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Artificial Neural Network Assessment of the Impact of Trade Liberalisation and its Related Policies on Innovation Adoption in Ghana

Seidu[1] M., Sanjay[2*], Yankyera[3] K. O., Seidu[4] A., and Frimpong[5] F. K.

[1,2]Department of Agricultural Economics, College of Agricultural,
Chaudhary Charan Singh Haryana Agricultural University, Hisar, 125004, Haryana, India
[3,5]Department of Agricultural Economics, Agribusiness and Extension;
[4]College of Agriculture and Natural Resources,
Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
*Corresponding Author E-mail: sanjaybhyan@gmail.com

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ABSTRACT

Trade liberalisation and its related policies affect yam producers both positively and negatively by either bringing opportunities such as better innovations or disengaging them from their competitive position and/or laying them off from production. Using a cluster analysis (Artificial Neural Network Assessment) and cross sectional data on 510 yam farm households in Kpandai district of Ghana; the paper estimated the effects of trade liberalisation and its related policies on yam innovation in yam production and the categories of farm households that are directly affected by the impact of open trade. The results of the cluster analysis revealed that among innovation adopters, trade liberalisation, and its related policies had positive and greatest impact on cluster 2 followed by cluster 4. Moreover, the impact felt has made farm households being average adopters of yam production innovations. The study therefore recommended that policies should be focused on increasing farm household population in cluster 2 and 4 especially the former in order to increase the likelihood of innovation adoption by farmers. Moreover, in order to further increase the impact positively on the levels of innovation adoption the various categories of farm households should be important in policy drawing and implementation process.

Key words: *Trade Liberalisation, Related Policies, Cluster Analysis, Innovations, Households*

INTRODUCTION

In many countries, including Ghana, innovations play a large role in agricultural production, especially because of the need to increase production to feed both the local and international economy. However, the effectiveness or direction of innovation is affected by government policies such as trade liberalisation and other economic reforms.

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Stemming from the fact that government policies can influence innovation positively or negatively. Finding the effect of trade liberalisation and its related policies in the agricultural sector has therefore become a focus for many research programmes.

The yam subsector of Ghana agriculture has been on the radar in terms of finding the effect of trade liberalistion and its related policies on innovation. Various innovations have evolved in the yam subsector ranging from the use of minisetts, mini tubers, vine cuttings, milk seeds, partial sectioning[30], fertilizer use, non-staking[32], to the employing of services of hire and skilled labours[27,31]. Moreover, tractor ploughing[28], the use of weedicides[29] and double harvesting have also flooded the subsector. However the adoption of these innovations is greatly influenced by the environment thus trade liberalisation and its related policies (such as liberalisation of foreign exchange, free price formation, and removal of subsidies on inputs). Trade liberalisation has created an environment for the yam sector to receive the necessary investment through the incentive packages it offers to the suppliers or investors in the yam supply chain. According to Seidu[32] the major incentive package offered by trade liberalisation in the yam sector in Ghana include increased producer prices, reduce marketing and trading costs and partial displacement of most strong monopolistic local farmers such as rice, tomato and poultry farmers from production that used to capture production, marketing and greater share of government attention and assistant. Moreover, liberal trade policy and reforms have created adequate framework conditions for the yam sector by ensuring that prospective investors are exposed to the right set of trade incentives[20]. However, the well disposed environment of the subsector has not been utopian for all producers since some producers have not been able to meet the dictates of liberalisation of trade and its related policies leading to a discontinuity in innovation adoption and production in general[2,24]. Thus meeting the demands of the market has been a problem for some yam producers so they are not able to compete well consequently, they are laid-off from production.

The organisation for Economic Co-operation and Development (OECD) report highlights that the degree of openness of an economy plays a key role in the innovation performance of a country, by increasing competition, enhancing technology transfers and triggering economies of scale[23]. In India, China, Bangladesh, Finland, countries in the Middle East, North Africa and South Africa, the integration of the respective country into the Africa Union (AU), European Union (EU) and the global economy single trade contributed to the increased in competition, production, export, and emergence of innovations[17]. Nevertheless, according to Midelfart-Knarvik *et al*[21], evidence from the ground, augmented by reports of field studies and interviews conducted by various organisations such as FAO[11]suggested a contrary assertion to Lesser's[17] for countries like Burkina Faso, Benin, Zimbabwe, Nigeria, Congo, Cameroun, Congo and Niger.

What is obvious at this point is that trade liberalisation and its related policy can affect the adoption of innovations positively or negatively. As already mentioned, one of the major motivations of trade liberalisation in the Agricultural sector especially the yam subsector, is the belief that liberalisation stimulates innovation adoption, encourages efficiency, and drives prices down. However in Ghana the impact of trade liberalisation and its related policies on innovation adoption in the yam subsector is addressed with mixed feelings and doubt. This is because very little is known about the effect of trade liberalisation and its related policies on innovation adoption by yam producers.

The objective of the paper is to identify, the impact of trade liberalisation and its related policies on innovation adoption in yam production by considering the influence that the transmission channels of liberal trade have innovation adoption at the farm level. Moreover the paper also focused on farm households in terms of their characteristics by

clustering them based on how the transmission channels of trade liberalisation and its related policies affect them. The study employed a non parametric analysis (cluster analysis) in achieving the objectives. The study considered the following transmission channels of trade liberalisation and its related policies: producer price, integration into market economy, size of land cultivated, competition among producers, outlet of sales, cost of transportation, mode of transportation, export, market proximity, variety of yam cultivated, handling of consumer complaints, and time of marketing. The study also defined innovation as technologies and practices that have been modified, emerged or gained recent patronage which used not to exist in the past however have done so because of the changes trade liberalisation and other related economic reforms have brought to the environment.

Knowing the impact of trade liberalisation and its related policies on innovation adoptions as well as the cluster(s) of households that affect innovation adoption will assist policy analyst and makers to put on table cogent policies that will actually meet the actual and factual demands of the yam subsector. Satisfying the quest require a holistic view and appreciation of the numerous changes and the general dynamism of the subsector.

MATERIALS AND METHODS

The study was conducted in Kpandai District of Northern Ghana. Multistage sampling was employed in the study. The first and second stages were purposive selection of the region (Northern) and the district (Kpandai) because of their respective massive yam production relative to other regions and districts. Also, more than 50% of the farm households in the district are engage in yam production. The district consists of four major Agricultural Zones namely; Kpandai, Katiejieli, Jamboi and Ekumidi. In the third stage, the study included all the zones in the survey in order to get representative sample from each zone in the district. In the fourth stage, within each Agricultural zone four[4] communities were randomly sampled except Katiejieli where five communities were randomly sampled because the number of communities engaged in yam production in the zone was many relative to the other zones. The total number of communities that were sampled was seventeen[17.] The random sampling technique was again employed in stage five to select thirty[30] farm households within each selected community. In all 510 farm households were selected and interviewed using structured questionnaires.

A non parametric analysis (cluster analysis) was employed for the characterisation of farm households as well as the impact of trade liberalisation and its related policies on household's innovation adoption levels in the study area. The analysis was possible using NeuroXL Clusteriser. The level of adopted innovation was measured as the frequency of farmers taking on a particular technology. Moreover, the study identified technologies and practices that were innovative by considering technologies that have been modified, emerged or gained recent patronage which used not to exist in the past however has done so in the environment of trade liberalisation and its related policies. The study used basically 18 independent variables phased out into 168 characteristics (variables) against six innovations classes (seed yam innovation [minisett, small setts cuttings, milked seeds], non staking, skilled labour, hired labour, tractor ploughing and chemical weed control). Considering the 18 characteristics, six were basic general characteristics of the population whereas 12 were trade potential factors. The population characteristics were age, gender, formal education, group membership, financial assistance and level of solvency. Whereas the trade potential factors (also referred to as the transmission channels of trade liberalisation and its related policies) include producer price, integration into market economy, size of land cultivated, competition among producers, outlet of sales, cost of transportation, mode of transportation, export, market proximity, variety of yam cultivated, handling of consumer complaints, and time of marketing. Undoubtedly, each variable had a different impact on each technology or innovation

adopted. In this study, five clusters were specified. This resulted in five colour codes based on their respective cluster weights (see Figure 1 & 2). The five clusters were chosen in order to classify farm households into those that recorded very high, high, average, low, and very low adopters of innovation. Based on the classifications, the cluster which has the highest cluster weight would certainly have more trade transmission channels or factors affecting the farm households. These characteristics again would influence innovation adoption. Therefore, the study determined the impact of trade liberalisation and its related policies on innovation adoption on farm households by considering the innovation adoption levels of the farm household clusters that have more trade liberalisation characteristics (cluster weight) influencing the innovative activities of the cluster.

RESULTS AND DISCUSSION

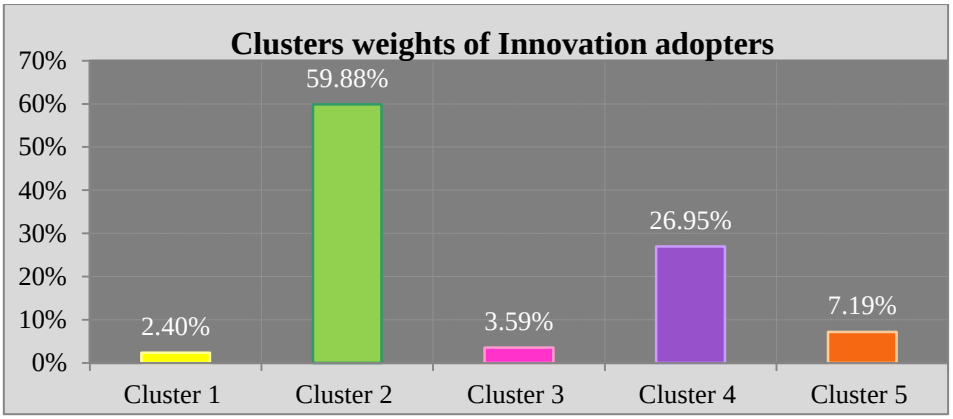
Forecast parameters of ANN used in each learning / forecast

The study followed similar procedure of Seidu[33], hence ANN was made to assign 0.5 as the start learning rate and epochs (Limit of the learning cycles) was also assigned a value of 100 which means that the ANN ran 100 learning iterations on each variable. Considering the high value of epoch, it suggests that the final cluster weights assigned by the ANN are as close to accurate as possible. The learning rate was specified to be 0.3. The learning rate defines the rate at which the network "learns". This, in turn, has an impact on the period ANN will obtain cluster weights that start to closely align with accurate weights. Finally the activation function was set to Zero-based Log-Sigmoid Function.

Description of households classifications (Clusters)

Cluster 1

As shown in Figure 1, cluster 1 has the smallest significant weight of 2.40%, an indication households group which do not show keen interest in adopting innovations. Table 1 reveals that the group has the lowest adoption levels of seed yam innovation and hired labour use. Furthermore the group has low adoption level of tractor ploughing technology though not quite as pronounced as in cluster 5. Chemical weed control adoption level in the group was a little higher than average. Cluster 1 contains by far the highest level of adopters of non-staking practice which might be due to less expensive nature of this practice. Moreover, the group has households that were the highest adopters of skilled labour (*see* Table 6 & 7, Figure 2). Households produce yam variety that was complained not preferable by a number of consumers. They utilize mainly the village market for the sales of their produce and sold between 40 to 60% of their produce. Very few of their produce were sold in the urban markets. They produce very big tubers so they spent very high transportation cost (above GH₵ 40 per "batch of yam") when conveying to the urban market (see Table 1) and hence do not benefit from good export.



Source: Generated from field survey data

Fig. 1: Cluster weight of Innovation adopters

Table 1: Description of Cluster 1 in terms of Household characteristics

Household characteristics	Innovations adopted at the production level					
	MSM	**NSP**	**HL**	**SL**	**TP**	**CWC**
Household receive or hear complaints on the quality of yam: No	9	19	7	21	14	30
Complaint: Variety not preferred: Yes	0	44	0	38	19	0
Yam tubers sold by household in the village market: 40.01-60%	5	26	18	21	10	21
Cost of transporting a batch of yam: above 40 GH Cedis	0	36	14	21	7	21

NB: MSM:-Minisett/ small.setts /milked seeds; NSP:- Non staking practice; HL:- Hired labour; SL:- Skilled Labour; TP:-Tractor ploughing; CWC:-Chemical weed control
Source: Generated from field survey data

Cluster 2

The households in cluster 2 has the highest significant weight of 59.88% (see Figure 1) and generally characterised as average adopters of innovations. Thus households in this cluster were average adopters of hired labour and chemical weed control technology. What is more, the cluster has suppliers that were below average adopters of non-staking and skilled labours. Conversely, the households in the group were slightly above average adopters of seed yam innovation and tractor ploughing technology (see Table 6 & 7, Figure 2).

The study isolated from Table 2 that household ages in the group varies from 21 years and above, comprising energetic young men and women as well as few old age generation above 50 years. The group also comprised literate and illiterate households. Some of the households belong to associations and the others were not. Household main source of funding for production was cash saving. However, most of these households level of solvency was between low to average. Very few of the households have very high solvency.

Land cultivation for yam farming is relatively large; most often between 41-50 acres however small farm sizes were also observed (thus less than 10 acres). Households in this cluster relatively recorded high outputs ranging from 1000 to at least 70001 tubers of yam. Out of these harvested outputs, most of the households offered 80% or more for sale nonetheless very few also committed 20% or less for sale. Clearly, the indication was that most of the households were commercial producers and few were subsistence farmers. Hence households in this cluster were basically commercial and subsistence farmers. Moreover, producers in this group received varying price for their yam ranging from GH₵ 100.00 - at least GH₵210.00.

Furthermore, some households in this cluster were involved in export. Therefore, it was unsurprising for the study to discover that producers in this cluster had contact with export agents and middlemen who also have contact with export agents. These households sold yam tubers varying from 0.1 to at least 40.1% of their output in foreign markets. Households received many complaints on the quality of their produce nonetheless they were able addressed some of the problems and were willing to address complaints that they had not got remedy yet.

Households mainly used the farm gate and urban market as their main outlet of sales. Farm gate sales ranges from 0.01 to 60% whiles urban market sales ranges from 60.01 to 100%. Farmers spent between less than 12hrs and 19hrs to transport yam to the urban markets, which was an indication that households in this cluster were closed to the market centers or roads to the markets were quite good. This assessment was arrived because of the relative short duration involve in the transportation of the yam. What is more, farmers spent relatively low to average (below GH₵20 to GH₵29 per "batch of yam") cost on transportation of yam to the urban markets.

Households sold their produce both during the main market season and lean season. Farmers were able to sell between 40.1 to 80% tubers of yam during the lean season. However the level of competition was generally very high among this group ranging from 5 to at least 21 farmers. Households in this group mainly cultivated the white yam variety (*see* Table 2).

Table 2: Description of Cluster 2 in terms of Household characteristics

Household characteristics	Innovations adopted at the production level					
	MSM	**NSP**	**HL**	**SL**	**TP**	**CWC**
Age of Household head: 31-40 yrs	16	17	19	16	15	18
Age of Household head: >50 yrs	16	16	16	18	17	16
Gender of Household: Female	20	13	20	11	16	20
Gender of Household: Male	16	17	18	17	16	17
Level of Literacy of Household head: No	16	17	19	17	16	16
Level of Literacy of Household head: Yes	15	19	15	17	16	19
Household group membership: No	16	17	18	17	16	17
Household group membership: Yes	16	17	17	17	16	17
Household type of fund for production: Cash savings	15	17	17	17	17	17
Household level of solvency: Very Low solvency	17	20	11	19	18	16
Household level of solvency: Average solvency	15	15	17	18	17	18
Household level of solvency: Very High solvency	15	18	18	16	16	16
Size of land cultivated by Household: less than 10 acres	21	17	14	19	14	16
Size of land cultivated by Household: 10-20 acres	16	16	18	17	16	17
Size of land cultivated by Household: 41-50 acres	16	18	18	13	20	16
Total number of yam tubers produced: 1001-10000 tubers	17	17	16	17	16	18
Total number of yam tubers produced: 10001-20000 tubers	16	17	18	17	16	17
Total number of yam tubers produced: 40001-50000 tubers	15	15	18	15	18	18
Total number of yam tubers produced: 60001-70000 tubers	18	18	18	9	18	18
Total number of yam tubers produced: At least 70001 tubers	15	18	18	16	16	16
Number of yam sold: 1001-10000 tubers	16	18	17	16	16	18
Number of yam sold: 10001-20000 tubers	16	16	18	17	16	17
Number of yam sold: 30001-40000 tubers	16	17	17	15	18	17
Price of 100 tubers of yam (GH Cedis): 100-110 GH Cedis	17	18	17	15	16	17
Price of 100 tubers of yam (GH Cedis): 120-150 GH Cedis	17	14	15	19	17	18
Price of 100 tubers of yam (GH Cedis): 160-200 GH Cedis	15	18	18	16	17	17
Price of 100 tubers of yam (GH Cedis): 210 GH Cedis and above	16	16	18	17	17	16
Household offer 20% or less of yam for sale: No	16	17	18	17	16	17
Household offer 20% or less of yam for sale: Yes	18	24	18	12	18	12
Household offer between 20% to 80% of yam for sale: No	16	16	18	16	17	17
Household offer 80% or more of yam for sale: Yes	16	16	18	16	17	17
Contact with Export agents: No	15	18	18	17	16	17
Contact with Export agents: Yes	19	14	18	15	17	17
Contact with middlemen who sell directly to export agents: No	15	18	18	17	16	17
Contact with middlemen who sell directly to export agents: Yes	18	16	16	16	17	17
Yam tubers offered for export : 0.1-10%	18	14	15	18	17	19
Yam tubers offered for export : 10.1-20%	19	15	17	15	16	18
Yam tubers offered for export : 20.1-30%	17	16	18	15	18	17
Yam tubers offered for export : 30 and 40%	18	17	16	15	18	17
Yam tubers offered for export : At least 40.1%	17	18	14	18	17	16

Household receive or hear complaints on the quality of yam: Yes	16	17	18	17	16	17
Complaint: Yam too big: Yes	16	16	17	16	16	17
Complaint: Yam too small: No	16	17	18	17	15	17
Complaint: Yam too small: Yes	16	17	16	17	17	17
Complaint: Yam has pest and disease damage (rot): No	15	18	18	17	16	17
Complaint: Yam has pest and disease damage (rot): Yes	18	13	17	17	15	19
Complaint: Variety not preferred: No	16	17	18	17	16	17
Complaint: Complicated/non uniform/irregular shape of yam: No	16	17	18	17	16	17
Complaint: Complicated/non uniform/irregular shape of yam: Yes	14	18	17	17	18	16
Complaint: Physical injuries (breakages/bruises): No	16	17	17	17	16	17
Complaint: Physical injuries (breakages/bruises): Yes	17	15	19	17	15	17
Complaint: Rough skinned "nkrosakrosa"yam: No	16	18	18	17	16	17
Complaint: Lateness in meeting customer demand: No	16	17	17	17	16	17
Complaint: Lateness in meeting customer demand: Yes	14	17	19	16	18	16
Complaint: Unclean yam tubers: No	16	17	18	17	16	17
Complaint: Inadequate state of maturity: No	16	17	18	17	16	17
Complaint: Inadequate state of maturity: Yes	16	16	18	17	15	18
Ability and willingness to address consumer complaints: Yes	19	15	17	16	16	17
Farm gate sales by household: No	16	17	18	17	15	17
Farm gate sales by household: Yes	16	17	18	16	17	16
Village market sales by household: No	16	18	18	17	16	17
Village market sales by household: Yes	16	16	17	18	16	18
Urban market sales by household: Yes	15	17	17	17	16	17
Yam tubers sold by household at farm gate: 0	16	17	17	18	15	17
Yam tubers sold by household at farm gate: 0.01- 20%	14	18	16	16	18	18
Yam tubers sold by household head at farm gate: 20.01-40%	15	18	17	16	18	18
Yam tubers sold by household at farm gate: 40.01-60%	16	16	19	16	16	16
Yam tubers sold by household in the village market: 0%	16	18	18	17	16	17
Yam tubers sold by household in the urban market: 60.01-80%	16	16	18	16	16	18
Yam tubers sold by household in the urban market: 80.01-100%	16	17	16	17	17	17
Time taken to travel from farm/home to village market: <1hr	15	16	16	18	17	19
Time taken to travel from farm/home to village market: 1hr-2hrs	16	15	18	17	15	17
Time taken to travel from farm/home to urban market:<12hrs	17	11	17	22	17	17
Time taken to travel from farm/home to urban market: 12hrs-15hrs	16	16	17	17	17	18
Time taken to travel from farm/home to urban market: 16hrs-19hrs	17	17	17	14	17	17
The of cost of transporting a batch of yam: below 20 GH Cedis	20	15	15	17	16	16
The of cost of transporting a batch of yam: 20-24 GH Cedis	19	15	17	16	15	17
The of cost of transporting a batch of yam: 25-29 GH Cedis	18	18	17	14	17	16
Competition among yam suppliers: 5-10 yam farmers	17	16	17	15	17	18
Competition among yam suppliers: At least 21 yam farmers	16	18	18	18	14	18
The major variety of yam household cultivate: white yam	16	17	18	17	16	17
Household offer yam for sale before main market season: Yes	16	16	17	17	17	17
Household offer yam for sale during main market season: No	16	16	19	17	16	16
Household offer yam for sale during main market season: Yes	16	17	17	17	16	17
Household offer yam for sale after main market season: No	16	17	18	18	14	17

Household offer yam for sale after main market season: Yes	16	17	18	16	17	17
Yam tubers sold by household before market season: 0.01-20%	16	14	17	17	17	18
Yam tubers sold by household before market season: 40.01-60%	17	15	17	17	17	17
Yam tubers sold by household before market season: 80.01-100%	15	17	19	15	15	19
Yam tubers sold by household during market season: 0%	16	16	18	16	16	17
Yam tubers sold by household during market season: 0.01-20%	17	17	17	17	17	17
Yam tubers sold by household during market season: 60.01-80%	16	17	17	16	16	16
Yam tubers sold by household during market season: 80.01-100%	16	17	17	17	15	18
Yam tubers sold by household after market season: 0%	16	17	18	18	14	17
Yam tubers sold by household after market season: 0.01- 20%	15	18	16	14	20	17
Yam tubers sold by household after market season: 40.01-60%	18	13	16	17	20	17
Yam tubers sold by household after market season: 60.01-80%	17	16	19	15	16	18
Yam sold in the lean season: 40.01-60%	17	16	19	16	17	15
Yam sold in the lean season: 60.01-80%	16	15	17	16	17	19

NB: MSM:-Minisett/ small.setts /milked seeds; NSP:- Non staking practice; HL:- Hired labour; SL:- Skilled Labour; TP:-Tractor ploughing; CWC:-Chemical weed control

Source: Generated from field survey data

Cluster 3

The cluster has 3.59% significant weight (*see* Figure 1). Households in this group have almost the same seed yam innovation and skilled labour adoption levels as that of cluster 2. It is a cluster in which non-staking was least practiced not only that but also low adoption of hired labour was dominant in this category. Nevertheless, households in this group were the most eminent adopters of tractor ploughing and chemical weed control technology (see Table 6 & 7, Figure 2).

Producers in this group were very energetic because they were the youngest age group (less than 21years). They were subsistence farmers and dispose their produce via the village market. Their modes of transportation to the market were by bicycle and motorcycle. Households in this cluster mainly sell their produce in the lean season. The main complaints they were confronted with were rough skinned yam (nkrosakrosa) [see Table 3].

Table 3: Description of Cluster 3 in terms of Household characteristics

Household characteristics	**Innovations adopted at the production level**					
	MSM	**NSP**	**HL**	**SL**	**TP**	**CWC**
Age of Household head:<21yrs	18	10	8	15	23	26
Complaint: Rough skinned "nkrosakrosa" yam: Yes	18	8	15	19	20	21
Yam tubers sold by household in the village market: 0.01- 20%	16	13	14	16	21	19
Mode of transportation to the village market: bicycle	19	5	8	18	25	25
Mode of transportation to the village market: motorcycle	9	9	16	14	28	23
Yam sold in the lean season: 0.01- 20%	18	15	13	16	21	18

NB: MSM:-Minisett/ small.setts /milked seeds; NSP:- Non staking practice; HL:- Hired labour; SL:- Skilled Labour; TP:-Tractor ploughing; CWC:-Chemical weed control

Source: Generated from field survey data

Cluster 4

The fourth cluster accounts for 26. 95% (see Figure 1) of total weight and gives low level of adoption to seed yam innovation. The adoption of non-staking was distinctly above average though lower than that of clusters 1. The group has the highest adopters of hired labour. The same holds for cluster 5. Households were relatively average adopters of skilled labour though slightly above average. Similarly the

households in this group were slightly below average adopters of tractor ploughing technology. Moreover, it was the group that patronise the adoption of agro chemical weed control technology the least (see Table 6 & 7, Figure 2).

Observation of Table 4 revealed that suppliers in this group were at the tail end of their farming career, they were between the ages 41-50 years. Their main sources of funding were cash savings and remittances from abroad. Their level of solvency was relatively high. They cultivated yam on very large acres ranging from 21 acres to at least 51 acres. They harvested large quantity of yams varying from 20000 to 60000 tubers of yam in the season considered. Moreover, they were basically semi subsistence farmers but they did not integrate into foreign markets. They usually sold their produce in the urban market (0.01-60% of yam tubers) however they sold large quantities of yam at the farm gate (60.0-80% of yam tubers) and village market (80.01-100% of yam tubers) any time the opportunity presented itself.

Transportation to the village market was by cargo tricycle, lorry, and tractor. They mostly spend 2.01 to 4hrs on the way during transportation. This implies that farms of these households were relatively far from the village market. Similarly, households were very far away from urban market, they took 20 to at least 24hrs in transporting yam to the market. The cost of transporting a "batch of yam" to the urban markets was expensive (GH₵30-GH₵40) so it was not surprising that they use the village market.

Table 4: Description of Cluster 4 in terms of Household characteristics

Household characteristics	Innovations adopted at the production level					
	MSM	**NSP**	**HL**	**SL**	**TP**	**CWC**
Age of Household head: 41-50 yrs	15	16	20	17	16	16
Type of fund for production: Remittances	17	17	20	17	14	15
Type of fund for production: Both	14	17	20	20	11	17
Household level of solvency: High solvency	13	20	19	17	16	15
Size of land cultivated by Household: 21-30 acres	14	19	19	17	16	16
Size of land cultivated by Household: 31-40 acres	13	20	20	17	16	15
Size of land cultivated by Household: 51 acres and above	13	19	19	16	17	16
Number of yam tubers produced: 20001-30000 tubers	12	17	19	19	15	18
Number of yam tubers produced: 30001-40000 tubers	13	19	18	16	18	15
Number of yam tubers produced: 50001-60000 tubers	10	21	21	16	18	15
Number of yam sold: 20001-30000 tubers	15	19	19	17	16	15
Number of yam sold: 40001-50000 tubers	11	21	21	15	18	15
Number of yam sold: At least 50001 tubers	13	18	18	17	17	17
Household offer between 20% to 80% of yam for sale: Yes	15	18	18	19	13	16
Household offer 80% or more of yam for sale: No	15	19	18	19	14	16
Yam tubers offered for export: 0%	14	18	18	18	15	16
Complaint: Yam too big: No	13	19	18	18	16	16
Ability and willingness to address consumer complaints: No	9	21	19	19	16	18
Yam tubers sold by household at farm gate: 60.01-80%	15	19	19	17	16	14
Yam tubers sold by household in the village market: 80.01-100%	14	24	17	22	13	11
Yam tubers sold by household in the urban market: 0.01- 20%	12	24	16	22	14	12
Yam tubers sold by household in the urban market: 20.01-40%	15	17	21	18	16	14
Yam tubers sold by household in the urban market: 40.01-60%	14	17	18	18	15	17
Mode of transportation to the village market: cargo tricycle	14	20	17	19	15	17
Mode of transportation to the village market: lorry	15	21	22	13	13	14
Mode of transportation to the village market: tractor	16	18	21	20	13	14
Time taken to travel from farm/home to vil. market: 2.01hrs-4hrs	15	18	18	18	16	15
Time taken to travel from farm/home to urban market: 20hrs-23hrs	15	18	21	17	13	16
Time taken to travel from farm/home to urban market: >24hrs	16	19	17	18	15	14

The of cost of transporting a batch of yam: 30-34 GH Cedis	12	19	18	19	16	16
The of cost of transporting a batch of yam: 35-40 GH Cedis	3	22	20	20	17	18
Competition among yam suppliers: 11-15 yam farmers	15	20	18	16	17	14
Competition among yam suppliers: 16-20 yam farmers	13	16	18	18	17	16
The major variety of yam household cultivate: water yam/other	13	23	18	19	14	13
Household offer yam for sale before main market season: No	16	19	18	17	15	16
Yam tubers sold by household before market season: 0%	16	19	18	17	15	16
Yam tubers sold by household before market season: 20.01-40%	15	18	18	17	16	16
Yam tubers sold by household before market season: 60.01-80%	11	20	18	18	18	16
Yam tubers sold by household during market season: 20.01-40%	14	17	19	18	18	16
Yam tubers sold by household during market season: 40.01-60%	13	18	18	17	18	16
Yam tubers sold by household after market season: 20.01-40%	14	20	17	18	15	17
Yam tubers sold by household after market season: 80.01-100%	15	18	19	17	16	15
Yam sold in the lean season: 0%	16	19	18	17	13	16
Yam sold in the lean season: 20.01-40%	13	18	19	18	15	17
Yam sold in the lean season: 80.01-100%	14	18	19	17	16	15

NB: MSM:-Minisett/ small.setts /milked seeds; NSP:- Non staking practice; HL:- Hired labour; SL:- Skilled Labour; TP:-Tractor ploughing; CWC:-Chemical weed control

Source: Generated from field survey data

Furthermore, based on the cost of transportation, it can easily be deduced that they produce big yam tubers. Suppliers in this group were not willing to address consumer complaints. The level of competition in the area is high varying from 11 to 20 households. Water yam variety was mainly cultivated among households in cluster 4. They sold large quantities (20.1-100%) of their produce in the lean season nonetheless some few quantities (20.01- 60%) of yam were also sold during the main market season.

Cluster 5

The cluster has the third highest significant weight of 7.19% (Figure 1). Households in the group has the most adopters of seed yam innovation and hired labour. Adoption levels of non-staking and chemical weed control were lower than average with skilled labour adoption being average. However, households in the cluster show least adoption of tractor ploughing technology (see Table 6 & 7, Figure 2).

Households in this group have a low solvency level thus they face difficulties in their ability to raise fund to meet debt obligations. Households' level of production were very low (at most 1000 tubers) however they commit most (at most 1000 tubers) of their output to the market. Furthermore, a "batch of yam" was sold at very low price (less than GH₵100) may be because the tubers are very small or unclean. Households sold their produce at farm gate (80-100%) and village market (20-80%). Producers' mode of transportation to the market was by foot. Finally the levels of competition among the households were very low (less than five households) [see Table 5].

Table 5: Description of Cluster 5 in terms of Household Characteristics

Household characteristics	**Innovations adopted at the production level of yam**					
	MSM	**NSP**	**HL**	**SL**	**TP**	**CWC**
Household level of solvency: Low solvency	20	16	20	15	11	17
Number of yam tubers produced: At most 1000 tubers	24	19	14	17	10	17
Number of yam sold: At most 1000 tubers	25	20	15	18	8	14
Price of 100 tubers of yam (GH Cedis): less than 100 GH Cedis	16	17	20	20	12	15
Complaint: Unclean yam tubers: Yes	19	18	14	19	13	16
Urban market sales by household: No	19	19	20	15	13	13
Yam tubers sold by household at farm gate: 80.01-100%	25	14	22	12	14	14
Yam tubers sold by household in the village market: 20.01-40%	19	14	25	16	9	17
Yam tubers sold by household in the village market: 60.01-80%	17	11	28	22	6	17
Yam tubers sold by household head in the urban market: 0	20	19	20	16	13	13
Mode of transportation to the village market: foot	31	0	14	21	10	24
Competition among yam suppliers: less than 5 yam farmers	17	17	17	17	12	19

NB: MSM:-Minisett/ small.setts /milked seeds; NSP:- Non staking practice; HL:- Hired labour; SL:- Skilled Labour; TP:-Tractor ploughing; CWC:-Chemical weed control

Source: Generated from field survey data

Impact of trade liberalisation and its related policies on innovations on farm households

Figure 1 makes very obvious that cluster 2 and 4 have the highest cluster weight respectively which implies that the two groups of households have more trade transmission channels influencing innovation adoptions in the groups. Moreover the impact of trade liberalisation and its related policies on the farm households is most manifested in cluster 2 followed by cluster 4. Cluster 2 experienced the greatest impact of trade liberalisation as depicted in Figure 1 as the group with the highest cluster weight because most possesses characteristics of trade transmission channels which made it possible for trade liberalisation to effectively influence the producers. Trade liberalisation impact on innovations of yam farm households in cluster 2 act through the following channels: cultivated farm size[4,7,22] degree of market integration[6], export[10,38], producer price[13,15,34,36] cost of transportation[8.37] outlet of sales[3], time of marketing, market proximity[1,14,19], competition among producers[12,16,25,35] willingness to handle consumer complaints[5,9,18,26], variety of yam cultivated (white yam). These channels which according to the aforementioned authors' affect innovation adoption

From Table 6, 7, & Figure 2, the impact of trade liberalisation and its related policies via its channels is realized on farm households. Obviously following the line graphs and values of cluster 2 in figure 2 and Table 6, & 7 it can be observed that liberalisation and its related policies have reduced yam farm households into average adopters of hired labour and chemical weed control technology. Moreover, households engulfed in cluster 2 (thus households that have greatest impact of trade liberalisation and its related policies) were lower than average adopters of non-staking and skilled labours. Nevertheless, households in this cluster were slightly higher than average adopters of seed yam innovation and tractor ploughing technology.

Similarly the impact of trade liberalisation and its related policies was also effectively felt in cluster 4 though not as strong as in cluster 2 because, of the relative few number of channels that characterised cluster 4. In cluster 4 the impact was felt through the following fundamental channels; cultivated farm size, degree of market integration, cost of transportation, time of marketing, competition among producers, producer price, and variety of yam (water yam) cultivated. Trade liberalisation and its related policies effectively affected households via the aforementioned channels and have made households adoption of non-staking distinctly above average though lower than that of clusters 1 as well as the highest adopters of hired labour. The impact also made households relatively average adopters of skilled labour though slightly above average. Similarly they were slightly below average adopters of tractor ploughing technology. Nonetheless, it was noticeable that the impact made households the group that least patronize the adoption of agro chemical weed control technology (see Table 6, 7, & Figure 2).

Although trade liberalisation has somewhat increased innovation adoption nevertheless, the margin of increase is not that wide, the increase is a little above average, average or slightly below average hence it can be generalized that trade liberalisation impact on yam farm households has made them average adopters of innovation.

Table 6: Summary of averages of Innovation adoption

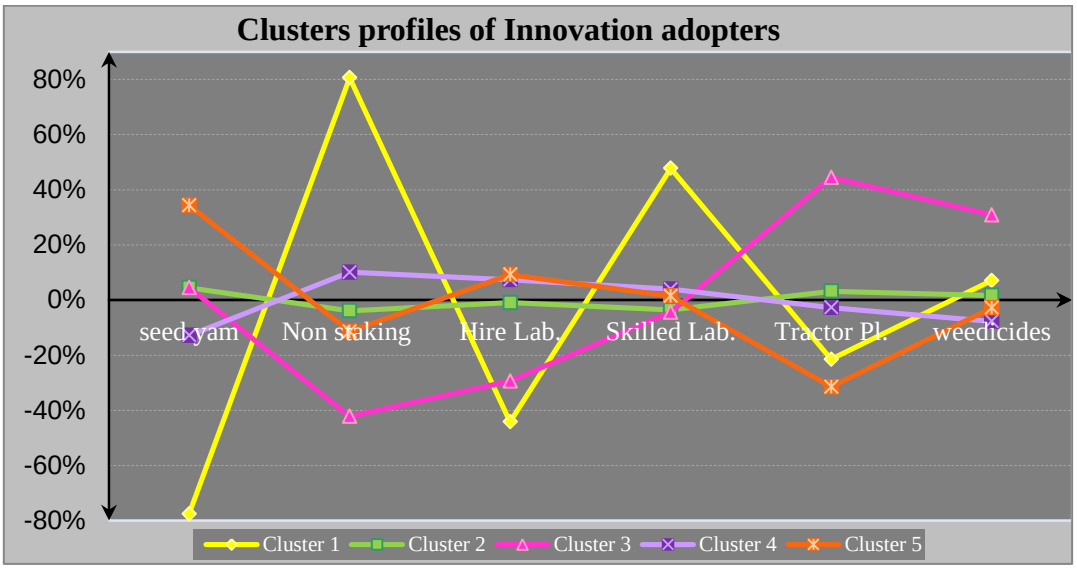
Cluster	Seed yam	Non-staking	Hired labour	Skilled labour	Tractor Ploughing	Weedicides
1	3.50	31.25	9.75	25.25	12.50	18.00
2	16.33	16.63	17.31	16.47	16.43	17.09
3	16.33	10.00	12.33	16.33	23.00	22.00
4	13.62	19.04	18.76	17.76	15.49	15.51
5	21.00	15.33	19.08	17.33	10.92	16.33

Source: Computed from field survey data 2012

Table 7: Summaries of weighted averages (%) of Innovation adoption

Cluster	Seed yam	Non-staking	Hired labour	Skilled labour	Tractor Ploughing	Weedicides
1	-77.61	80.64	-44.18	47.80	-21.49	7.09
2	4.49	-3.87	-0.90	-3.59	3.19	1.68
3	4.51	-42.19	-29.39	-4.39	44.45	30.89
4	-12.84	10.09	7.38	3.93	-2.72	-7.72
5	34.37	-11.36	9.25	1.46	-31.44	-2.83

NB: Negative values represent low adoptions levels while positive values represent high adoption levels. Source: Computed from field survey data 2012



NB: Negative values represent low adoptions levels while positive values represent high adoption levels. Source: Generated from field survey data

Fig. 2: Cluster profiles of Innovation adopters

CONCLUSION AND RECOMMENDATION

The cluster analysis of farm households identified specific patterns with respect to innovative activities based on the characteristics of the households. It was revealed that among innovation adopters, trade liberalisation, and its related policies had positive, significant, and greatest impact on cluster 2 followed by cluster 4. The aforementioned clusters exhibited characteristics or channels that made it possible for trade liberalisation and its related policies to have such impact. Cluster 2 and 4 where generally average adopters showing adoption rates little above average and in some few instances adoption levels slightly below average were also observed. The paper therefore recommends that policies should be focused on increasing farm household population in cluster 2 and 4 especially the former in order to increase the likelihood of innovation adoption by farmers. Moreover, in order to further increase the impact positively on the levels of innovation adoption the various categories of farm households should be important in policy drawing and implementation process.

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