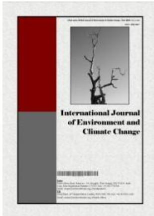

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Climate Change and Climate-Smart Agricultural Practices: Opportunities and Challenges in the Semi-deciduous region of Ghana

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Authors' contributions

This work was carried out in collaboration among all authors. Authors EO, AO and HOT designed the study, wrote the protocol and wrote the first draft of the manuscript. Author APPS managed the literature searches. Author CGK performed the statistical analysis and managed the analysis of the study. All authors read and approved the final manuscript.

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ABSTRACT

Aim: This study was conducted to investigate small holder farmers' awareness of climate-smart agricultural practices and challenges to climate change adoption in the semi-deciduous zone of Ghana.
Study Design: A descriptive research design was used for the study.
Place of study: The study was conducted within the Sekyere South district in the Ashanti Region of Ghana.
Methodology: Questionnaire was the main tool for data collection. Statistical Package for Social Science [SPSS], version 20 was used for data analysis. Pearson Product Correlation was used to determine the correlation between variables and CSA at 0.05 significant level.
Results: Results from the study revealed that agroforestry (52.0%) and rainwater harvesting techniques (80.0%) were never known among majority of the respondents' as CSA strategy. Besides, farmers were moderately aware of fire and pest management (48.0%) and crop rotation

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(36.0%) strategies as CSA approach (48%), as well as, minimum tillage which farmers testify of having a considerable idea on it (52%). Nonetheless, respondents often used improved seed variety (64%) and also resorted to residue management and usage (52%) as CSA options in crop productivity. The study further revealed that a higher segment of the farmers attested that no proper training/education, no governmental support, lack of finance, lack of climate information and non-availability of extension field officers, representing 64%, 76%, 84%, and 76% respectively were the major challenges faced by farmers in adopting and practicing climate-smart agriculture.
Conclusion: Farmers little knowledge on climate change impeded the successful adoption of CSA practices.

Keywords: Farmers; climate-smart; agriculture; climate change; adaptation.

1. INTRODUCTION

Agriculture is the primary income for an estimated 70% of the world's poor who live in rural areas. This sector employs about 1.3 billion smallholders and landless workers in the whole world [1]. Agricultural production systems are expected to produce food for the global population that is expected to reach 9.1 billion people in 2050 and over 10 billion by end of the century [2]. According to [3], agricultural systems need to be transformed to increase the productive capacity and stability of smallholder agricultural production in the wake of climate change. Agriculture plays a fundamental role in Ghana despite the recent transition to an industry and service sector-led economy [4]. The sector contributes about 20% of the country's GDP, generates about 30% of the foreign exchange earnings and employs about 50% of the work force [5]. Small scale farming dominates agriculture in Ghana mostly operating on less than 2 ha in total landholdings. Small scale farming provides food security and income for many rural households as well as supplying the urban population with food and contributing to the national economies of their individual countries.

The major challenges faced by smallholders in Ghana were climate change, drought, poor information dissemination, inadequate extension officers, low soil fertility due to intensive farming over the same area of land, weed competition and poor agronomic practices. Among the above constraints, climate change, drought and poor information dissemination have been pointed out as the key challenges faced by small smallholders in Ghana [6]. Rainfall is becoming more variable and unpredictable and may cause water shortages, shorter growth periods, and more frequent flooding and drought [7]. As a result, some areas may become unsuitable for farming while other areas, such as those at higher latitudes and altitudes but with more fragile soils, may become farmable [8].

Adaptation to climate change and its mitigation potentials are the greatest current challenges facing agriculture globally. Climate variability and change negatively affect food security and livelihoods of the poorest farmers, fishers and forest-dependent people. Coupled with land degradation, increasing energy and food prices, and reduced investment support [9], climate change will exacerbate poverty and food insecurity for the poorest smallholder farmers. Climate change has already caused significant impacts on water resources, human health and food security. Moreover, the impacts of climate change are unequally distributed as men and women farmers living in rural areas, conflict-prone areas, dry lands, mountain areas and coastal zones are more prone to shocks and stresses. Added to other non-climatic stresses (e.g. poverty, inequality, and market shocks), climate change will make achieving Sustainable Development Goals on food security, livelihood, poverty reduction, health, and access to clean water more difficult to achieve for vulnerable communities. Agriculture development policies that support adaptation to and mitigation of climate change amongst financially poor, vulnerable communities will be key to addressing these multiple challenges.

Agriculture can have both climate change adaptation and mitigation functions, while playing a beneficial role in economic growth and livelihoods [10]. Although the promotion of climate-smart agriculture in sub-Saharan Africa is ongoing as part of many developing countries' sustainable agricultural development policy [11], empirical evidence shows that adoption rates among smallholder farmers are still low [12,13]. Promotion of climate-smart agriculture in Ghana gained momentum since the country ratified the United Nations Framework Convention on

Climate Change in 1995 [14]. The Kyoto Protocol was adopted by Ghana's Parliament in 2002 and eventually led to the current National Climate Change Policy. Through various state and non-state agencies, Ghana has sought to make climate-smart agriculture part of its agricultural development policy [15].

However, the policy direction, adoption strategies, practice procedure and technical understanding among the small holder farmers are the major limiting factor affecting the success of policy. Moreover, the integrated options for adapting to the erratic climate variability to achieve the millennium challenge goal for 2050 seem to be unrealistic. Notwithstanding, the few studies conducted in Ghana on small holder farms was on mono-cropping perspective, which evaluated the adoption and impacts of multiple climate-smart practices [13]. This according to [16], might affect the adoption potential as it can lead to under-estimating or over-estimating the true impacts; since in mixed cropping setting, there could be synergistic or antagonistic interactions that could affect the outcome of the field results and hence the subsequent future adoption of the practice.

This study therefore was aimed to investigate small holder farmers' awareness of climate-smart agricultural practices and challenges to climate change adoption in the semi-deciduous zone of Ghana.

2. RESEARCH METHODOLOGY

2.1 Study Area

The study was conducted within the Sekyere South district in the Ashanti Region of Ghana. The Sekyere South District is located in the north eastern part of the Ashanti Region. Agona Ashanti being an administrative capital is located 37 kilometers from Kumasi, along the Kumasi-Mampong trunk road. The District shares common borders with Ejura Sekyeredumasi to the north, Mampong Municipal and Sekyere East to the east, Kwabre East to the south and Offinso Municipal to the west. The District has a total land area of 416.8 square kilometers representing about 1.7% of the total land size of the Region. The population density in the district is 226 person/sq/km. The District lies between latitude 60 50'N and 70 10'N and Longitude 10 40'W and 10 25' W.

2.2 Research Design

In this study the descriptive research design was adopted. According to [17], descriptive research is used to describe characteristics of a population or phenomenon being studied. Descriptive research design was used because the study was to investigate small holder farmers' perception on the impact of climate change on food production and revenue returns in the semi-deciduous zone of Ghana, which involved collecting data in order to answer research questions concerning the topic under study. Descriptive analysis and interpretation of the information collected were employed alongside the use of quantitative approach to the study. The aim of using the close and open ended questions was to draw a conclusion about the opinion of respondents.

2.3 Population, Sample and Sampling Technique

The target population for this research work was twenty-five farmers who are citizens living in the Sekyere South District in the Ashanti Region of Ghana. First, a cluster sampling technique was used for sampling, considering the heterogeneous nature of the population of the study area. This technique was used in order to obtain adequate representation of the various homogenous subsets within the various units of analysis. Based on this, purposive, snowball and simple random sampling technique were employed to select the number of small holder farmers needed for the study. The snowballing method helped to locate exactly where to find the small holder farmers without going through the whole town in search of them. The use of simple random sampling gave chance to all small holder farmers within the Sekyere South District to be selected for the study. For the selection of sample size of small holder farmers to participate in the study, convenience sampling technique was used by the researcher because of the ease of their volunteering and availability. In total, a sample size of twenty-five (25) was used for the study.

2.4 Data Collection Instrument

Questionnaire was used as the main data collection instrument. A total of sixty-seven (67) item questionnaire was designed for twenty-five small holder farmers within the Sekyere South District. The first part of the questionnaire aimed at recording the general demographic information (such as age, gender, etc.) of small holder farmers, whereas the other sections was questions related to small holder farmers' awareness of climate-smart agricultural (CSA) practices and challenges to climate change adoption in the semi-deciduous zone of Ghana. All the questionnaires administered were completed and returned by the farmers which were used for analysis.

2.5 Pre-Testing of Research Instrument

A pre-test was conducted to check for consistency in the responses and to ensure that the instruments would yield fair and reliable results. The purpose of the pre-test was to allow the researcher to make the necessary changes to the test items which were inappropriate and also determine the level of ambiguity of the questions for modification. A total of ten (10) small holder farmers were selected and used for the piloting. Small holder farmers used for the piloting were selected randomly.

2.6 Validity and Reliability of Research Instrument

To enhance validity of the instrument, a pilot study was conducted within the Sekyere South District. This population was not used in the final research. Reliability is a measure of the degree to which a research instrument yields consistent results or data after repeated trials [18]. In this study, the validity of the research has been considered through the identified approach of Wood that includes a sustained method and respondents' validation of data [18]. Small holder farmers were also at liberty to redraw from the study anytime they feel uncomfortable or compromised.

2.7 Data Analysis

For this research, the compilation of the field data was done using Statistical Package for Social Science [SPSS], version 20. Descriptive statistical tools such as dispersion was used in analyzing the closed ended questions. Tables and percentages were employed to display various responses. The data collected on open ended questions were subsequently analyzed using the qualitative technique of content analysis. Significance test was also analysed using Pearson correlation at significant level of 0.05 (2-tailed).

3. RESULTS

3.1 Socio-demographic Information of Farmers

The study revealed that 60% of the respondents were males while 40% were females. Majority of the respondents representing 40% were above 51 years with mean age of 25 years. Most (40%) of the respondents had MSCL as their highest academic qualification with an average family size of 8 members. Majority (72%) of the respondents cover < 3 km to the farm site (Table 1).

3.2 Farmers Level of Awareness of CSA Practices

Data presented in Table 2 indicated that respondents in the study area very often followed climate smart practices such as use of improved seed variety (40%) and minimum or zero tillage practices (52%). Whereas, 80% respondents never used rainwater harvesting techniques and 52% never practiced agroforestry in the fields.

Pearson Product Correlation analysis of farmers' awareness of CSA practices (Table 3) showed that the use of improved seed variety, fire and pest management and crop rotation were positively correlated with farmers' awareness of CSA practices. Irrigation management, control of soil erosion and run-off, minimum or zero tillage practices, agro-forestry and rainwater harvesting techniques were negatively correlated with farmers' awareness of CSA practices. Control of soil erosion and run-off was observed to be negatively significant ($P<0.05$) and correlated with CSA practices.

3.3 CSA Practices Employed by Farmers

Results from Table 4 shows that a greater segment of the sampled farmers never resorted to the use of mixed farming (72%); contour farming (76%); terracing and earth bunds (68%); minimum tillage (60%), as well as, rainwater harvesting (84%) as CSA technology in field operations. Nonetheless, farmers per the data gathered often used improved seed variety (64%) and also resorted to residue management and usage (52%) as CSA options in crop productivity. Despite the increase in awareness in organic farming and the use of organic fertilizers and manures, only 40% of the sampled farmers admitted the use of mulch and organic manure in their farming activities as a climate-smart approach in addressing climate change effect on farming.

Table 1. Socio-demographic characteristics of small holder farmers

Background information	Variables	Percentage (%)
Gender	Male	60.0
	Female	40 .0
Age	21-30 years	28.0
	31-40 years	12.0
	41-50 years	20.0
	> 51 years	40.0
Education	MSLC	40.0
	SSCE/WASCE	20.0
	Tertiary	28.0
	Non-formal education	12.0
Family size	<5	32.0
	6-10	36.0
	11-15	4.0
	> 15	28.0
Distance covered	<3 Kilometers	72.0
	4-5 Kilometers	20.0
	> 5 Kilometers	8.0

Table 2. Descriptive analysis on farmers' awareness of CSA Practices

CSA Practices	Extremely aware	Moderately aware	Somewhat aware	Not at all aware
Use of improved seed variety	44.0%	24.0%	24.0%	8.0%
Irrigation management	8.0%	36.0%	28.0%	28.0%
Control of soil erosion and run-off	4.0%	20.0%	32.0%	44.0%
Minimum or zero tillage practices	52.0%	20.0%	12.0%	36.0%
Agroforestry	8.0%	12.0%	28.0%	52.0%
Rainwater harvesting techniques	4.0%	8.0%	8.0%	80.0%
Fire and pest management	12.0%	48.0%	36.0%	4.0%
Crop rotation	24.0%	36.0%	32.0%	8.0%

Table 3. Correlation analysis on farmers' awareness of CSA Practices

CSA Practices	Std. Deviation	Pearson Correlation	Sig. (2-tailed)
Use of improved seed variety	14.74	0.919	0.081
Irrigation management	11.94	-0.734	0.266
Control of soil erosion and run-off	17.08	-0.958*	0.042
Minimum or zero tillage practices	11.01	-0.074	0.926
Agro-forestry	19.96	-.874	0.126
Rainwater harvesting techniques	36.71	-0.801	0.199
Fire and pest management	20.49	0.084	0.916
Crop rotation	12.38	0.460	0.540

** = Correlation is significant at the 0.05 level (2-tailed).*

Table 4. CSA practices employed by farmers

CSA Practices	Very often	Often	Rarely	Never
Minimum or Zero tillage	8.0%	24.0%	8.0%	6.0%
Mixed cropping	48.0%	48.0%	4.0%	0.0%
Mixed farming	4.0%	4.0%	16.0%	72.0%
Use of mulch materials	32.0%	40.0%	24.0%	4.0%
Application of organic manure	32.0%	40.0%	4.0%	24.0%
Cover cropping	8.0%	32.0%	20.0%	40.0%
Contour farming	4.0%	8.0%	12.0%	76.0%

CSA Practices	Very often	Often	Rarely	Never
Terraces and earth bunds	0.0%	16.0%	16.0%	68.0%
Planting of improved seed variety	28.0%	64.0%	8.0%	0.0%
Irrigation	0.0%	32.0%	20.0%	48.0%
Planting of trees and shrubs	0.0%	8.0%	44.0%	48.0%
Harvesting of rain water	0.0%	4.0%	12.0%	84.0%
Residue management and usage	8.0%	52.0%	20.0%	20.0%
Integrated soil fertility management	0.0%	28.0%	28.0%	44.0%

Table 5. Correlation analysis on CSA practices employed by farmers

CSA Practices	Std. Deviation	Pearson Correlation	Sig. (2-tailed)
Minimum or Zero tillage	24.52	0.853	0.147
Mixed cropping	26.60	-0.476	0.524
Mixed farming	31.72	0.903	0.097
Use of mulch materials	15.44	-0.960*	0.040
Application of organic manure	15.44	0.165	0.835
Cover cropping	14.00	0.993**	0.007
Contour farming	34.15	0.947	0.053
Terraces and earth bunds	29.64	0.959*	0.041
Planting of improved seed variety	28.54	-0.322	0.678
Irrigation	20.23	0.993**	0.007
Planting of trees and shrubs	24.52	-0.991**	0.009
Harvesting of rain water	39.64	0.937	0.063
Residue management and usage	18.86	0.124	0.876
Integrated soil fertility management	18.29	0.770	0.230

** = Correlation is significant at the 0.05 level (2-tailed), ** = Correlation is significant at the 0.01 level (2-tailed).*

Table 6. Challenges faced by farmers in using CSA practices (N=25)

Challenges faced by farmers	Major	Minor	Not at all
No Proper Training/Education	64.0%	20.0%	16.0%
No Government Support	76.0%	8.0%	16.0%
Unavailability of Improved Seeds	20.0%	60.0%	20.0%
Difficult in Application	20.0%	64.0%	16.0%
Tenancy	5.00%	52.0%	28.0%
Lack of finance/high cost	84.0%	16.0%	0.0%
Lack of climate information	76.0%	24.0%	0.0%
Non-availability of extension officers	60.0%	24.0%	16.0%

Table 7. Correlation analysis on challenges faced by farmers in using CSA practices

Challenges faced by farmers	Std. Deviation	Pearson Correlation	Sig. (2-tailed)
No Proper Training/Education	26.63	0.997*	0.048
No Government Support	37.16	0.997*	0.048
Unavailability of Improved Seeds	23.09	-0.434	0.715
Difficult in Application	26.63	0.997*	0.048
Tenancy	16.65	-0.637	0.560
Lack of finance/high cost	44.60	1.000**	0.006
Lack of climate information	38.85	0.972	0.152
Non-availability of extension officers	23.43	1.000**	0.006

** = Correlation is significant at the 0.05 level (2-tailed), ** = Correlation is significant at the 0.01 level (2-tailed).*

Results (Table 5) on correlation analysis of CSA practices employed by farmers showed that minimum or zero tillage, mixed farming, application of organic manure, contour farming, cover cropping, terraces and earth bunds, irrigation, harvesting of rain water, residue management and usage and integrated soil fertility management were positively correlated with CSA practices employed by farmers. However, cover cropping and irrigation were highly significant (P<0.01) while terraces and earth bunds were significant (P<0.05) and correlated with CSA practices employed by farmers. Mixed cropping and planting of improved seed variety were negatively correlated with CSA practices employed by farmers but were not significant (P>0.05). However, planting of trees and shrubs was highly significant (P<0.01) and negatively correlated with CSA practices employed by farmers, while the use of mulch materials was significant (P<0.05) and negatively associated with CSA practices employed by farmers.

3.4 Challenges Faced by Farmers in using CSA Practices as Climate Change Adoption Strategy

Farmers were faced with lot of challenges pertaining to adoption of CSA technology in addressing climate change issues. According to the data collected and response from farmers from the study area, it was observed that majority of the respondents faced challenges such as no proper training/education, no governmental support, lack of finance, lack of climate information and non-availability of extension field officers, representing 64%, 76%, 84%, and 76% respectively in adopting and practicing climate-smart agriculture. Besides, unavailability of improved variety of seed (60%), difficulty in application of the CSA technology (64%), and tenancy (52%) were the least (minor) factors hindering the adoption of CSA practices by farmers.

Pearson Product Correlation analysis on challenges faced by farmers in using CSA practices as shown in Table 7 revealed that difficult in application and inadequate climate information were positively associated with adaption of CSA practices. However, lack of finance/high cost and non-availability of extension officers were highly significant (P<0.01) while no proper Training/Education and no Government Support were significant (P<0.05) and positively associated with the adaption of CSA practices. Unavailability of improved seeds and tenancy were negatively associated with adaption of CSA practices but was not significant (P>0.05).

4. DISCUSSION

4.1 Socio-demographic Information of Farmers

The adoption of climate smart practices implies that households will make a decision to change their practices, such as a modification in farming practices. Result of this study is contrary to previous findings in literature where women are less likely to adopt innovative practices. However, the result corroborates with the findings of [19] who reported that men are more likely to adopt innovative practices such as climate smart agriculture as compared with their women counterpart. Results on age and educational background observed in this study are in agreement with the findings of [7] who reported farmers' age of above 50 years with low level of education making it less likely to adopt innovative practices such as climate smart agriculture since they are old with low level of education. Shongwe et al. [20] noted that old age had a negative relationship to adopting climate change adaptation strategies explaining that agriculture is a labor intensive venture which requires healthy, risk bearing and energetic individuals.

4.2 Farmers Awareness of CSA Practices

The results of the study were consistent with other studies in sub-Saharan Africa [2,21], which confirmed that poor fire and pest management, financial constraints, water shortages, small land space and insufficient information impeded the successful adoption of CSA practices. This accounted for the low adoption rates of irrigation, rain water harvesting, improved livestock breeds and manure management because it required major investments [22]. To appropriately address this, there is the need for institutional support including collaborative efforts through public-private partnerships to invest in CSA practices with high start-up costs. CSA practices which promote soil water conservation such as minimal tillage (ploughing with a hoe) and mulching were the least adopted by farmers. Most respondents expressed their disinterest in this practice because of the tedious nature in carrying out that task as it required extra labour. Moreover, farmers adopted minimal tillage because they could not afford the cost in renting a tractor [23]. This result is consistent with [24] who noted that farmers most often used improved seed variety due to high awareness. Similar findings were also reported by [9]. Positive correlation between farmers' awareness of CSA practices and the use of improved seed variety, fire and pest management and crop rotation indicates that as farmers becomes more aware of CSA practices they are more likely to use improved seed variety, control fire and pest on the farms and also practice crop rotation. On the other hand, farmers low knowledge on or awareness of CSA practices affect the adaptation of climate smart agriculture. The negative correlation between irrigation management, control of soil erosion and run-off, minimum or zero tillage practices, agro-forestry and rainwater harvesting techniques observed in this study indicates that as one of the variables increases, the other tends to decreases and vice versa. Similar findings were reported by [25].

4.3 CSA Practices Employed by Farmers

The adoption of improved seed variety, residue management and usage, mulching and organic manure improve soil water retention, reduction of soil temperatures, limits leaching of soil nutrients and promotes high yields especially in semi-arid agro ecosystems [3]. The adoption of mulching as a CSA practice is however impeded by lack of available grasses to undertake that initiative [9]. Seasonal variations such as low humidity and high temperatures scorch grasses and crops residues [26]. Moreover, low productivity is also associated with less crop residues for use as mulch. The little available ones have other competing uses such as livestock feed and fuel for domestic uses. Therefore, there is the need to promote agricultural intensification to maximise productivity on farmlands, at the same time, institutions need to design innovative ways to address this issue [27]. The adoption of soil amendment strategies is associated with low capital investments and the ease in it usage [2,20]. Minimum or Zero tillage, mixed farming, application of organic manure, contour farming, cover cropping, terraces and earth bunds, irrigation, harvesting of rain water, residue management and usage and integrated soil fertility management were positively correlated with CSA practices employed by farmers, which indicates that farmers are more likely to adapt innovative technologies and modern approaches to farming. Cover cropping and irrigation were highly significant indicating that farmers very often employed these CSA practices. Mixed cropping, planting of improved seed variety, planting of trees and shrubs and the use of mulch materials were negatively correlated with CSA practices employed by farmers and indicates that as one of the variables increases the other tends to decreases and vice versa. Hence, farmers' adaptation of these variables depends on each other.

4.4 Challenges Faced by Farmers in using CSA Practices as Climate Change Adoption Strategy

CSA practices adoption challenges may be due to inactiveness of institutions and organizations directly involved in agriculture. No proper training/education, inadequate government funds, high cost nature of some technologies, lack of climate information and non-availability of extension field staffs were the major significant challenges which are institutional and organizationally oriented. These institutions, as reported in a paper by [28] are essential in creating and transferring useful information, and guiding farmers to integrate the new technologies into understanding and practicalizing them. Furthermore, institutions such as farmer field schools that guide and facilitate farmers for the implementation of new technologies; shows of farm radio that share agricultural information which are easily available, useful, applicable and weather-related knowledge to farmers [28] and others such as extension works, when in full operation would be potential instrument in farmers adoption of CSA technology. Therefore, as reported by [29], adoption is not a unilineal process in which technology can just be delivered to farmers, rather there is the need for inter-institutional support, otherwise the technology may not be appropriate for the local farmer's needs. The correlation analysis revealed that difficult in application, inadequate climate information, lack of finance/high cost, non-availability of extension officers, no proper training/education and no Government Support were positively associated with adaption of CSA practices. This means that as these conditions or variables improved, farmers are more likely to adapt CSA practices and vice versa. The negative correlation between adaption of CSA practices and unavailability of improved seeds and tenancy means that farmers are less likely to adapt CSA practices unless all the variables are seriously taken into consideration.

5. CONCLUSIONS

1. This study concludes that farmers little knowledge on climate change impeded the successful adoption of CSA practices.

2. This study concludes that no proper training/education, no governmental support, lack of finance, lack of climate information and non-availability of extension field officers were the major challenges to farmers adoption of CSA technology.

6. RECOMMENDATIONS

1. This study recommends that, extension officers, institutions and news agencies should encourage farmers to incorporate all CSA practices as much as possible to increase crop and livestock productivity.
2. Considering the complexities in terms of changing farmer's behaviour and strategies in adopting CSA technologies, there will be the need for frequent extension services to farmers to enable them successfully adopt best practices.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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