International Journal of Environment, Agriculture and Biotechnology
Vol-9, Issue-5; Sep-Oct, 2024
Peer-Reviewed International Journal
Journal Home Page Available: https://ijeab.com/
Journal DOI: 10.22161/ijeab

Assessing the Introduction of Genetically Modified Organisms (GMOs) into Ghana: The Perspectives of Agriculture Professionals in Northern Region

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Received: 03 Sep 2024; Received in revised form: 05 Oct 2024; Accepted: 12 Oct 2024; Available online: 18 Oct 2024

Abstract— *The role of agriculture officers is essential and cannot be ignored when introducing technology such as Genetically Modified Organisms (GMOs). However, there is no known study presently that examines agriculture officers' perspectives of GMOs emergence in Ghana. Our study assesses agriculture officers' perceptions on the introduction of GMOs into Ghana and its impact on food and seed security as well as officer's level of involvement in GMOs related activities and willingness to promote it. We further solicited their views on GMOs as a successful solution to tackle farming challenges and assessed what influenced their views. Our findings revealed that 53% of agriculture officers agreed that GMOs will have positive impact on food/ seed security/sovereignty. Also, 56% said they will champion GMOs, however, 67% said there is limited information on GMOs and 74% of the respondents indicated that they have never attended or participated in GMOs related activity. We highlighted officers' divergent views around the introduction of GMOs as a successful solution to tackle farming challenges and the key influencers include: GMOs is unsafe for human consumption, gene escape into wild relatives, and possibility of creating insect resistant and limited capacity to genetically engineered crops locally. The study recommended that there is the need for pro and anti-GMO groups to involve officers in GMO activities for effective dissemination of information on GMO to farmers or citizens.*

Keywords— ***Agriculture Officers, GMOs, Perception, Seed/food security, Successful solution.***

I. INTRODUCTION

Biotechnology is a novel technique of the 21st era that is considered as a tool for enhancing agriculture output that could lead to agriculture and economic growth while saving labour (Essen 2022). Yet, there are still ongoing controversies over agrobiotechnology (Shanahan et al., 2001). In line with this, some authors are of the view that there are prospects in exploring solutions that are adoptable, adaptable, and exchangeable; they are worried that if too much attention is paid to biotechnology, this could limit the research capacity of nation states (WHO 2005). Among the present biotechnology of significance to food security and food safety is genetic modification (Gbashi et al., 2021). Although across the globe, crop genetic modification is highly contested (FOE, 2022). According to Edwards (2017), one contentious issue in agriculture is employing genetic engineering[1] to produce Genetically Modified Organism (GMO)[2]. Therefore,

[1] Kloppenburg (2010) notes that genetic engineering presently employs a technic known as 'Genetic Use Restriction Technologies' that only permit the seed to germinate upon application of branded chemicals.
[2] GMO involves altering any living thing excluding human beings, through genetic manipulation ensuing from recombination technology rather than natural mating to produce a 'new product'. These include foods, feeds, medicines and vaccines (Ghana Public Health Association 2014).

genetically modified organisms (GMOs) have been a controversial topic in the agricultural sector for years.

It is claimed that genetically engineered crops will feed the world, as these crops are assumed to provide a solution to anxiety over possible starvation emanating from increasing population. These crops could be engineered to be more nutritious, resist to disease/pest, drought tolerant, and have a higher yield (Ewens, 2000). Lamichhane (2014), Ampadu-Ameyaw et al. (2021), and Gbashi et al. (2021) are in favour of this argument. Debatably, some questions remain unanswered as to whether to (dis)continue the cultivation of GM crops. Such decisions should engage a larger society since research findings on GM crop safety are limited, sometimes contradictory, not conclusive and open more debate around biosafety, especially in relation to risk acceptability and socioeconomic considerations (Hilbeck et al., 2015).

However, as indicated by Lang and Heasman (2015), Genetically Modified Organisms are being introduced into global food systems at a rate that cannot be reversed, yet the long-term consequences for agrarian environments and the power relations in the food chain, are unknown. Following this, opponents of GMOs largely premise their arguments on the fears of possible side effects on human health as well as on the ecology following GMOs introduction. Likewise, arguments in favour of GMO's introduction in Africa are situated within the context of the continent's food and nutrition insecurity status as proponents for GM crops' introduction in Africa argue that this is likely to address food and nutrition challenges in the global south (Arvidsson, 2015). Despite these developmental functions being played by GMOs, there are nonetheless concerns in relation to safety issues. Muzhinji and Ntuli (2021) note that (not) introducing GMOs on safety concerns will not hurt the policy maker/scientist or the politician but rather the small-scale farmers who exert so much energy yearly cultivating unproductive soil with little fertility hoping for a higher yield.

Globally, to address food insecurity, some steps have been initiated with potential positive outcomes. Specifically, advances in genetic engineering have shown some level of success in tackling some farming challenges such as low crop yield, diseases and pests, as in the case of GM insect resistant maize (Gbashi et al. 2021). Whereas in Africa a promising agrarian intervention such as GMO techniques could play a role in addressing food insecurity on the continent, there are divided opinions among actors with respect to its merits relative to its hazards (Gbashi et al. 2021). Hence, controversies around GMO have not only highlighted the divided opinions within and among the stakeholders, but also the debate and struggle on GMO has different perspectives, which include economic and legal issues, biological concerns, farmers rights as well as ethical issues (Ewens 2000).

The Northern region of Ghana is one of the food hubs of the country due to the abundant land and agricultural intensification. The introduction of GMOs in the region is envisaged to improve productivity and increase farmers' resilience to climate change. Involving and engaging farmers is a core task of agriculture officers at various levels of the agrarian sector throughout the country. A study of agriculture professionals' perspectives and opinions about the issues surrounding GMOs will provide opportunities for rich discussion on the technology. In line with agriculture technology, agriculture officers should be actively involved in the discussions regarding the kind of technology, such as GMOs and how it will impact the seed/food security. So, what do agriculture officers think about introducing GMOs into Ghana? In the context of introducing GMOs in the agriculture sector in Ghana, there exist multiple perspectives depending on the school of thought or paradigm to which one is aligned. It's important to note that these opinions may vary, and it is crucial to survey a wide range of professionals to get a comprehensive understanding of their viewpoints on GMOs. Therefore, this research seeks to examine the perception of agriculture officers in Ghana with a focus on Northern Region. Significantly, there exist different narratives of GMOs depending on the person's profession or interest or how one understands the GMO technology. But there is the need to keenly look at agriculture officers' views and the role they play at various levels in relation to GMOs as their roles could shape farmers use, understanding and uptake or rejection of these products. This study explores agriculture officers' views because they could shape farmers' ideologies and their sense of hope or otherwise in GMOs.

According to a study conducted in Northern Ghana with respect to the source of information on GMOs, only 10% of the study participants indicated extension officers as their primary source of information (Zakaria et al., 2022). It is important for farmers to obtain the right information with respect to GMOs as this will guide them so they can make informed decisions and offer them the opportunity to decide about what to grow and what they will eventually offer to consumers.

To unpack the introduction of GMO, the current study seeks to bring to the fore perceptions of agriculture officers' as well as their perspectives on GMO in the light of the underlying assumption of what it offers for their clients. The African Centre for Biodiversity (ACB) notes that the Ministry of Food and Agriculture is responsible for information dissemination through extension to

farmers as well as offering training to farmers (ACB, 2015). To this end, it is the agriculture officers at various districts, zonal, and operational levels who are responsible for disseminating messages and information with respect to GMO at their respective levels of operations. Amid growing focus and agenda on the pathway towards successful solutions to agriculture challenges, it is the agriculture officers who will be faced with the task of convincing the farmers that GM crops and by extension their cultivation is beneficial to farmers and their livelihood. Even though Agriculture officers play an important role in dissemination of information, they are an understudied group whose perceptions on GMOs could shape debate and farmers understanding or possible adoption or other wise of the GMO. However, there is no known study presently that examines agriculture officers' perspective of GMO; this study will explore their understanding, experience, and willingness to promote the GMO among their farmers.

II. METHODOLOGY

This paper adopted the use of Google Form and purposefully gathered data from the agriculture officers. We reached out to 297 participants on the agriculture platform to gather their opinions and thoughts about GMOs, as we wanted to understand how they perceive the GMOs.

Data collection started from 20 October to December 2023. The Google Form was shared on the agriculture platform and through a known person in each district, especially the Management Information System officer or the District Director of Agriculture. In all, 74 responses were received. One challenge was security concern; thus, how secure the form was a major concern by some participants who were not comfortable because of their past experiences with data breaches.

The survey was designed using a Google Form to assess agricultural officers' views, involvement, and experiences related to GMOs, amongst the platform participants of Northern Agriculture Information Ghana.

Data was analyzed using tables to categorise responses into percentages and power BI employed to determine key influencers. The survey examined their views on GMOs and willingness to promote them. Combining the successful solution framework and agriculture officers' perspectives with the insights from the literature review, this paper highlights officers' views around the introduction of GMOs into Ghana. The study further assessed their views on GMO contribution as a successful solution to tackle farmers' challenges.

III. BRIEF DESCRIPTION OF THE STUDY PARTICIPANTS AND FRAMEWORK

The platform was created on 26 February 2016 by a group of agriculture officers in the then Northern Region, now Northern, North East, and Savanna Regions. The platform is made up of all classes of agriculture professionals and technical officers.

In recent months, anytime the issue of GMOs is up on the agriculture platform, it attracts debate and attention among the platform participants. This attention and debate are borne out of the contentious nature of the technology, which has progressively come to be seen as a central reference point for participants with divergent interests and views who take seriously the role of GMOs in agriculture.

Framework for Analysis

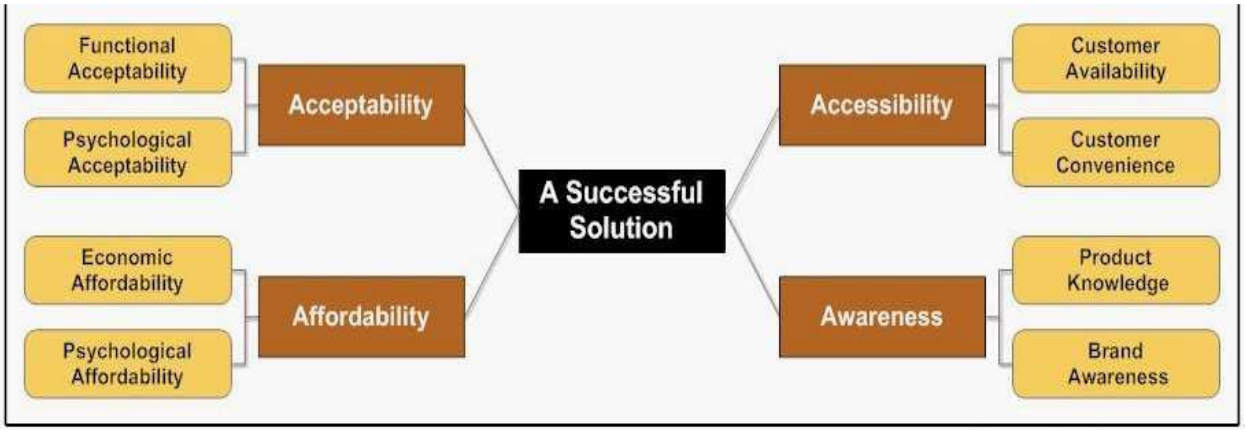

Fig.1: Framework for assessing a successful solution (Adapted from Badmus 2022 on analysis of food waste reduction)

From the Figure 1 above, there are four (4As) features of successful solutions, namely: Acceptability, Accessibility, Affordability and Awareness. Raising awareness about GMOs is a key factor that can influence people's

acceptance and attitude with respect to GMOs and subsequent adoption. As farmers become aware of GMOs, there is a likelihood of acceptance among farmers (Gbashi et al., 2021). However, more effort is required to raise awareness among actors often through discussion, especially in Africa (ibid.). Accordingly, organization such as Friends of the Earth (FOE) 2022 note that organizing awareness campaigns will help citizens appreciate the consequences of GMOs on health, food security and sovereignty to resist prevalent of GMO introduction into Ghana (FOE, 2022).

Whereas, in relation to acceptability of GM technology, Gbashi et al. (2021) report that there is old age hesitancy in many African states in accepting GMOs though upon recognizing their merits, they relax their stands and opinions on GMOs. Even though, some authors were of the view that there is high acceptability of genetic modification when employed in improving food safety as opposed to food quality among citizens (Shanahan et al. 2001). However, if farmers do not accept technology as being suitable within the perspectives of their community, traditional, and economic settings, the technology could be ignored (Badmus, 2022 as cited in Affognon et al., 2015). On the other hand, it was opined that age and gender among other factors, can influence the acceptance of GMOs (Ampadu-Ameyaw et al., 2021). Juxtaposing this to education, according to Ampadu-Ameyaw et al. (2021), the level of education attained by individual influences the level of consciousness of the individuals because information on GMOs at higher levels of schooling exposes individuals to a lot more knowledge on the subject.

Also, Ampadu-Ameyaw et al. (2021) observed that accessibility of GMOs in relation to access to information is challenging as the initial time individuals access information on GMOs affects awareness. In terms of affordability, according to the Africa Center for Biodiversity (ACB), smallholder farmers can barely afford the price of GM seeds and other agro chemical inputs needed when cultivating GMO seeds. So, the high cost of inputs, which is the feature of GM hi-tech package, will contribute to endangering delicate socio-economic systems (ACB, 2015).

IV. RESULTS AND DISCUSSIONS

Characteristics of the Study Respondents

From table 1, a total of 74 responded to this question; this implies that out of 74, 62 (84%) of respondents were male while the remaining 12 (16%) were female. According to Ampadu-Ameyaw et al. (2021), age and gender, among others can impact the acceptance of GMOs.

The majority (55%) of the respondents was between the ages of 31-40 years, followed by those within the ages of 41-50 years (24); whilst 18% indicated that they were below 30 years and 3 (3%) said they were above 50 years. Also, the study shows that the majority (50%) of the study participants indicated that they have a BSc/BTech whilst 28.4% said they have a masters whereas, 10.8% stated they have a Diploma or certificate and none had a PhD. Indeed, the higher the level of education of individuals, the more aware and conscious they become of GMOs, Ampadu-Ameyaw et al. (2021). Also, Zakaria et al. 2021 identified low level of education is as a challenge that faces the introduction of GM technology among smallholder farmers in Ghana and Nigeria.

With respect to years of work experience 32% of the study participants have between 3-5 years of work experience, 27% indicate they have worked between 6-10 years, 15% have worked between 11-15 years, while 10% said they had worked 16-20 years, and 8% have less than two years of work experience. Others stated 21-25 as the number of years they had on the job, and the least years of work experience was 30 years and above.

Agriculture Professionals Perspectives

Agriculture officers' views on GMOs and environment

Analysis of the data from the study indicates that 37% of the respondents agreed and 27% strongly agreed with the statement that GMOs could reduce chemical use in the ecosystem. This implies that the majority of the study group perceives GMOs as a possible solution that may reduce chemical usage because GMOs can breed variety that could resist insects or variety tolerant to disease, which will decrease use of pesticides. Although some study participants, thus, 11% disagreed and the 5% strongly disagreed with the statement that GMOs could decrease environmental chemicals on the ecosystem. Possibly, this group could have reservation about the long-term impacts of GMOs in the environment, including damage to non-target plants, or this could result in resistant pests within the environment. On the other hand, about 19% of respondents indicate their stands as neutral; this shows they are not certain about the effect of GMOs in the environment and their relationship with reducing chemicals in ecology.

On GMOs to contaminate the food chain and wider environment, some 32% of respondents disagreed and 7% strongly disagreed with the statement. On the other hand, 26% of the study participants agreed and 12% strongly agreed with the statement that GMOs could contaminate the food chain and wider environment. This implies that these respondents believe that GMOs do pose a risk of polluting the food chain and broader environs. These

individuals may be concerned about the potential for allergenic or toxic effects from genetically modified organisms, as well as the impact on soil health and beneficial insect populations. Yet, 23% of the respondents were neutral, which reflects their weak opinion concerning the issue of GMO contamination of the food chain and broader environs. According to Stephen and Mannion (2008), genetically modified crops have the ability to both aid in the protection of natural ecosystems and contribute to their continued decline. Therefore, GM crops elicit a wide range of opinions although there is no proof that they will have the same negative effects on the environment with respect to pesticide usage, hence, opinions on the use of genetically modified agriculture have been divided between fierce resistance and enthusiastic approval (ibid.).

Whereas, with GMOs benefit linked to environment, farmers, and society, data gathered suggests that 46% of respondents agreed and 11% strongly agreed with the statement. Thus, the majority perceives GMOs as having positive impacts. Although, 19% of respondents were neutral, as they seem to be uncertain about the benefits of GMOs to society, the environment and farmers. However, from the data, opinions of other respondents showed that 17% disagree and the rest (7%) strongly disagree. It is important to note that although 23% (disagree and strongly disagree) is lower than that of the 57% (agree and strongly agree), a lot of education of officers with regards to the benefits of GMOs will be required to aid in information dissemination.

Officers views on GMOs and sustainable food and nutrition security/safety

Results of the data analyzed indicate that 45% of participants disagreed with the impression that GMOs will worsen food security. Likewise, 7% strongly disagreed when they expressed opinions in relation to GMOs and food security deteriorating. However, 19% expressed their opinions by strongly agreeing that GMOs will worsen food security. Similarly, 8% agreed that introducing GMOs could worsen our food security. Of the respondents who took part in the study, 22% were neutral without a clear position on the role of GMOs in worsening food security. Agreeably, 44% believe GMOs will improve food security, whilst 27% strongly agreed. On the other hand 14% took a neutral position. Whereas 10% disagreed and the remaining respondent (5%) said they strongly disagreed.

According to the data gathered, 44% of participants agreed that GMOs can enhance nutrition but 20% remained neutral. It's worth noting that 15% of the respondents both disagreed and strongly agreed with this statement, indicating a split in opinions within this group. Additionally, 6% of the participants opted to strongly disagree with the idea of GMOs improving household nutrition. Again, majority of the study participants, thus, (43%), representing 32% disagree and 11% strongly disagree that GMOs are unsafe for consumption. About 28% of the study participants were neutral with the statement that GMOs are unsafe for consumption. Though 19% agreed that GMOs are unsafe for consumption and 10% strongly agreed that GMOs are unsafe for consumption. The majority opinions are in line with the finding from Gbashi et al. (2021), which suggest that the GMO cassava variety was developed with features such as a low cyanide level, which is considered safe at the same time being tolerant to virus and having a better shelf life.

Officers views on GMOs and agribusiness

Respondents' views on GMOs contributing to the success of agribusiness were also solicited. Results indicate that about 51% and 26% agreed and strongly agreed, respectively that GMOs contribute to the success of agribusinesses. This suggests that the majority believe GMOs play a role in enhancing agribusiness. However, 14% of the respondents to the study were neutral or uncertain about the possibility of GMOs playing a role in enhancing agribusiness. On the other hand, 6% simply disagreed with the idea of GMOs contributing to agribusiness, while 4% strongly disagreed. When the question of whether GMOs are geared towards agribusiness was asked, the majority (60%) representing 34% agreed and 27% strongly agreed that GMOs are geared towards agribusiness. Though 24% said they were neutral as they express uncertainty on their position. On the other hand, 10% disagreed and 5% strongly disagreed with the assertion that GMOs are geared towards agribusiness. With reference to BT cowpea, ACB 2015 reports that there is a lucrative market along the seed production value chain, especially for foundation and certified seeds. This therefore will ultimately enhance the agribusiness narrative for farmers awareness and adoption.

Most of the respondents, thus, 49% (30% strongly agreed and 19% agreed) with the notion that GMOs will lead to monopolies. However, 31% were neutral and uncertain about how GMOs introduction will lead to monopolies. Other respondents differed in their opinions, with 16% disagreeing and 4% strongly disagreeing. On the matter of employing GMOs in making seed sterile, officers' views were as follows: Out of the total study respondents, 38% were neutral, as they did not have a clear opinion on this statement. Whereas 28% agreed, 5% strongly agreed, with the same percentage of 15% disagreeing with this assertion. Only 4% disagreed with GMOs seed sterility.

GMOs promotion, benefit and impact on food security/sovereignty

From the data presented in Table 2, the majority (40% likely and 16% very likely) representing 56% of respondents said they will champion GMOs. While 28% are not sure of whether they will promote GMOs and 10% are unlikely to promote GMOs. The remaining (6%) of respondents said they are not very likely to promote. Also, from the same table, 44% said GMO is helpful, while 23% agreed that it is very helpful. However, 19% and 14% mentioned that it is not very helpful and unhelpful, respectively. According to 67% of the study group, GMO technology is considered to be beneficial to farmers, whereas 33% stated that it will not be beneficial to farmers. A significant proportion of the respondents, 67% think that there is no available information on GMO technology, whilst 33% said there is available information on GMO technology. This suggests that, to make use of the officers as a link to the farmers, more information on the GMO needs to be available to change agents.

Ampadu-Ameyaw et al. (2021) argued that there is the need to find a middle point amid differing opinions; therefore, appreciating GMOs will depend on the level of participation as well as individuals' attitudes towards GMOs in Ghana. From the data analyzed, the majority 54 (74%) of the respondents indicated that they have never attended or participated in any GMOs related program, whereas 26%, representing 19 participants, stated that they have been involved in GMOs related activity or program. One respondent did not respond to this question.

Sources of information on GMOs

From the data analyzed, 28% representing 20 respondents indicated that an article or a journal/newspaper, thus print or online media, is their source of information or how they got to know about GMOs. While 21% (15) of the study participants said television is their source of information. About 20% responded that word of mouth is how they got to know about GMOs. Accordingly, 14% (10) of respondents specified that they got to know about GMOs through conferences. Also, 9 respondents, representing 13%, said social media (Facebook, Twitter, Instagram, WhatsApp) was where they got to know about GMOs; 3 (4%), stated radio as a medium through which they found out about GMOs.

Assessing GMOs through successful solution lens

From the data presented in Table 3, 32% of the respondents indicated that GMOs would have average acceptance among their clients. While 30% were of the view that its acceptance will be very low among farmers. On the other hand, 22% of the respondents said its acceptability will be high, whereas 15%, stated that its acceptance will be low among farmers. Therefore, acceptability among farmers will be low, as 45% indicated low and very low acceptance of GMOs among farmers.

Again, from the analyzed responses in the table it was indicated that 30% of the study group thinks GMOs will be average in terms of how affordable they will be. While, 29 linked very low to its affordability. About 23% of the study participants said its affordability will be low whereas, 10% are of the view that its affordability will be high, and 8% contemplate that its affordability is very high. Generally, the affordability of GMOs, as indicated by 52% of the study participants said, it will not be affordable by farmers.

According to the study group, in terms of accessibility, 36% believe that there will be low access to GMOs among their clients as indicated in Table 3, while (33%) of the respondents associated low access to GMOs. On the other hand, 24% indicated that its access will be average and whilst 5% said its accessibility will be high. Similarly, 2% say its accessibility is very high. From the analysis above, 69% (36% low and 33% very low) claimed there is a likelihood of farmers' low accessibility to GMO.

Table 3 shows that 40% and 30% claimed that GMO awareness among the farmers is very low and low awareness, respectively. While 19% and 11% said awareness is average and high respectively. Hence, the majority (70%) believed there is low awareness of GMOs among farmers.

V. CONCLUSION

This study assessed agriculture officers' perceptions on the introduction of GMOs into Ghana and its impact on food and seed security, as well as their level of participation in GMO-related events and readiness to promote them. The study sought their views on GMOs as a successful solution to tackle farming challenges and also assessed what influenced their views.

The responses gathered were analyzed using Power BI. While descriptive statistics such as percentages were employed to show how their opinions differ from a wide range of perspectives based on factors such as environmental, sustainable food and nutrition security/safety, and agribusiness viewpoints on GMOs emergence in Ghana.

The study revealed that 53% of agriculture officers agreed that GMOs will have a positive impact on food, seed security, and sovereignty. Also, 56% said they will champion GMOs; however, 67 % said there is limited information on GMOs and 74% of the respondents indicated that they have never participated in GMOs related programs or activities.

The paper highlighted officers' views around the introduction of GMOs into Ghana, although there were divergent views on GMOs as a successful solution to tackle farming challenges. From the officers' point of view, 45% of the study respondents suggest that GMO acceptability among farmers will be low. Also, more than half of the studied group (52%) said it will not be affordable by farmers. Again, most respondents (69%) claimed that there will be low access to GMOs by the farmers and 70% claimed there is low awareness of GMOs among farmers. The study further seeks to understand what influenced their opinion and the key influencers include: GMOs is unsafe for human consumption, genes escape into wild relatives; GMOs will create insect resistance and genetically engineered crops will have limited capacity locally.

It is important to note that agriculture officers' opinions are not exhaustive and that there is a wide range of perspectives within the agriculture community. There exist varied views, as some agriculture professionals have a more nuanced view, acknowledging that GMOs can have both helpful and adverse effects. Some are of the view that specific traits, potential risks, and benefits of GMOs should be assessed on a case-by-case basis.

The study recommended that there is a need for pro- and anti-GMO groups to involve officers in GMO activities for effective dissemination of information on GMOs to farmers and citizens.

Table 1 Demographic or Socio-Economic Characteristic of Respondents

VARIABLES	**FREQUENCY**	**PERCENTAGE**
GENDER		
Male	(63)	84%
Female	(12)	16%
AGE (YEARS)		
Below 30	(13)	18%
31 – 40	(40)	55%
41 – 50	(18)	24%
Above 50	(3)	3%
EDUCATIONAL LEVEL		
PHD		0%
Masters	(21)	28%
BSc. B/Tech	(37)	50%
Diploma	(8)	11%
Certificate	(8)	11%
YEARS OF EXPERIENCE		
Less than 2 years	(6)	8%
3 -5 years	(24)	32%
6 – 10 years	(20)	27%
11 – 15 years	(11)	15%
16 – 20 years	(7)	10%
21 – 25 years	(5)	7%
30 years and above	(1)	1%

Table 2 Impacts of GMO on Farming, Food Security, Promotion of GMO and Benefits

VARIABLES	PERCENTAGE	PERCENTAGE
GMO IMPACTS ON FARMING		
Very Positive	(5)	7%
Positive	(26)	35%
Neutral	(15)	20%
Negative	(11)	15%
Very Negative	(10)	14%
Not Sure	(7)	9%
GMO IMPACTS ON FOOD SECURITY		
Very Positive	(10)	14%
Positive	(29)	39%
Neutral	(11)	14%
Negative	(9)	12%
Very Negative	(8)	11%
Not Sure	(7)	10%
PROMOTION OF GMO		
Very Likely	(12)	16%
Likely	(30)	40%
Not Sure	(21)	28%
Not Very Likely	(4)	6%
Unlikely	(7)	10%
Very Helpful	(17)	23%
Helpful	(33)	44%
Not Very Helpful	(14)	19%
Unhelpful	(10)	14%

Table 3 Ranking of GMO Technology via Sustainable Solution Lens

FACTORS	RANKING				
	Very Low	Low	Medium	High	Very High
Acceptability	(22)30%	(11)15%	(24)32%	(16)22%	0%
Accessibility	(24)33%	(27)36%	(18)24%	(4)6%	(1)1%
Affordability	(21)29%	(17)23%	(22)30%	(7)10%	(6)8%
Awareness	(30)40%	(22)30%	(14)19%	(8)11%	0%

Table 4 Agriculture officers' views on GMOs

Statement: GMO ….	**Responses** **Strongly agree (S.A), Agree (A), Neutral (N), Disagree (D), Strongly disagree (S.D)**				
	S.A	**A**	**N**	**D**	**S.D**
Will contribute to sustainable agriculture	26%	51%	14%	5%	4%
Will enhance productivity per unit area	31%	49%	8%	6%	6%
Will reduce environmental chemical on the ecosystem	27%	37%	19%	11%	6%
Could contaminate the wider environment	12%	26%	23%	32%	7%
Genes may escape from a crop into wild relatives	11%	33%	27%	26%	3%
Will Create insect resistant	14%	42%	30%	7%	7%
Have potential contamination of the food chain	18%	25%	25%	27%	5%
Is unsafe for consumption	10%	19%	28%	32%	11%
Will lead to diversity of features been engineered in plants	14%	51%	24%	8%	3%
Will improve the situation in our food security	27%	44%	14%	10%	5%
Will worsen our food security	19%	8%	22%	44%	7%
Could lead to monopoly via patents	14%	51%	24%	8%	4%
Will reduce the need for potentially environmentally damaging, expensive pesticides	26%	36%	22%	6%	10%
Will be better for the farmer, the environment and society	11%	46%	19%	17%	7%
Is geared towards agri-business	27%	34%	24%	10%	5%
Will benefits resource-poor subsistence farmers	18%	42%	20%	11%	8%
Limited capacity to genetically engineered crops locally	19%	32%	28%	17%	4%
GMO seeds are or could be sterile	15%	28%	38%	15%	4%
Will lead to decline in chemical pesticide use	26%	36%	22%	6%	10%
Will reduce contamination of soils and water	22%	36%	23%	8%	11%
Will improve nutrition	15%	44%	20%	15%	6%
Will increase yield and increase income of farmers	38%	45%	9%	4%	4%
Will protect the environment	15%	29%	33%	12%	11%
Could reduce poverty	30%	34%	19%	10%	7%

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