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ORIGINAL ARTICLES

The Need for Information Sharing Among Stakeholders: Lesson for Sustainable Biotechnology Adoption

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ABSTRACT

Farmers in developing countries face monumental constraints which directly impact food security and socioeconomic wellbeing. Conceivably, the sustainable adoption of any viable agricultural innovations such as biotechnology (biotech) is capable of providing some palpable solutions. However, biotech for food security enhancement or farmers' empowerment can be stalled due to the dissemination approach utilized by stakeholders. Consequently the need for sound institutional approach in the design and dissemination of appropriate agricultural innovations especially in Africa is imperative considering the production challenges confronting farmers and the enormous socioeconomic hardships that a non-adoption or disadoption of such relevant innovation can have on the intended users. This article considered biotechnology awareness level among farmer, information sources, level of trust ascribed on information sources, possible biotech attributes that will motivate farmers to adopt it and farmers' opinion regarding participatory innovation development and dissemination approach. Using a semi-structured questionnaire method, empirical data were obtained from respondents in Kaduna and Nasarawa States of Nigeria. Results indicated that farmers demonstrated very low knowledge of modern biotechnology although they are familiar with the traditional biotech such as fermentation and in some cases equated hybrid seeds with biotech products. Generally, potential adopters would only adopt biotech if it fulfilled certain predetermined evaluation. Conversely, farmers ascribed different level of trust on information sources in their institutional environment. Lack of information access and consultation revealed a negative effect on biotech awareness. Adopters find it irrational to bequeath scarce resources to an innovation with low awareness level or lack of understanding of its working dynamics or potential benefits. Participatory innovation dissemination approach was more favorable among farmers than other methods. Equally, innovations which were disseminated without farmers' involvement or consultation recorded low adoption rate as farmers adopted the 'seeing is believing' attitude. In order to reduce risk perception on biotechnology, which is prevalent in developing countries such as Nigeria or to determine priority areas and farmers' preferences, information sharing among stakeholders should be facilitated. It is also expected that this approach will decrease the time required to convince potential adopters to try the innovation because they will be part of the process from inception. Moreover, this approach will fundamentally reveal the perceptions of farmers about any relevant agricultural innovation like biotech and if they actually want the innovation or not.

Key words: Institutional environment, Urgent needs, Innovation, Awareness, Biotechnology

Introduction

New innovations increases competitiveness, its availability and affordability vis-à-vis the usage enhances economic, social or intellectual improvement of the users. Farmers seek information constantly based on the

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need to overcome risk and farming constraints or production improvement and income enhancement opportunities. But innovation availability, affordability or accessibility does not always determine farmers' adoption rates based on factors that relate to socioeconomic, sociocultural, innovation attributes as well as information sharing among stakeholders and attributes of the adopter. Conventional agricultural practices or unsustainably introduced innovations have impacted negatively to the environment. In effect, most lands in developing countries are not capable of sustaining increased productivity under present conditions. Some have argued that biotech is as one of the benign tools necessary for reinvigorating the agricultural sector (Tonukari and Omotor, 2010; McHughen, 2008; Gressel, 2008 and Walgate, 1990) and thus the development of the rural economies. However, such assessment by proponents of biotechnology on what it can accomplish or not, have been marred by intense criticisms regarding its sanctity, safety and rationality (FoE, 2006; Greenpeace, 2002; Shiva, 2002; Altieri and Rosset, 1999; Trewavas, 2002). Some of the apprehensions are not atypical to new technologies since there is no risk-free innovation (David, 2008; Walgate, 1990). Still, others are specific to biotechnology alone such as the effect of gene combinations or alterations and the control of genetic resources (Gaskell, 2008; Mellon, 2008). To compound problems, biotechnology multinational companies and some government institutions failed to respond with genuine openness to legitimate concerns raised by opponents and users (McHughen, 2008). If the apprehensions and fears surrounding biotechnology introduction and application to our food chain and environment had been addressed with sincere openness, probably the unintended anxieties and hype trailing the innovation as well as the resultant position polarization regarding its safety and sanctity will be minimal (Gjerris, 2008; Bailey, 2002). Some have argued that the profiteers of biotech advancement are multinational seed companies and middlemen with their monopolistic orientation (FoE, 2010, 2006; Greenpeace, 2002; Lappe, 2002). Others have maintained their fiercest attack based on the projection that even if farmers can benefit, it will obviously not be the resource-poor that dominates farming business in developing countries (Ismael *et al*., 2002; Tripp, 2002). Such arguments have necessitated remarkable change of attitude by some seed companies like Monsanto through promotion of public-private sector partnership. This recent changes though are still short of the right institutional approach required to guarantee sustainable adoption (Nwankwo, 2010) because it is bereaved of a prior determination of users' urgent needs through participatory approach. It is debatable whether this latest turnaround approach by Monsanto is a sympathetic maneuver based on business strategy or the company actually intends to improve its corporate image. Incidentally, the mention of biotechnology is often construed as synonymous with genetically modified organisms (GMOs) among many people especially in Europe. Evidently, Biotech, which has been widely defined (McHughen, 2008; OECD, 2005; Persley, 1990), is not restricted to GMOs alone. It includes traditional biotech techniques (fermentation, cross-breeding) and modern genetic engineering. One main aspect of genetic engineering is that it is more precise, accurate, targeted and less-time consuming than other traditional biotech techniques. But the impact of agricultural biotech on the food chain, environment and human health in the long run is completely incomprehensible. Conversely, it is not exclusively obvious whether all the negative critiquing ascribed to it are justified or not. Agricultural biotech may possesses several desirable attributes but the overarching source of concerns lies on how the innovation will benefit various strata of resource-poor farmers and how to ensure a sustainable adoption process.

The Imperativeness of Institutions on Biotech Adoption Process

North (1990) has conceptualized institutions to include formal and informal dimension. Brenner (1996) identified the relevance of institution on innovation introduction and how it determines the rate and direction of the learning process and change. The significance of institutional effect on biotech adoption has also been identified (Laxmi, *et al*., 2007). Nonetheless, such discussions concentrate only on regulations and enforcement rather than on a sustainable approach (Fukuda-Parr, 2006; Moschini, 2001). However, awareness and attention of sustainable biotech adoption is growing. Institutions matters in economic development (Yeager, 1999). Understanding the right sustainable adoption approach matters a great deal. It is noted here that vertical and horizontal information sharing among stakeholders is capable of revealing users' urgent needs. Lack of appropriate information sharing about actors' intentions and motivations can promote exploitation due to ignorance. Such atmosphere increases risk and uncertainty perception and affects decision to utilize the information being disseminated. In some instances, farmers refuse to adopt a particular innovation due to incompatibility with users' urgent needs due to the approach of the institution promoting the innovation.

Innovation-information seeking in Adopters' Institutional Environment

Adoption is dependent on adopters, their environment and how they perceive innovation attributes relative to the one it is capable of replacing. Farmers seek solution-based information constantly. The purpose is to overcome risk and numerous constraints which hinder productivity and income. Information seeking and processing is the starting point of adoption process (Rogers, 2003). The importance of information on adoption-

decision process cannot be overemphasized as well as the significant role that information channel and sources play. Proportionately, the way adopters perceive information content regarding an innovation is correlated with institutional approach (Heim, 1990, Lapbim, *et al*,. 2008). There is no disputing that biotechnology may possess all the 'desirable' attributes and adjudged 'fit' for improving food productivity and availability, yet it can be rejected by potential adopters based on dissemination approach. The controversies generated by biotechnology especially in developed countries have resulted into increased risk and uncertainty perception in developing countries majorly. This is partly because biotechnology is often equated with GMOs. From inception, biotechnology multinational companies implemented wrong approaches in responding to criticisms and several issues regarding perceived and real risks (Mellon, 2008), assuming their critics will 'understand' and be 'convinced' in the long run. However, the public was already wary of the scientific community and have begun to show distrust in regulatory institutions (Sagar *et al*., 2002). Moreover, the public are increasingly susceptible to misinformation, demonstrating a sense of fear due to lack of foundational resources to significantly wield systemic influence (McHughen, 2008). It should be noted that despite how beneficial biotechnology is portrayed by its proponents, its acceptance in societies can be opposed. The exceptionally large degree of hysteria witnessed is necessitated by the fact that it impacts the future of our food chain or might have long or short-run environmental impact. More so due to protectionism approach adopted by some biotech multinational corporations in responding to criticisms, the hype about biotech have continued to swell. This therefore requires a change of approach capable of lowering risk and uncertainty perception that farmers and consumers already display (Terawaki, 2008). Brenner (1996) have demonstrated the importance of institutions in biotechnology adoption, noting that institutions matters in adoption process as they connect to establish the basis for production, exchange and distribution of goods and services. North (1993) defined institutions and characterized how they interact in a given society. The cultural, social and religious institutions shape tradition, norms, taboos, expected conduct and how people react. Several scholars have argued the advantages and disadvantages of institutional regulations and interventions on the diffusion of biotechnology. Fukuda-Parr, 2006 argue that institutional regulatory systems especially in developing countries are too weak and may hinder adoption and hurt the spread of GMOs. Knowing farmers' needs in terms of priority choices and channeling institutional resources into solving them is crucial. Perception affects risk and uncertainty, relevant information reduces it. The knowledge of farmers' priority needs is only possible if they are consulted through cooperative participation and information sharing. Ackoff (1965) argue that cooperation reduces conflict, and enhances adoption.

Biotech Awareness Campaign

Rather than consulting with farmers ab initio to determine priority areas, Nigerian Government initiated biotechnology roadmap and outlined areas of interest where biotechnology can help increase agricultural productivity, reduce food insecurity and empower rural farmers. Studies have revealed that even where government has emphasized on productivity increase; it had further created income inequality (Nwankwo and Bokelmann, 2008). Most agricultural products are perishable, lack of storage and processing facilities constitutes major handicap for developing country farmers. Inefficient markets and transportation system is also prevalent. When farmers manage to transport their perishable products to markets, they are coerced into selling them at prices offered by organized middlemen especially to settle transportation cost. Increased production therefore cannot be the answer in scenarios where proper market facilities and institutional framework are deficient. The National Biotechnology Development Agency (NBDA) had organized and conducted biotechnology awareness campaign in the six geopolitical zones. The awareness campaigns were carried out mainly in state capitals. Intuitively, it was difficult for majority of farmers and other stakeholders to participate in the seminars. Most farmers carry out their business in remote areas and only EAs who are equipped with transport facilities can contact them.

Predetermined evaluation, institutions and adoption-decision

Based on decision theory, adopters have goals, predetermined evaluation of utility and capacity to make choices. This is described in Figure 1 below.

Appropriate subjective decision is based on available information appertaining to modus operandi of the decision object. Overt or covert adoption decisions are greatly determined and influenced in congruence with institutional approach. Risk perception as well as information mechanism affects decision. The more the intentions and motives of various actors involved in information sharing are perceivable, the lesser the conflict of ideas. A contrary scenario leads to conflict of interest and thus affects decision. Information seeking comprises of active and passive information. Acceptance and applicability are affected by Real Information Dynamics (RID) and Perceptional Information Dynamics (PID) factors.

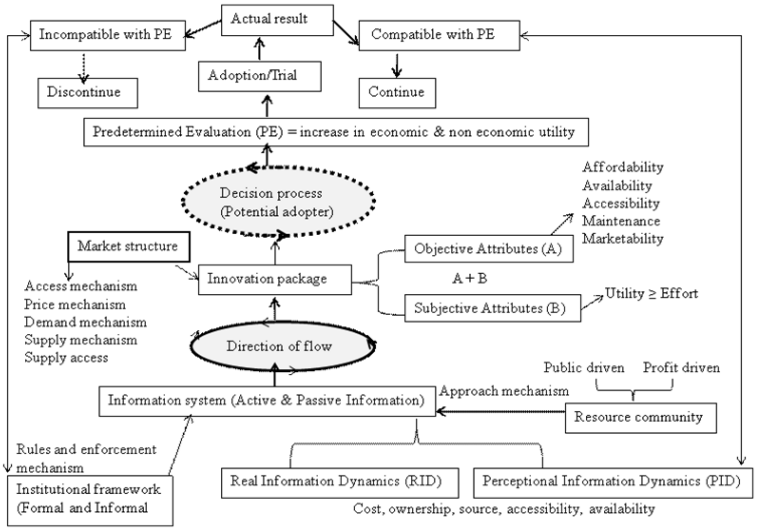

Fig. 1: Effect of institutions and information dissemination approach on adoption-decision

These included, but not limited to: information availability, accessibility, understandability, cost, ownership, validity, environment, source, perception, adopter's and communicator's attributes. Institutional framework is made up of formal and informal institutions. Enforcement mechanisms include rules and regulations, taboos, norms, restriction and excommunication. The Predetermined Evaluation (PE) increases economic and non-economic utility based on the attributes of the innovation relative to the one it is replacing and how adopters perceive innovation's capability to tackle priority need(s). The following stakeholders were taken into perspective: individual adopters and consumers, cooperative institutions, government and non-governmental institutions, research institutions, seed companies and foreign agencies.

Nigerian Agricultural Biotechnology Status

Presently, there are no officially approved and commercialized genetically modified (GM) crops in Nigeria. However, the Nigerian Government has indicated avowed determination to pursue a strong biotechnology policy aimed at reviving the ailing agricultural sector. Areas of interest are mainly on crops which are relevant to the food and industrial need of the country. Emphases are also on pests and herbicide resistant varieties, vaccines, feedstock, livestock improvement, diagnostic techniques, and pharmaceutical products. However, tissue culture and micro propagation techniques are being employed to improve crop delivery to farmers. Also genetic marker and finger printing techniques are being utilized to conduct research on some target crops. In 2009, the government proposed to conduct field trial of genetically modified cassava. This move has been widely opposed and criticized by local and international activists (Nwankwo, 2010).

This paper explores the relevance of involving stakeholders in participatory approach through information sharing. Presumably, such process will enable biotechnology institutions to discover users' urgent needs and to insure that biotechnology innovation disseminated in developing countries possesses subjective and objective attributes. This have been lacking in biotech design and dissemination. The approach is capable of further awareness creation as well as reduction of risk and uncertainty perception. This is capable of elucidating positive adoption decisions appropriate for sustainability. This paper also aims at determining the level of trust farmers' ascribe on information content from various stakeholders as well as the scope of biotechnology awareness among farmers.

Materials and Method

Data presented in this work formed part of a wider survey covering six states in Nigeria (representing six geopolitical divisions of the country) aimed at determining factors that will affect sustainable biotechnology adoption. The data set analyzed here represents two states, Kaduna (North West) and Nasarawa State (North Central).

Table 1: Areas surveyed

Nasarawa		Kaduna		No of respondents per state	
LGA	Village	LGA	Village	1st stage	2nd stage
Doma	Doma village, Rutu	Birni-Gwari	Bagoma, Birnin Gwari	80	60
Lafia East	Asiakio, Gida Maikuyai	Chikun	Gonigora, Kujama	80	60
Lafia	Akuruba, Lafia	Kaduna South	Barnawa, Tudun Wada	80	60
Obi	Dedere, Obi village	Kajuru	Kasua Magani, Mararaba Kajuru	80	60
Total	4	8	4	8	320240

In collaboration with the Agricultural Development Programme (ADP) in the respective state, the innovations that have been adopted by farmers in the study area and the information sources of innovation(s) were determined (See Nwankwo, 2010 for various institutions and agencies consulted). A semi-structured questionnaire was used in obtaining quantitative data. Empirical data were collected from farmers in collaboration with extension agents (EAs). Group interviews were also utilized while secondary data was obtained from ADP progress reports and the Ministry of Agriculture. Data was collected twice (July – October 2006 and March – July 2007) as shown in Table 1.

During the first phase, a randomized sampling technique was used to obtain empirical data from 40 farmers in each village. Sample size was reduced to 30 respondents per village in the second stage. Overall, empirical data was collected from 1120 respondents in the two states. The baseline questionnaire was aimed at eliciting information on adopter categories, adopted innovations, production constraints, information access, consultation among stakeholders, who influences adoption decisions, cooperative membership/participation, biotech awareness, perception and reaction to terminator gene, adopters' urgent needs regarding new innovations (Nwankwo, 2010).

Data Analyses

Data was analyzed using descriptive and inferential statistics. Chi-square and correlation are widely used analytical tools in social science research (Field, 2005; Gill and Johnson, 1997). For data which were ranked, Friedman test of ranking was used based on respondent's preference of information sources and its authenticity. Ranking of variables was necessary to determine the payoff which adopters assign to level of trust on information sources (See Nwankwo, 2010). Logistic regression analysis was utilized to determine factors that will influence biotech awareness and factors that determined adopted innovations. The use of logistic regression in adoption studies is well known (Krishna and Qaim, 2006; Darr and Chern, 2000; Griliches, 1957). The general form of a logit model proposed by Griliches is given as:

$$\frac{\partial_{nt}}{\partial_t} = \frac{\beta_{nt}}{N\left[N - nt\right]} \quad \text{or} \quad f(Y) = \frac{1}{1+e^{-y}} \tag{1}$$

Where n_t = number of individuals who adopted a given innovation at a time t, N = fixed population of potential adopters. ß is a parameter that reflects adoption rate, the value will depend on innovation attributes, attributes of the adopter, social network system, channel of communication and attitude/attributes of the change agent. The dependent variable Y_i, is predicated by the effects of independent variables, which is explainable through a combination of each predicator variable multiplied by the respective regression coefficient as follows:

$$Y_i = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + ...\beta_n X_{xn} + \varepsilon_i \tag{2}$$

Therefore biotech awareness is determined by the variables presented in equation 2.1 and equation 2.2 represents factors that played role in previously adopted innovation.

$$Btec_{Awas} = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \varepsilon_i \tag{2.1}$$

$$Ad_{Ino} = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \varepsilon_i \tag{2.2}$$

Where $Btec_{Awas}$ reveals biotech awareness level among adopters and Ad_{Ino} denotes respondents who adopted recently introduced innovation (within the last 5 years).

The probability function is predicted by equation 3 and equation 4 describes the fitness of the logit model.

$$P(Y) = \frac{1}{1+e^{-(b_o + b_1 X_1 + b_2 X_2 + ... b_n X_n + \varepsilon_i)}} \tag{3}$$

$$R^2 = \sum_{i=1}^{N} \left\{ Y_i I_n(P(Y_i)) + (1 - Y_i) I_n \left[1 - P(Y_i) \right] \right\} \quad (4)$$

Results and Discussion

Farming is the major occupation and source of living in the two states, cutting across gender and educational attainment (Table 1). In Kaduna State, females constituted a lower proportion of respondents compared to Nasarawa state.

Generally, the contribution of females to farming was a little higher compared to male (79% and 76% respectively). Notwithstanding, female access to inputs and extension information was very low compared to male farmers. Farming constituted the major occupation (77%) and accounted for the main source of livelihood (84%). Those who combined farming with other business (petty-trading, handiwork, taxi drivers, commercial motorbike riders and other crafts) were low. A contrast between Nasarawa and Kaduna revealed that the percentage of farmers in Kaduna State is higher but those who combined farming and civil servant were higher in Nasarawa than in Kaduna State. More farmers in Kaduna State depended on farming as the source of livelihood.

Table 2: Demographic characteristic of the respondents (n = 1120)

Variable name	Kaduna & Nasarawa		Kaduna		Nasarawa	
Gender	%	F	%	F	%	F
Female	40.7	456	38.4	215	43.0	241
Male	59.3	664	61.6	345	57.0	319
Occupation						
Farming	77.3	866	81.1	454	73.6	412
Civil servant	3.6	40	4.1	23	3.0	17
Farming and civil servant	6.5	73	3.9	22	9.1	51
Others	12.6	142	10.9	61	14.3	80
Source of living						
No	9.4	105	6.8	38	12.0	67
Partly	6.6	74	4.1	23	9.1	51
Yes	84.0	941	89.1	499	78.9	442
Education						
No basic education	10.8	121	9.1	51	12.5	70
Primary/adult education	28.8	322	34.5	193	23.0	129
Uncompleted Secondary	4.6	51	4.6	26	4.5	25
Secondary education	24.5	285	23.2	130	27.7	155
Diploma	12.9	144	10.5	59	15.2	85
Religious education	14.0	157	14.5	81	13.6	76
Higher education	3.5	39	3.4	19	3.6	20
Mean (Education)	3.36±1.72		3.30±1.75		3.42±1.73	

Results further revealed that only 11% had no formal education while a greater percentage (29%) possessed primary/adult education qualification, only very few were University graduates and this is relatively similar between the two states.

Although studies have suggested a positive correlation between education and adoption of technical innovations (Tesema, 2006), distinction is infrequently made between applicable knowledge and extractable knowledge. Educational attainments are capable of facilitating the rate at which farmers' process and understand innovation information. However, real information dynamics (RID) and perceived information dynamics (PID) as revealed in Fig. 1 play more crucial roles. Even highly educated farmers can be selective on which information to 'hear' (Rogers, 2003) based on perception about the intentions of the communicator (Ackoff, 1965). This is capable of swaying adoption decision either ways. Also religious education can affect the type of crop and animal to be produced and consumed.

Constraints Limiting Productivity and Income

Lack of capital affected farmers' capacity to purchase fertilizer, improved varieties, hiring of labor to cultivate or weed the farm on time and other inputs. Income inequality is a major problem for farmers in developing countries (Sundrum, 1991). Some improved varieties of maize available to farmers require early fertilizer application (after four weeks of planting). Fertilizer availability and affordability constituted one of the major limitations (89%). Sometimes, fertilizer arrived when the season for its application had expired. Lack of hybrid seeds (high quality) and adulterated chemicals or insecticides also constituted major constraints. Inadequate capital to purchase necessary inputs resulted into low yield, affecting income level. Weed infestation

constituted another major problem (86%). Striga (witch weed) infestation is prevalent in Northern Nigeria. Lack of proper weed control measures resulted in poor harvest while inadequate apposite information on herbicide application resulted in poor health. The problem of low yield caused by unavailability of improved seeds and the prevalence of weed infestation can be mitigated through biotechnology. However, not all the constraints are resolvable through it.

Information access and ability to apply given information in the absence of EAs posed a significant constraint (65%). Other constraints included: problems of labor, road and marketing (63%), lack of processing/storage facilities and transportation problem (37%), lack of improved seed and animal feeds (53%). Rogers (2003) argued that adoption of technical innovation begins with information acquisition and processing. Adequate innovation-based information was deficient. Feder and Slade (1984) concluded that active information seeking can be expensive. Studies have proved that farmers are capable of adopting innovations that addresses their needs (Lemchi, *et al*., 2005; Heim, 1990). Conversely, when agricultural institutions fail to understand farmers' needs before disseminating an innovation, it can lead to rejection (Adeyemo, 1998; Bordenave, 1976). Farmers reckoned that weed control, fertilizer and information availability or affordability were urgent needs. Providing financial incentives was not regarded as urgent needs per se nor encouraging them to increase production. Majority did not have access to market or market information to sell produce. Results revealed that lack of relevant information access greatly affected income. New innovations are usually expensive, active or passive information acquisition has direct cost as well as opportunity cost (Feder and Slade, 1984). Farmers in developing countries lack access to relevant information. Alphunu and Otoikhian (2008) reported similar results.

Biotechnology Awareness (Equation 2.1)

Biotech awareness level is very low irrespective of educational attainment, gender, occupation or age. This is not unusual since information access is significantly low.

Table 3: Logit regression of factors influencing biotech awareness

X_i (Biotech awareness)	Coefficient	Std. Err	P > |Z|
Constant	-4.322	0.890	0.000
X_1 (Gender)	-1.161	0.563	0.039
X_2 (Higher education)	0.382	1.242	0.758
X_3 (Information access)	-3.873	1.176	0.001
X_4 (Consultation)	-1.782	0.923	0.050
X_5 (News media)	6.847	1.638	0.000
X_6 (Cooperative group)	7.119	2.024	0.000
X_7 (NGOs)	6.302	2.682	0.019
Wald X^2	39.01		
Pseudo R^2	0.7916		
Prob > Chi^2	0.000		
Log likelihood	-38.237		

The goodness of fit for equation 2.1 was measured by Pseudo R^2 of 0.7916 and Wald X^2 of 39.01, by implication, 79.16% predicted the goodness of fit of the variables in the equation with a coefficient constant of -4.322, $p < 0.001$. The effect of gender (X_1) on the model was negative but statistically significant (coefficient -1.161, $p < 0.05$).

Generally, religious inclination often affects women's access to information and other agricultural inputs. In most instances women are disallowed from contact with male EAs. One of the major problems affecting agricultural production in developing countries is lack of relevant and adequate information. The variable X_2 (Information access) was statistically significant with a negative relationship (coefficient -3.873, $p < 0.01$). The lesser the farmers are exposed to relevant and applicable information, the more they will be unaware about the benefits of biotech innovation and subsequently the less enthusiastic they will be on information utilization. Farmers are not often consulted to discuss their constraints and priority need(s) for possible solution. News media served as one of the sources of biotech information. The British Broadcasting Service (BBC) broadcasts program in Hausa language, most farmers possesses small transistor radio. The problem of electricity however affected farmers' ability to have constant access to news media, nonetheless small transistor radios uses battery which also require financial resources. The more farmers have access to news media, the greater their awareness about biotech (coefficient 7.119, $p < 0.001$). In some instances, anti-biotech information is what news media disseminate, this have affected perception regarding the innovation. Membership to cooperative group increased the chances of biotech awareness (coefficient 6.847, $p < 0.001$), 95% belonged to cooperatives. They trust information disseminated through the group as relevant and helpful. The activities of Non-governmental organizations (NGOs) increased the possibility of biotech awareness especially foreign-funded NGOs that are geared towards improved agricultural productivity. The variable 'biotech awareness from EAs'

was dropped from equation 2.1 because it predicted the success of the model perfectly. The variable representing awareness from marketing agents was also dropped from the equation because it predicted the failure perfectly. Farmers are often skeptical about information from marketing agents due to adulterated and low quality inputs. The low awareness of biotech is an indication that the awareness campaign program by NBDA neither properly targeted the relevant stakeholders nor took institutional environments into cognizance. Generally, improved variety, cross breeding and hybrid crops or animals was synonymous with biotech products to many farmers while others indicated knowledge of traditional biotechnology. Despite low awareness level, farmers showed significant interest on biotech products especially if the adoption is capable of overcoming major constraints as well as yield marketable products. Other studies have shown that farmers in developing countries lack relevant information about the actual benefits of agricultural biotech (Oladele and Akinsorotan, 2007; Mnyulwa and Mugwagwa; 2003; Zhong *et al*., 2002), what many farmers know about biotech are often rumor-based. McHughen (2008) noted that this scenario is applicable in developed countries also.

Perception and Feelings about Consultation before Innovation Dissemination

Participation and consultation among stakeholders promote mutual trust, reduce risk and the time required to form opinion regarding message content, since the user will be part of problem identification and the solution mechanism. Conventionally, farmers are not consulted before agricultural innovation dissemination. The importance to which adopters attach to participation and information sharing can be revealed by how they feel during such moments. Only 45% noted they were consulted before an innovation was introduced to them. Incidentally, what they regarded as consultation turned out to be the fortnightly training meetings (FNT). This is not real consultation; it is only an avenue to disseminate information. Regarding adopters' opinion on what effect participation would have on adoption decision, majority (98.7%) noted it will increase the rate of biotechnology adoption. The rest did not care so long as information received addressed their needs. Through a multi-choice approach, 86% observed that they will be happy to participate in determining areas that biotech can address farmers' urgent needs, eighty percent noted that such participation is necessary because it will imply that farmers' opinion about their predicaments and solution pathway mattered a great deal among other stakeholders, 77% observed that such participation will make farmers feel good because their opinion mattered. Only a very few (0.7%) observed that such participation will make no difference in the way biotech innovation is perceived.

Table 4: Logit regression of participation and adopted innovation

X_i (Adopted recommended innovation)	Coefficient	Std. Err	P > |Z|
Constant	-3.513	0.488	0.000
X_1 (Age)	0.541	0.078	0.000
X_2 (Gender)	0.317	0.130	0.015
X_3 (Basic education)	-.039	0.208	0.852
X_4 (Higher education)	-0.140	0.142	0.324
X_5 (Participation)	-0.002	0.002	0.256
X_6 (Happy to participating)	0.413	0.212	0.044
X_7 (Happy my opinion mattered)	0.7765	0.215	0.000
X_8 (Happy my opinion was solicited for)	0.156	0.173	0.368
Wald X^2	70.31		
Pseudo R^2	0.5090		
Prob > Chi^2	0.000		
Log likelihood	-711.280		

Results in Table 4 are a representation of logistic regression analysis on some factors that affected previously 'pushed' innovation. A Pseudo R^2 of 50.90% predicted the goodness of fit for equation 2.2 which was statistically significant (coefficient, -3.513, $p < 0.001$). Gender (X_2) showed a positively statistical significant correlation within the model. Male farmers have more access to extension services and other inputs than the women despite that women's labor contribution to farming activities is higher. Some women cooperative groups flourish in the two state, innovations can be disseminated through such groups. Majority of the adopters obtained one form of education or the other, education affected information assimilation of innovations that require technical knowledge like chemical application, drug and vaccine administration. The positive statistically significant correlation between education and adopted innovation imply that the more people are educated, the more they will understand information content of technical innovations (coefficient 0.317, $p < 0.05$). Generally, farmers would be happy to participate in innovation design and dissemination. Apart from its consequences in elucidating a sense of belonging, participation enhances the understanding of intentions of stakeholders. Ackoff (1965) noted that such is capable of reducing conflict albeit the promotion of positive adoption decision. The variable X_6 had a positive statistical significant effect on the equation, indicating that the more farmers participate in determining what innovation(s) is suitable for them, the higher it will promote positive adoption decision. Several literatures have proved the importance of linkages and

participation between research institutions and adopters (Brenner 1996; Merrill-Sands and Collion, 1994). It is extremely complicated to perfectly predict farmers' urgent needs or predetermined evaluation (PE) without their involvement (Nwankwo, 2010). Hence, the variable X_7 exhibited a highly positive statistical significant effect on the model. Extension agents noted that some innovations that recorded low adoption rate were attributable to incompatible with farmers' needs at the moment. One instance is the yam minisett technology which has been disseminated to farmers since more than ten years. The innovation has recorded low adoption rate especially in Nasarawa State. In order to address farmers' urgent needs (PE) through biotechnology, consultation and information sharing among stakeholders is inevitable. Consultation with adopters does not only reveal their urgent needs (Nwankwo *et al*., 2009a), how they prefer it to be solved, their capacity to manage the innovation, but it significantly bestows on them the competence to manage their affairs sustainably.

Information Authenticity in Adopters' Institutional Environment

Information sources were ranked in order of importance. Results indicated that within farmers' sociocultural institutional environment, consultation presented opportunities to discuss weaknesses, potentials and challenges. Due to inadequate information and the urgent need to proffer solution to farming constraints, farmers often consult with neighbors, cooperative groups, family members, opinion leaders or extension agents. Consultation with family members had an inverse relationship with consultation among opinion leaders, cooperative leaders/members and extension agents. Farmers correctly reckoned the likelihood of family members or neighbors facing similar constraints and hence it is unjustified to consult them for solution to problems. Preferably, they consulted those who are more trained and equipped to proffer solutions. Conversely, consultation with cooperative members and family members were positively related. The more farmers consulted with cooperative members or leaders, the less they consulted with other stakeholders. Farmers reasoned that cooperative leaders represented farmers' interest while EAs represented government interest.

An analysis of whose information farmers' regard as more authentic and trustable among stakeholders (Table 5) indicated that they judged information from cooperative members/leaders as more authentic and trustable than information from marketing officers or NGOs (5.08±.84, 1.20±.57 and 1.95±.62 mean ranking respectively). Information from family members was deemed more trustworthy and reliable compared with information from friends and close relatives. Equally, the third most trusted source of information is EAs (Mean ranking 4.43±1.13).

Table 5: Level of trust on various information sources (n = 1113)

Level of information trust	Mean Ranking
Cooperative members/leaders	5.08±0.84
Family members	4.53±1.36
Friends/close relatives	3.81±0.94
Extension agents	4.43±1.13
Agricultural input marketing officers	1.20±0.57
NGOs	1.95±0.62
χ^2	3.892E3
d.f	5
Kendall's *W*	0.669***

Regarding consultation for solution to problems, results indicated that farmers consulted cooperative leaders/members more than other sources while EAs was the second highest source of consultation. Farmers consulted with EAs because presumably they have been trained to solve agriculturally-related problems. Due to failed promises from government however, farmers are skeptical about information from EAs and other government agencies. Some programs of the ADPs have enabled farmers to accord relative trusts on EAs. Results of the Kendall's test of concordance which measure the level of agreement for ranked variables, revealed a high-level statistical significant coefficient (W 0.699, d.f. 5, $p < 0.01$, 2-tailed,). This illustrated a 69.9% agreement that farmers ascribed consistent level of trust on information sources available to them. Similar results have been obtained elsewhere (Katungi, *et al*., 2007; Asiabaka and Owen, 2002). Disseminating agricultural innovation through stakeholders whose information package is regarded as more authentic and reliable is capable of leading into a positive adoption decision than the contrary. Level of information trust determines rate of information applicability (Lapbim *et al*., 2008). According to adoption theory, awareness is a vital ingredient for the process to commence. Awareness can stem from farmers learning about new innovation and discussing it with neighbors (Rogers, 2003). Such procedure produces phenomenal effect. Arguably, farmers have people whom they consult when faced with problems and stakeholders whose information, advice and admonition are envisaged as more authentic and reliable (Katungi, *et al*., 2007).

Information Sharing and Consultation is Preferred

The awareness campaign executed by NBDA within the six zones was intended to enlighten and broaden understanding of stakeholders concerning the potentials of biotechnology to enable them make 'informed' decisions. Farmers showed willingness to adopt modern biotech products if it addresses urgent needs. However, they expressed concerns on whether biotech can be used to transform monocotyledonous plants and if so, how sustainable will such transformation be, as well as the safeness of the product. Erosion is a major agricultural constraint in the area; farmers are also concerned about whether biotechnology innovation is capable of addressing this menace through the development of crops that can withstand the effect of run-off water or wind. Priority areas and anticipation of what biotechnology can accomplish have been set by the government without consulting farmers to determine their own priority needs. Farmers' priority needs are many although such needs are in preferential order. In order of ranked preferences or payoffs, farmers outlined conditions which are motivational factors for agricultural biotech adoption. Figures in bracket represented the mean ranking (payoff) for each variable.

1. If the product is marketable and capable of income increase (4.57±1.38)
2. If it can increase production more than the current production level (4.09±1.45)
3. If it can lead to overcoming problems which the old practice could not solve (4.17±1.22)
4. If the innovation is affordable and available (3.20±1.34)
5. If the innovation and its product are manageable (3.98±1.32).

These factors are regarded as relative advantage (Rogers, 2003). However, marketability as an attribute of biotech innovation is also the top priority for farmers. The motivation for income increases as an incentive on innovation adoption has been reported in Onweremadu and Matthews-Njoku (2007). The reasons attributed to farmers' skepticism on the adoption of modern biotech or GMOs in some African countries have been linked to marketing problems due to export restriction by some European countries. It is necessary to determine whether the crop targeted for genetic modification is to serve the local or international market as well as whether the consumers are willing to patronize GMOs since farmers' income depend on the sale of their produce.

Conclusion

The debates about the fitness and unfitness of agricultural biotechnology have ignored real issues of economic benefits for intended users, their diverse needs, capacities, social and institutional environments as well as the correct sustainable adoption approach to be employed. If agricultural biotechnology is wrongly targeted to urgent needs of stratified potential adopters, the same fate that forestalled the benefits of the Green Revolution may be witnessed. Adopters ascribe various levels of trust on information sources while awareness about biotechnology was abysmally low. Awareness precedes trial and subsequent adoption. Without it, adoption process cannot commence. Before extension agents can disseminate biotechnology information to farmers, they need to understand how it works and why it works. Nevertheless, knowledge of biotechnology or GMOs is relatively low. In order to understand urgent needs of farmers, a change of institutional approach that will embrace participation and information sharing among stakeholders is required. Participatory innovation development-adoption process approach (PIDAP) through information sharing is mandatory in other to determine users' urgent needs. Such approach is capable of reducing risk perception. Lack of information sharing regarding the intensions of stakeholders increases risk perception. This will obviously affect biotech adoption decision among farmers.

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