be managed by identifying annual crop needs with soil testing and perennial crops needs with plant analysis (MoA, 2006). Farmers that are carrying out soil analysis annually were at par (6%) with those that do it twice in a year and 3% of farmers indicated that they do soil analysis once in three years. Notwithstanding that horticultural farmers are entrepreneurs, hence practices that results in more yield such as the use of chemical fertilizers are inevitable. Thus, such magnitude of production without soil analysis means indiscriminate use of fertilizers and according to Wimalawansa and Wimalawansa (2014), this is detrimental to the environment and food chain.

Majority of farmers (81.82%) use both chemical and organic fertilizers (Kraal or poultry manure), followed by 12.12% who solely use chemical fertilizers and the least being those that use solely organic fertilizers. This results substantiated that chemical fertilizers are commonly used in vegetable farming than organic fertilizers (Bosekeng, 2019a &b). In spite of the type of fertilizers used, the utter most concern is with regard to the quantity applied particularly that producers do not carry out soil analysis of their fields. The study further indicated that 84.38% of farmers apply fertilizers every time when planting crops whilst 18.75% of farmers apply fertilizers only when crops shows deficiency.

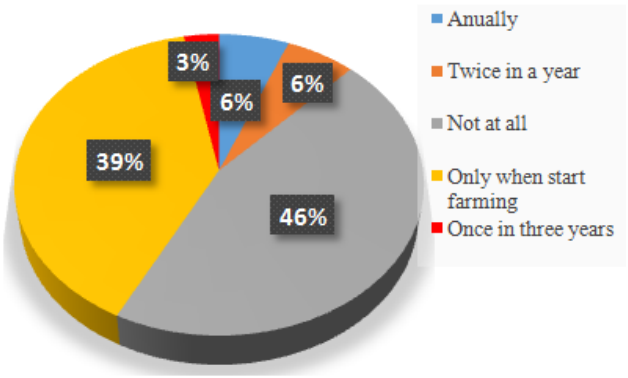

Fig. 5. Frequency of soil tests.

3.14. *Cropping Plan*

Crop planning assist in knowing the time and the type of crops to produce. It surfaced from this study that more percentages of the youth and adults at 37.5% and 43.75% respectively, have a cropping plan. Whilst only 18.75% of elderly farmers showed to be having cropping plans. Thus, age seems to be contributing to lack of cropping plans. This could be due to the fact that the elderly depend on experience rather than following paper work. The consequences of lack of cropping plan cut across the value chain. It may lead to flooding of crops in the field and in the market, causing a decline of market prices. On the other hand, it can result in unaccountable planting intervals which will lead to lack of vegetables at a particular period of the year. According to Hennessy (2004), planning for the crops is not only for agronomic benefits but also increase in crop revenues. Boyabatli *et al*. (2019), stated that making crop planning based on multiple crops with rotation is a component of sustainable agriculture.

3.15. *Pest Control Methods*

All interviewed producers pointed out that they depend on synthetic chemicals for controlling pests. These findings are in line with the findings of Madisa *et al*. (2010) who noted that all farmers in peri-urban areas of Botswana entirely relied on synthetic pesticides. Other studies also in this country indicate that majority of farmers heavily relied on extremely hazardous pesticides in horticulture without taking into account the economic damage of pests to crops (Leungo *et al*., 2012). If pesticides are not used considerably, their residues are usually traced in routinely consumed vegetables (Machekano *et al*., 2019) and this is detrimental to human health. Farmers who controlled pests by means of mechanical or cultural, were equal by 6.06%. Biological methods were used by 2.94% of farmers. Additionally, 82.35% of farmers apply pesticides prior to pest's infestation as a preventative method, 33.33% control pests upon identification thereof, 8.82% control pests when are at economic threshold level and 2.94% control pests when pests are at peak stage or at the time of identification. Though it is not surprising, but it should be a concern that 100% of farmers depend on synthetic chemicals in combating pests. The leading factor in using synthetic pesticides, perhaps, maybe due to the fact that controlling pests with toxic chemicals have been a priority in the past seven decades rather than allowing ecosystem to balance itself. Lewis *et al*. (1997), stated that a satisfactory solution to pest's problems will be depending on biological pests control and allowing a balance of agricultural ecosystem as well as maintaining cropping system that will enable natural forces to maintain pests within acceptable bounds.

3.16. *Market Outlets and the Market Demand*

Farmers were asked to indicate market places they use out of the seven prevailing ones across the country. Figure 6 shows that majority of farmers (85.29%) supply to the street vendors, and this is not the case with the vegetable producers in Nepal (Rai *et al*., 2019), who found out that farmers sell their produce to the collection and distribution centers as opposed to street venders. The retailers were taking the second large share (79.41%) of the markets, then institutions and wholesalers were at par by 32.53%, followed by fresh produce markets at 20.59% and lastly farm stall (11.76%). Notwithstanding that middlemen are parasites who enjoy more profit in marketing chain (Mariyono, 2019), current study shows that middlemen are preferred than the processing plant and government institution markets, and perhaps farmers are bonded with their usual markets or are not aware of new existing markets.

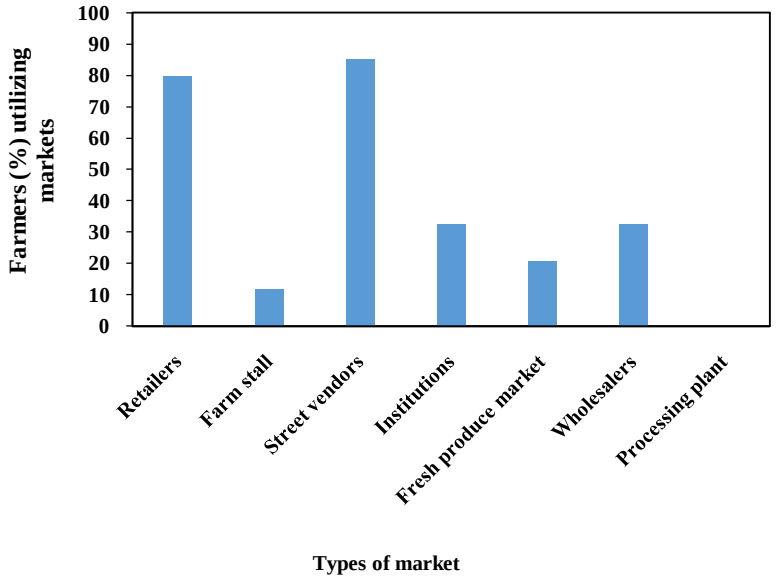

Fig. 6. Farmers utilizing various available markets.

In addition, the study revealed that 33.33% of farmers are able to meet the seasonal market demand of cabbage, beetroot, tomatoes, onion, butternut and watermelon. Among these crops, cabbagewas taking the largest stake (81.82%), followed by tomatoes and onion both at 27.27%. This might be attributed to the fact that these crops were in the top agenda of the Department of Crop Production (DCP) as it provided farmers with more technical support on these crops. Butternuts and watermelon also showed to be satisfying the market by 18.18% of farmers, then beetroot with 9.09% of farmers. On the other hand, 66.67% of farmers indicated that they are not able to meet customers demand on the same mentioned crops above. The number of producers who failed to meet the demand of cabbage and tomatoes were matching (40.91%), followed by beetroot and butternut farmers who were both at 22.73%, lastly watermelon by 4.55% of farmers. This concur with the study of Baliyan (2014) who stated that vegetable producers in Botswana are unable to sustain production that would meet the local demand. Failing to satisfy the market demand results in more importation of vegetables and eventually losing trust on local producers by the prominent buyers of the produce. Farmers highlighted the following as challenges regarding marketing their products; 1) lack of finance, 2) failure to adhere to cropping plan, 3) competition with other farmers, 4) lack of machineries, 5) low buying price by retailers and 6) lack of marketing skills together with limited land to produce more.

3.17. *Record Keeping*

It is evident in figure 7 that the most kept records were of production and sales. These findings are consistent with that of Dudafa (2013) who found out that the bulk of records kept by farmers pertained to production and sales. The same tallying trend was observed on those that kept fixed cost and the non-records keeping farmers. Variable cost records were kept by 23.53% of farmers. As much as horticulture is a business enterprise, no farmer there in is exempted from keeping farm records as they assist farmers in tracking progress. According to Obinaju and Ekpo (2017), record keeping determine the success of enterprises. Additionally, records can be of a paramount whenever farmers seek financial assistance from financial institutions such as banks (James, 2019). Tham-Agyekum *et al*. (2010) stated that quality research findings of precise and correct data depend on the records maintained in the farms.

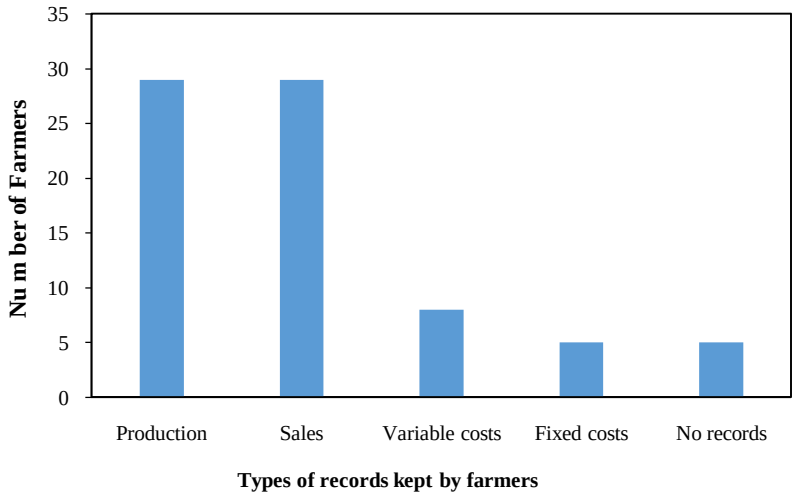

Fig. 7. Farm records kept by farmers.

3.18. *Use of Crop Residues*

Figure 8 shows that more percentages of farmers (53.13%) use crop residues to feed their animals, followed by those (34.38% of farmers) who use residue as compost, then those who burn residue were at 15.63% and about 9.38% of farmers throw away crop remnants. About 6.25% of farmers prefer to sell crop remnants and lastly 3.13% of farmers opt to use them as 'green manure'. Although burning of crop residues is the third option of dealing with crop remnants as per this study, Nankya *et al*. (2019), highlighted that the costs associated with the loss of residuals from burning outstand its benefits. Thus, crop residues are not to be burned rather alternatives can be considered. In Botswana, farmers generally practice arable and pastoral farming simultane--ously. Thus, this might account for more percentages of residues being part of animal feeds. However, education on the use of residue in benefiting the soil and the crop is necessary.

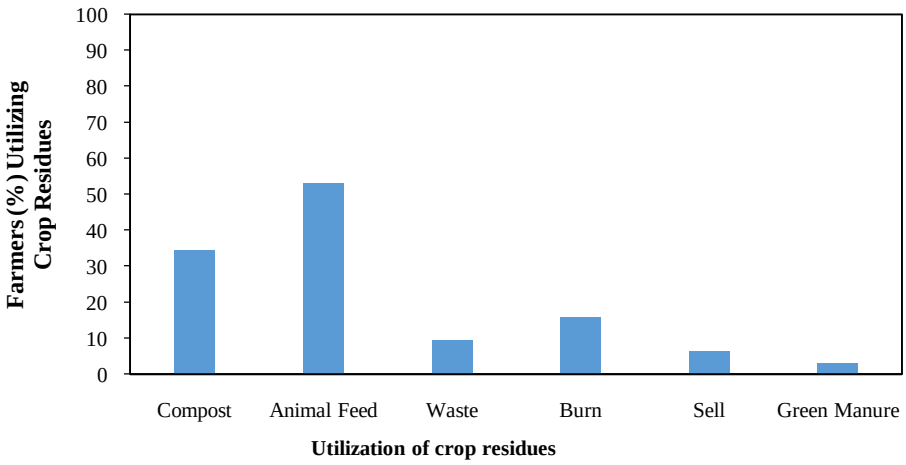

Fig. 8. Various means of utilizing crop residues.

3.19. *Utilization of Programs and Financial Institutions*

Figure 9 shows government programs (financially and technically) that were initiated such as ISPAAD, FAP, Small Medium Micro Enterprises (SMME), Youth Development fund (YDF), together with CEDA, National Development Bank (NDB) and other commercial banks (C. BANKS) for aiding farmers with regards to finance.

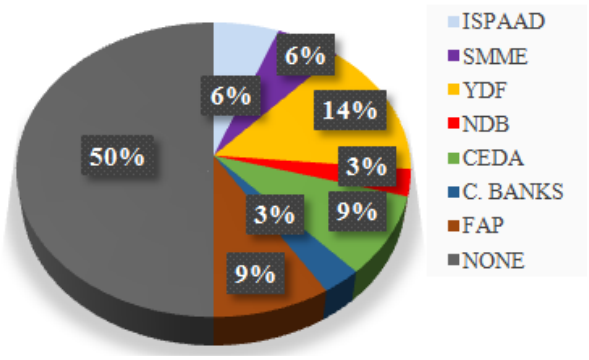

Fig. 9. Percentage of farmers utilizing government programmes, parastatals and financial institutions.

It is evident that half of the farmers are not utilizing any of the available programs nor financial institutions. This renders farmers to constantly run short of funds in bettering their production. Farmers indicated that program procedures/processes ought to be simplified and if possible paper work therein be minimized for them to utilize programmes. Despite that government initiated various programs, only YDF seems to be the most preferred, followed by FAP, then ISPAAD together with SMME. With the YDF package, 50% of it is a grant, hence it is a privilege and is not complicated to obtain. Regarding parastatals and commercial banks, CEDA had an edge. The source of credit and simplicity of accessing it plays a critical role in production (Mariyono, 2019).

3.20. *Farmers Association and Extension Outreach*

Farmers association cultures an atmosphere whereby farmers share beneficial information and ultimately they develop a bond of trusting each other. More than half (55.88%) of farmers were affiliated to regional horticultural association namely *Tshukudu* horticultural management association and 44.12% were not affiliated. Associations are mouth piece for their members (Agriculture Public Expenditure Review, 2014). Other than acting as an advocacy body, the leadership of *Tshukudu* association erratically liaise with seed retailers for trainings which are beneficial for improving production. Additionally, *Tshukudu* has a capacity to organize regional crop demonstrations as well as national field days where agronomic knowledge is shared to the farmers. Thus, unaffiliated farmers lose out on such critical trainings and updates which might not be conveyed by agricultural extension agents. According to Seleka (2005), a grounded farmer's association which is empowered with technical and entrepreneurial skills might be critical in supporting its members in technical competencies. In addition, active associations enhance farmers' access to information, build mutual trust among farmers (Suvedi *et al*., 2017) and improve management of common resources in boosting productivity (Darkey *et al*., 2014).

Most importantly, the success of a farmer depends on the link and frequent visits by extension or the agricultural experts. Nowadays agricultural extension is not only geared for technology transfer, but also it encompasses perfecting farmers' managerial and technical skills through workshops and coaching (Danso-Abbeam *et al*., 2018). Equipping of farmers with production skills is often done by government extension agents but to some extend some related stakeholders. Thus, the closer the farmer to these extension providers the better the farmer is equipped. In Botswana, it is common to relate agriculture extension expects with some of institutions/stakeholders outlined in Figure 10. Although Botswana University of Agriculture and Natural Resources (BUAN), produce solely agricultural professionals whom one way or the other might end up being farmers, only 17.65% of farmers indicated to have collaborations with it, this is a substandard relationship.

However, this university annually avail schedules for short courses that could enhance farmer's knowledge and might bridge the gap in collaborations. Other than short courses, annually BUAN calls upon farmers to receive/ attach their students in their farms at the expenses of the university and this also should have paved a way for linkages.

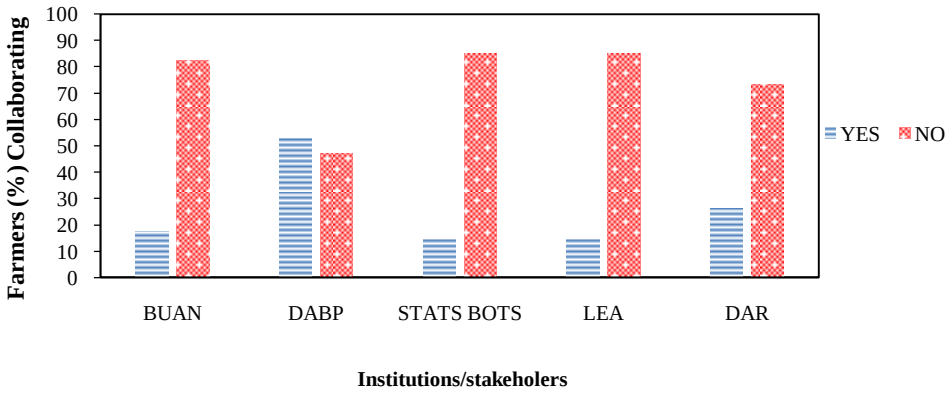

Fig. 10. The level of farmer's collaboration with relevant institutions/stakeholders. (BUAN = Botswana University of Agriculture and Natural Resources, DABP = Department of Agricultural Business Promotions, STATS BOTS = Statistics Botswana, LEA = Local Enterprise Agency and DAR = Department of Agricultural Research).

Statistics in Figure 10 again indicates poor linkages between farmers and Statistics Botswana, Local enterprise agency and department of agricultural research. This might account for low production as indicated in section (3.2) above. Where extension services have been executed adequately with researchers taking their role and other related stakeholders participate in uplifting farmers, an over whelming farming rewards are attainable. Only the Department of Agricultural Business Promotions (DABP) is admittedly by more than 50% of farmers to have some activities of collaborations in the area. This might be due to the fact that some farmers who are also traders are obliged to meet frequently with DABP seeking for imports permits. Again DABP organizes workshops for farmers and traders on quarterly basis in relation to market prevailing situations. Besides, this department on monthly basis, organize market days as another platform of marketing produce.

Furthermore, the study shows that 45.45% of farmers interact with extension agents more on quarterly basis than on other intervals, some farmers (3.03%) meet agricultural extension officers once a year, 24.24% of farmers meet extension officers on monthly, whereas others (3.03%) interact with extension agents fortnightly or weekly (Figure 11). On the other hand, 15.15% of farmers indicated that they never have a privilege of meeting with extension agents. This is in agreement with Madisa *et al.* (2010) who highlighted that studies on agricultural extension service issues indicates that extension services are either rare or absent. Subsequently, Paulus (2015) in Namibia, substantiated that majority of farmers do not receive extension services neither do they have a contact with extension agents, resulting in farmers depending on indigenous knowledge, adjacent farmers as well as on their own experience. Extension services is an integral part of farm enterprises, thus, frequent visits of extension agent to farmers is of paramount. Bonye *et al*. (2012) stated that extension service is a backbone in fostering the knowledge about new technologies to farmers and act as a catalyst in hastening up adoption rate. According to Abang *et al.* (2014), where extension expects fall short of visiting farmers, capability in farm management, ability to identify crop pests and diseases as well as basic knowledge on certain crop production activities eventually diminishes. Though extension agents are to be visible to farmers, Madisa *et al.* (2010) stated that they are technically inefficient when it comes to vegetable production.

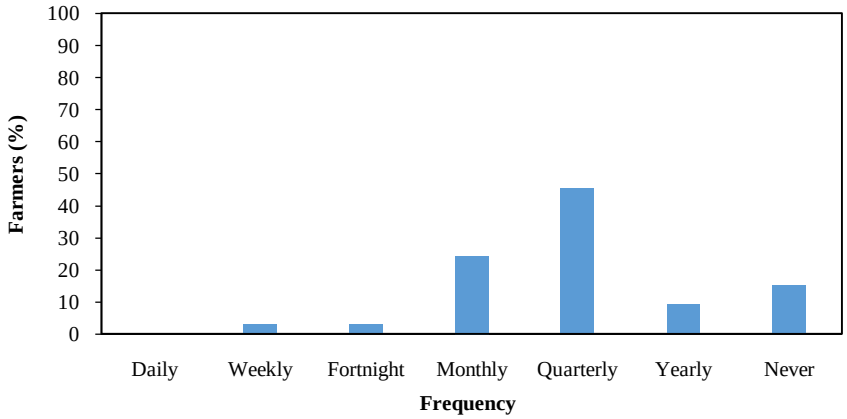

Fig. 11. Interaction intervals of farmers with extension agents.

Subsequently, farmers were varying with regards to the desired forms of interaction with agricultural extension agents. Majority of farmers (78.79%) preferred face to face interactions, others (42.42%) preferred the use of telephone be either text messages (SMS) or direct calls, and lastly by means of email or *kgotla* (traditional customary court) meetings of which all this were highlighted by 6.06% of farmers. The channels of information to which farmers are exposed to, plays a role in utilization of technologies. Thus, any form of contact between farmers and agricultural extension agents can be exploited. Golicz *et al*. (2019) indicated that an existing extension advice can be channeled to the beneficiaries using some portable and almost common devices such as smartphones.

3.21. *Training Organized by Agricultural Extension Agents*

Botswana government introduced Farmers Field Schools (FFS), herein officially named Rural Training Centres (RTC). The centres are in various places to facilitate information dissemination or to equip farmers by means of short courses (on station or field course) covering spectrum agricultural subjects. From this study, 64.71% of farmers confirmed that they benefited from such centres whereas 35.29% indicated that they have not attended any RTC trainings. The results further reveals that 81.82% of farmers were trained on basic vegetable production, followed by 54.55% who were trained on pests and weeds management and record keeping gained 36.36% of farmers. Training on harvesting, grading and sorting of vegetables was attended by 36.36% of farmers, while 22.73% of farmers were trained on fruit production and lastly 4.55% of farmers attended training on vegetable preservation. These short courses are designed to supplement the literacy of farmers who might have ventured in farming with lower education. Moreover, Friis-Hansen and Duveskog (2012), indicated that such institutions build the capacity of local people and enhance the rate of uptake of agricultural innovations.

3.22. *Climate Change*

Statistics shows that 91.18% of farmers interviewed have access to weather forecast information. Bosekeng *et al*. (2020) highlighted that radio and television broadcasts are the major source of such information in this locality. Therefore, other agricultural related programs or messages can be channelled to farmers through such avenues. This will expedite information dissemination and perhaps at the same time reduce the overwhelming visits of extension agents to the farming communities. Although a satisfying number of farmers are privileged to access weather forecast information, 70.59% of them showed to be utilizing such information, whereas 29.41% of farmers are unable to comprehend weather forecast information. This requires additional seminars for farmers

by the department of Meteorological Services in partnership with MoA. Additionally, farmers (94.12%) attested that they were aware of climate change in the area. Convincingly, 96.88% of farmers cited phenomenon such as shift of seasons, outbreak of crop diseases and pests were cited by 78.13% of farmers, heavy rainfall/floods and heavy storms were cited by 28.13% of farmers. Other farmers (68.75%) pointed out severe droughts, while occurrences of high temperature during summer was indicated by 96.88% of farmers and 56.25% mentioned lower temperatures in winter. These changes in this area were previously observed by Bosekeng *et al*. (2020) who noted that changes in the mean rainfall and temperatures were of more concern.

Regarding the coping strategies for climate change, farmers (28.13%) depend on adaptable crops (hybrids), 12.5% of farmers plant crops in the right season, frequent irrigation was highlighted by 43.75% of farmers, 18.75% depend on synthetic chemicals, 9.38% use net shade, 3.13% plant vegetables under trees and 13.13% practice forced vegetable production. None of the producers in the area practice moisture conservation, perhaps this is due to the fact that most farmers in the area do not account for the amount of water utilized as discussed earlier in section 3.10. This contrasts Kato *et al.* (2011), who cited moisture conservation as a critical tool during this era of climate change. Management of water can be a fundamental long term adaptation option. Callo-Concha (2018), added that a support that can be bestowed to farmers in adaptation as well as increasing the resilience in climate change can be done superbly by agricultural extension services.

3.23. *Other Operation Challenges and Solutions*

Although farming is a daily activity leading to food security both at household and national level, the role players there in particularly farmers encounter various challenges. Farmers were asked to state challenges they experience in complimenting those that are covered above and they outlined them as follows; dry spell around October and November, which was a concern to 79.41% of farmers, then 88.24% of farmers lamented on high input costs, 64.71% of farmers surfaced the delayed feedback from extension officers as a stumbling block while 70.59% of them were worried about lack of information regarding production, 73,53% of farmers revealed that costs of fuel is unbearable and 46.06% of farmers indicated lack of electricity connection as a challenge. Of the 34 farmers interviewed, 73.53% of them were devastated by the illegal river sand mining which affect water storage beneath the river sand while 8.82% of farmers highlighted shortage of labour. Those that indicated, transport and market as challenges were at par by 5.88%. Lastly those that viewed gravel road and disposal of empty chemical containers were each accounted for by 2.94% of farmers.

In response to these challenges, 56.25% of farmers suggested continued government subsidies, followed by those (46.88%) who suggested that illegal river sand mining be discouraged and 18.75% of farmers suggested to have frequent meetings with agricultural extension agents. Sourcing out funds, renting cars for transporting produce and revisiting of procedures/policies on labour issues were all suggested by 6.25% of farmers. Lastly 3.13% of farmers were in one accord by suggesting the use of solar panels, reducing dependency syndrome from government, if possible flashing or opening of Shashe dam when rains are not promising to escape dry spell, weather forecasts be specific to their location and lastly regular spraying of pests.

IV. CONCLUSIONS AND RECOMMENDATIONS

Production trend is fluctuating, the amount of vegetable production is low and cannot meet the market demand. Vegetable farmers are faced with all aspect of constraints such as lack of implements, lack of transport,

crop pests and diseases that results in heavy application of synthetic chemicals and climate change. Gullies were also a concern in the area. The size of farms showed to be an impediment as farmers are obliged to cultivate more than three crops at the same time in one hectare and this limit the abundance of other crops. Farmers do not practice moisture conservation though they are in a semi-arid conditions and suffers dry spell around October and November. Although the study shows a number of constraints faced by farmers, it is encouraging to note that farmers had developed some level of resilience. Although farmers are struggling financially, they do not utilize available financiers satisfactorily, citing the cumbersome processes and procedures therein. This research has established that farmers prefer face to face extension approach. Adequate mechanisms and networking of extension agents and other stakeholders should be fortified for improving farmer's production knowledge in improving vegetable production. The coping strategies used to withstand effects of climate change such as adaptable crops, time of planting, use of net shade are important in enhancing farmer's adaptability to climate change. Thus these practices need to be reinforced and be replicated to other Districts. The following then are recommendations;

- Establishment of the bottlenecks in tomato, Irish potato and onion production. Inclusion of other daily consumed vegetables such as carrots, butternuts, green pepper in the top list as these vegetables can be among the cash crops.
- Farmers be encouraged to specialize in certain crops and the clusters should agree on the cropping plan to avoid flooding of one crop in the market.
- Teaching farmers on the use of synthetic chemicals in order to minimize pesticides residues in vegetables.
- Initiate and conducting of collaborative on-farm demonstrations and trials together with farmers' associations, extension agents and researchers from both the government and private sectors.
- Batswana should consider farming as a carrier that one can embark on at a tender age or a priority after graduation rather than a project for the retirees.

ACKNOWLEDGMENT

The author is highly thankful to the management team of district agricultural coordinator (North East District) for bringing up the topic of this study and all the agricultural departments that assisted in the development of the questionnaire and data collection. My gratitude also to Mrs K.O. Odigetse for the logistics she made throughout the survey. Thanks also to Mr S.M. Mookantsa, Mrs L.C. Bosekeng and Mr, Z. Madzonga for their valuable contributions during the final write-ups.

REFERENCES

[1] Mbulawa, S. 2017. Accelerating agricultural productivity to enhance economic growth in Botswana. *Current Research in Agricultural Sciences*. 4(1), 14 – 31.
[2] UNDP. 2012. Reflecting on the challenges of attaining a green economy for Botswana. Botswana agriculture sector policy brief. retrieved: https://sustainabledevelopment.un.org/content/documents/1008Ntional%Report%20(Agriculture)%20-%20Botswana.pdf
[3] African Development Bank, 2014. Country strategy paper 2015-2019. Botswana. Retrieved from https://www.afdb.org/en/documents/document/botswana-contry strategy-2015-2019-108788.
[4] Botswana Country Report. 2005. Crop-livestock systems development in southern Africa: priorities for future research. Centre for Applied Research - Gaborone, Botswana. www.car.org.bw.
[5] Seleka, T.B. 2005. Challenges for agricultural diversification in Botswana under the proposed SADC-EU Economic Partnership Agreement (EPA). Botswana institute for development policy analysis. Working paper No. 27. November. Gaborone, Botswana.
[6] Baliyan, S.P. and Kgathi, D.L. 2009. Production and marketing problems in small scale horticultural farming in Botswana. *Acta Horticulturae*. 831, 31 – 40.
[7] Madisa, M.E., Obopile, M. and Assefa, Y. 2012. Analysis of horticultural production trends in Botswana. *Journal of Plant Studies*.

1(1), 25 – 32.
[8] Hess, T.M. and Molatakgosi, G. 2009. Irrigation management practices of cabbage farmers in Botswana using saline groundwater. *Agricultural Water Management*. 96(2), 226 – 232.
[9] Bosekeng, G. and Coetzer, G.M. 2015. Response of onion (*Allium cepa* L.) to sowing date and plant population in the Central Free State, South Africa. *African Journal of Agricultural Research*. 10(4), 179 – 187.
[10] Karaye, A.K., Sabo, B.B., Chamo, A.M. and Rabiu, A.M. 2017. Influence of agronomic practices on crop production. *International Journal of Sciences: Basic and Applied Research*. 31(1), 61 – 66.
[11] Moswetsi, G., Fanadzo, M. and Ncube, B. 2017. Cropping systems and agronomic management practices in smallholder farms in South Africa: constraints, challenges and opportunities. *Journal of Agronomy*. 16(2), 51 – 64.
[12] MoA. 2018. Monthly agricultural price bulletin. January, department of agricultural business promotion. Gaborone, Botswana.
[13] Batlang, U., Tsurupe, G., Segwagwe, A. and Obopile, M. 2014. Development and application of modern agricultural biotechnology in Botswana: The potentials, opportunities and challenges. *GM Crops and Food*. 5(3), 183 – 194.
[14] Madisa, M.E., Assefa, Y. and Obopile, M. 2010. Assessment of production constraints, crop and pest management practices in Peri-urban vegetable farms of Botswana. *Egyptian Academic Journal of Biological Sciences*. 1(1), 1 – 11.
[15] Nankya, E., Wasukira, A., Gidoi, R., Pande, J. and Owere, L. 2019. Factors and practices affecting nutrient management in Eastern Uganda. *International Journal of Innovations and Research*. 7(5), 527 – 532.
[16] Olawepo, R.A. 2010. Constraints to increased food Productivity in Rural Areas: An example from Afon District, Ilorin, Nigeria. *Asian Social Science*. 6(4), 106 – 116.
[17] Statistics Botswana. 2018. Botswana agricultural census report 2015. Gaborone, Botswana. Pp 11.
[18] Tauer, L.W. and Lordkipanidze, N. 2000. Farmer efficiency and technology use with age. *Agricultural and Resource Economics Review*. 29(1), 24 – 31.
[19] Tauer, L.W. 1982. The efficiency of the family dairy farm over its life cycle. *Journal of the Northeastern Agricultural Economics Council*. X1(2), 85 – 92.
[20] Saiyut, P., Bunyasiri, I., Sirisupluxana, P. and Mahathanaseth, I. 2019. The impact of age structure on technical efficiency in Thai agriculture. *Kasetsart Journal of Social Sciences*. 40, 539 – 545.
[21] Corner-Thomas, R.A., Kenyon, P.R., Morris, S.T., Ridler, A.L., Hickson, R.E., Greer, A.W., Logan, C.M. and Blair, H.T. 2015. Influence of demographic factors on the use of farm management tools by New Zealand farmers. *New Zealand Journal of Agricultural Research*. 58(4), 412 – 422.
[22] Afari, E. 2001. The effect of farmers' education on farm productivity and income in Ghana: Implication for food security. Master of Philosophy degree in agricultural economics (Thesis). Department of agricultural economics and agribusiness. University of Ghana, Legon, Ghana. Pp4.
[23] Kabiru, S.A. and Arshad, R. 2019. The effect of education on agricultural productivity: Implication for rural development. *Journal of Management and Economic Studies*. 1(6), 28 – 35.
[24] Mburu, S., Ackello-Ogutu, C. and Mulwa, R. 2014. Analysis of economic efficiency and farm size: A case study of wheat farmers in Nakuru District, Kenya. *Economics Research International*. Pp 1 – 10. http://dx.doi.org/10.1155/2014/802706.
[25] Uchiyama, T., Lobley, M., Errington, A. and Yanagimura, S. 2008. Dimensions of intergenerational farm business transfers in Canada, England, the USA and Japan. *The Japanese Journal of Rural Economics*. 10, 33 – 48.
[26] Ayamga, M. and Dzanku, F. 2013. The land rights and farm investment Ghana: The missing link in the operationalisation of tenure security. 4th International conference of the African association of agricultural economists. 22 – 25 September. Hammamet, Tunisia. Retrieved: https://ideas.repec.org/p/ags/aaae13/161478.html.
[27] Rai, M.K., Paudel, B., Zhang, Y., Khanal, N.R., Nepal, P. and Koirala, H.L. 2019. Vegetable farming and farmers' livelihood: insights from Kathmandu Valley, Nepal. *Sustainability*. 11 (889), 1 – 17. doi: 10.3390/su11030889. www.mdpi.com/journal/sustainability.
[28] Bosekeng, L.C., Mogotsi, K. and Bosekeng, G. 2020. Farmers' perception of climate change and variability in the North-East District of Botswana. *Livestock research for rural development*. 32(1). Retrieve: http://www.irrd.org/irrd32/i/ibose32012.html.
[29] Davis, B., Di Giuseppe, S. and Zezza, A. 2017. Are African households (not) leaving agriculture? Patterns of households' income sources in rural Sub-Saharan Africa. *Food Policy*. 67, 153 – 174.
[30] Nolte, K. and Ostermeier, M. 2017. Labour market effects of large-scale agricultural investment: Conceptual considerations and estimated employment effects. *World development*. 98, 430 – 446.
[31] MoA. 2009. Irrigation Research. Soil, Water management and engineering programme. Department of agricultural research. Division of arable crops research. Gaborone, Botswana. www.dar.gov.bw. Date accessed: 12/02/2020.
[32] Pule-Meulenberg, F. and Emongor, V.E. 2005. Sustainability of underground water for irrigated agriculture in some parts of Botswana. *Journal of applied Sciences*. 5(8), 1420 – 1423.
[33] Mburu, P.T. and Massimo, S.K. 2005. A comparative study of marketing problems faced by small-scale crop farmers in Botswana and Kenya. Is there a way out? *Journal of Applied Sciences*. 5(6), 1133 – 1141.
[34] Nhundu, K., Mushunje, A., Zhou, L. and Aghdasi, F. 2015. Institutional determinants of farmer participation in irrigation development post "fast-track" land reform program in Zimbabwe. *Journal of Agricultural Biotechnology and Sustainable Development*. 7(2), 9 – 18.
[35] Pokhrel, B.K., Paudel, K.P. and Segarra, E. 2018. Factors affecting the choice, intensity, and allocation of irrigation technologies by U.S. cotton farmers. *Water*. 10(706), 1 – 12. Doi: 10.3390/w10060706. www.mdpi.com/journal/water.
[36] Ghosh, B.K. 2010. Determinants of farm mechanisation in modern agriculture: A case study of Burdwan Districts of West Bengal. *International Journal of Agricultural Research*. 5(2), 1107 – 1115.
[37] Mottaleb, K.A., Krupnik, T.J. and Erenstein, O. 2016. Factors associated with small scale agricultural machinery adoption in Bangladesh: Census findings. *Journal of Rural Studies*. 46, 155 – 168.
[38] Thakur, P., Dash, S.P. and Kumar, K. 2016. Recent advances in hybrid seed production of cucurbits. *Journal of Agroecology and Natural Resource Management*. 3(3), 220 – 224.
[39] Sullivan, D.M., Peachey, E., Heinrich, A.L. and Brewer, L.J. 2017. Nutrient management for sustainable vegetable cropping system in Western Oregon. Nutrient management guide. Oregon State University. U.S. Pp8.
[40] MoA. 2006. Manual for vegetable production. Department of agricultural research. Gaborone, Botswana.Pp47.
[41] Wimalawansa, S.A. and Wimalawansa, S.J. 2014. Impact of changing agricultural practices on human health: Chronic kidney disease of multi-factorial origin in Sri Lanka. *Wudpecker Journal of Agricultural Research*. 3(5), 110 – 124.
[42] Bosekeng, G. 2019a. Response of Ethiopian Mustard (*Brassica carinata* A. Braun) to different levels of vermicompost in North East, Botswana. *World Journal of Agricultural Research*. 7(3), 112 – 118.
[43] Bosekeng, G. 2019b. Response of Rape (*Brassica napus* L.) var. English Giant to different levels of vermicompost in North East, Botswana. *International Journal of Agriculture Innovations and Research*. 8(3), 232 – 243.
[44] Hennessy, D.A. 2004. On monoculture and the structure of crop rotations. CARD Working papers. 400. http://lib.dr.iastate.edu/card_workingpapers/400.

[45] Boyabatli, O., Nasiry, J. and Zhou, Y.H. 2019. Crop planning in sustainable agriculture: Dynamic farmland allocation in the presence of crop rotation benefits. *Management Science*. 65(5), 2060 – 2076. Research collection Lee Kong Chian School of Business. https:// ink.library.smu.edu.sg/lkcsb_research/4935.
[46] Leungo, G., Obopile, M., Oagile, O., Madisa, M.E. and Assefa, Y. 2012. Urban vegetable farm workers beliefs and perception of risks associated with pesticides exposure: A case of Gaborone city, Botswana. *Journal of Plant Studies*. 1(2), 114 – 119.
[47] Machekano, H., Masamba, W., Mvumi, B.M. and Nyamukondiwa, C. 2019. Cabbage or 'pesticide' on the platter? Chemical analysis reveals multiple and excessive residues in African vegetable markets. *International Journal of Food Contamination*. 6(2), 1 – 13.
[48] Lewis, W.J., van Lenteren, J.C., Phatak, S.C. and Tumlinson III, J. H. 1997. A total system approach to sustainable pest management. *Proceedings of the National Academy of Sciences of the United States of America*. 94, 12243 – 12248.
[49] Mariyono, J. 2019. Stepping up from subsistence to commercial intensive farming to enhance welfare of farmer households in Indonesia. *Asia and the Pacific Policy Studies*. 6(2), 246 – 265.
[50] Baliyan, S.P. 2014. Improving sustainable vegetable production and income through net shading: A case study of Botswana. *Journal of Agriculture and Sustainability*. 5(1), 70 – 103.
[51] Dudafa, U.J. 2013.Record keeping among small farmers in Nigeria: Problems and prospects. *International Journal of Scientific Research in Education*. 6(2), 214 – 220.
[52] Obinaju, L.C. and Ekpo, R.R. 2017. Record keeping: An effective management practice in poultry business in Uyo local government area of Akwa Ibom State. Conference Proceedings of the 18th Annual national conference of the Nigerian association of agricultural economists. 16-19 October. Abeokuta, Nigeria.
[53] James, S.O. 2019. Farm records, bookkeeping and agricultural data: A case study of small scale farmers in Nasarawa State, Nigeria. *Production Agriculture and Technology*. 15(1), 23 – 32.
[54] Tham-Agyekum, E.K., Appiah, P. and Nimoh, F. 2010. Assessing farm record keeping behaviour among small-scale poultry farmers in the Ga East Municipality. *Journal of Agricultural Science*. 2(4), 52 – 62.
[55] Agriculture Public Expenditure Review, 2014. Strengthening national comprehensive agricultural public expenditure in Sub-Sahara Africa. Botswana, 97537. Pp 41, Retrieved: www.worldbank.org/afr/agperprogram.
[56] Suvedi, M., Ghimire, R. and Kaplowitz, M. 2017. Revitalizing agricultural extension services in developing countries: Lessons from off-season vegetable production in rural Nepal. *Journal of the International Society for Southeast Asian Agricultural Sciences*. 23(1), 1 – 11.
[57] Darkey, S.K., Dzoemku, B.M., Okorley, E.L., Gyimah, N.A. and Bluwey, F.A. 2014. Contribution of urban vegetable production to farmers' livelihood: A case of the Kumasi Metropolis of Ashanti region of Ghana. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*. 14(1), 77 – 82.
[58] Danso-Abbeam, G., Ehiakpor, D.S. and Aidoo, R. 2018. Agricultural extension and its effects on farm productivity and income: Insight from Northern Ghana. *Agriculture and Food Security*. 7(74), 1 – 10.
[59] Paulus, N.N. 2015. Factors affecting sustainable subsistence farmers' adoption of sustainable land management practices in Oshikoto Region, Namibia. United Nations University Land Restoration Training Programme. [final project]. http://www.unulrt.is/ static/fellows/document/Paulus2015.pdf.
[60] Bonye, S.Z., Alfred, K.B. and Jasaw, G.S. 2012. Promoting community-based extension agents as an alternative approach to formal agricultural extension service delivery in Northern Ghana. *Asian Journal of Agriculture and Rural Development.* 2(1), 76 – 95.
[61] Abang, A.F., Kouamé, C.M., Abang, M., Hanna, R. and Fotso, A.K. 2014. Assessing vegetable farmer knowledge of diseases and insect pests of vegetable and management practices under Tropical conditions. *International Journal of Vegetable Science*. 20(3), 240 – 253.
[62] Golicz, K., Hallett, S.H., Sakrabani, R. and Pan, G. 2019. The potential for using smartphones as portable soil nutrient analyzers on suburban farms in central East China. Scientific Reports. Nature Research 9: 16424 available. https://doi.org/10.1038/s41598-019-52702-8.
[63] Friis-Hansen, E. and Duveskog, D. 2012. The empowerment route to well-being: An analysis of farmer field schools in East Africa. *World Development*. 40(2), 414 – 427.
[64] Kato, E., Ringler, C., Yesuf, M. and Bryan, E. 2011. Soil and water conservation technologies: a buffer against production risk in the face of climate change? Insights from the Nile basin in Ethiopia. *Agricultural Economics*. 42, 593 – 604.
[65] Callo-Concha, D. 2018. Farmer perceptions and climate change adaptation in the West Africa Sudan Savannah: Reality check in Dassari, Benin, and Dano, Burkina Faso. *Climate*. 6(44), 1 – 19. doi: 10.3390/cli6020044. Retrieved: www.mdpi.com/journal/climate.

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