Agricultural Innovation in the Volta River Basin:
An Analysis of Changes in Knowledge, Skills and Livelihoods brought about by the Volta Basin Development Challenge

Kalie Lasiter
Anna Tarrant
Emory University
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EXECUTIVE SUMMARY:

Within the agricultural development sector, innovation has been identified as a primary pathway to achieve economic, social and environmental goals. Innovation is traditionally defined as a linear and relatively homogenous process involving the invention of a "new" technology that is then transferred and adopted by an intended user. However, recent definitions of innovation in agricultural development, most notably the Agricultural Innovation Systems (AIS) definition, describe innovation as a systemic process resulting from extensive knowledge networks, interactive learning, and negotiations among a heterogeneous set of actors. One way to create an innovation system (AIS) is through the formation and utilization of certain innovation configurations known as Multistakeholder Platforms (MSPs) and/or Innovation Platforms (IPs). CGIAR's Challenge Programs on Water and Food (CPWF) use both MSPs and IPs to bring together a diverse set of relevant stakeholders to address common challenges in river basins globally, and in the Volta River Basin system in West Africa in particular.

The Challenge Program's Volta Basin Development Challenge Project (VBDC) focuses primarily on strengthening integrated management of rainwater and small reservoirs. The Emory graduate student research team worked in conjunction with the V5: Coordination and Change Project in order to investigate how/if the knowledge produced by V2-V4 projects in two regions in northern Ghana is contributing to innovative changes in villagers' knowledge, skills and livelihood activities.

This particular research is part of a broader Innovation Research Project for V5 that aims to identify the concurrent changes that have also taken place among V2, V3 and V4 project implementers. Specifically, the broader research will identify project researchers' and technicians' definitions of innovation i.e. what they consider innovations as a result of their interactions with project participants. Because agricultural innovation involves change not only at the community level, but at the organizational and institutional levels as well, understanding the motivations and justifications of implementing partners is therefore integral to assessing if and how agricultural innovation has occurred.

Since this particular report is focused solely on the community level, it is difficult to ascertain the extent to which new practices and skills exhibited by community members are truly products of agricultural innovation systems. For the purposes of this report, therefore, innovation

is defined as *any* adoption of “technologies” (i.e. techniques and/or products of project interventions) that have led to changes in villagers’ knowledge, skills and practices. Furthermore, this research assesses not only the changes that have occurred among project participants, but also if/how the same new skills and practices have been learned and adopted by non-participants in order to determine knowledge spread.

Using a snowball sampling strategy, the Emory graduate student research team conducted semi-structured surveys of project participants and nonparticipants in two project sites for a total of 44 surveys. Based on the analysis of these surveys, this study outlines five determinant categories of factors leading to adoption of technologies among both participants and nonparticipants: (1) involvement in a project, (2) access to inputs, (3) access to information, (4) ability to sell products that result from technologies, and (5) risk mediation.

The conclusions of this study can provide valuable insights to organizations like the CPWF VBDC on how to understand and integrate factors that determine technology adoption into future research and programming efforts. In addition, the study’s analysis of agricultural innovation systems will hopefully engage all relevant stakeholders involved in agricultural development strategies in the Volta Basin River System on how to conceptualize, create and implement innovation configurations that not only produce, exchange and use knowledge, but do so for the purpose of enabling systemic and structural change. Without such change, achieving poverty reduction and sustainable natural resources management will remain a challenge.

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LITERATURE REVIEW:
Innovation in Agricultural Development

Within the agricultural development sector innovation has been identified as a primary pathway by which economic, social and environmental goals, such as poverty reduction and sustainable natural resources management, can be achieved. Agricultural innovation strategies are particularly salient in developing countries where agriculture remains foundational to national economies, and sustainable growth in the sector is needed to reduce poverty (Klerkx 2009: 410). Traditional definitions conceptualize innovation as a linear and relatively homogenous process involving the invention of a "new" technology that is then transferred and adopted by an intended user (Klerkx, 2012:459). It assumes that fundamental research is the source of innovation, and "formally organized public extension systems and mass media pass it to farming communities" for adoption, "often ignoring local and indigenous knowledge and practice" (Pant, 2009:116). And while agricultural research has generated several such technologies with high potential, "the impact of the technology on farmers' productivity, livelihood and quality of life have not matched this potential" (Adekunle 2009:v). According to authors Laurens Klerkx, et al., there has therefore been a paradigmatic shift in innovation thinking from the linear approach to innovation to a "systems approach in which innovation is the result of a process of networking, interactive learning and negotiation among a heterogeneous set of actors" (Klerkx 2009:459). This shift to a systems approach has resulted in the recognition that agricultural innovation "is not just about adopting new technologies" but "also requires a balance amongst new technical practices and alternative ways of organizing" (Klerkx 2009:459). This balance must take into consideration soft and hard institutional processes and arrangements such as markets, labor, land tenure, the distribution of benefits (Klerkx 2009:459), power differentials and social hierarchies, and cultural beliefs, values and norms. In the context of contemporary agricultural development, this shift has resulted in understanding and conceptualizing innovation not as an outcome, but rather as a process or system of reflexive learning.

The resulting emergent paradigm is known as Agricultural Innovation Systems (AIS). The World Bank defines Agricultural Innovation Systems as "networks of organisations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organisation into economic use, together with the institutions and policies that affect the way different agents interact, share, access, exchange and use knowledge" (Rajalahtl 2011:3). Klerkx, et al. highlight, however:

> *Although there is much emphasis on knowledge creation, exchange and use in the above definition of AIS, innovation systems need to fulfill several other functions that are essential for innovation. These functions include fostering entrepreneurial drive and activity, vision development, resource mobilisation (e.g., capital), market formation, building legitimacy for change and overcoming resistance to change by means of advocacy and lobbying* (Klerkx 2009:460).

Authors Laxmi Prasad Pant and Helen Hambly-Odame illustrate this need to balance knowledge generation with the other essential innovation functions highlighted by Klerkx, et al. through the example of three types of on-farm trials: researcher planned and implemented trials, researcher planned and farmer implemented trails, and farmer planned and implemented trials. According to the authors:

> *As we move along this continuum of the typology of trials, there is increasing participation of farmers in decision-making and relatively greater opportunity to integrate expert and local ways of learning and experimentation. However most of the on-farm trials are still limited to farmers' participation for material incentive as they participate by providing resources such as land and labor in return for food, cash and other material incentives* (Pant 2009:116).

This example illustrates that simply involving project participants in decision-making processes through knowledge production/sharing is not necessarily a sufficient precursor for innovation *systems*. Instead, project implementers must focus on creating networks of diverse actors beyond the researcher-farmer dichotomy that not only work to generate and integrate local and expert knowledge, but also work to develop a shared vision of change, rearrange and/or establish a supportive institutional and policy environment that includes access to and availability of markets, mobilize the necessary resources to form partnerships and businesses, etc.

One way to create an innovation system (AIS) is through the formation and utilization of certain innovation configurations known as Multistakeholder Platforms (MSPs) and/or Innovation Platforms (IPs) (Klerkx 2012:467). The function of these innovation configurations is to provide a space to discuss and create "shared visions, well-established linkages and information flows amongst different public and private actors, conducive incentives that enhance cooperation, adequate market, legislative and policy environments, and well-developed human capital" (Klerkx 2012:467). CGIAR's Challenge Program on Water and Food (CPWF) uses both MSPs and IPs to bring together the perspectives, knowledge and actions of a diverse set of relevant stakeholders to address a common challenge, for example integrated and sustainable water resources management in river basins around the globe.

BACKGROUND:
Volta Basin Development Challenge and Innovation

The Challenge Program on Water and Food is an international, multi-institutional initiative that aims to "increase the resilience of social and ecological systems through better water management for food production" by developing "water-related innovations to reduce poverty, improve food security, strengthen rural livelihoods, and maintain ecosystems services" (CPWF: 2012). The initiative employs an innovation research and development approach that brings together stakeholders from across a variety of sectors and disciplines, including scientists, policymakers and rural community members, to generate sustainable solutions to equitable water management. The research for development (R4D) methodology goes beyond the traditional role of research that simply generates knowledge, by ensuring that said knowledge is exploited for productive purposes. CPWF therefore uses a theory-of-change approach to identify "pathways by which research is expected to change stakeholders' knowledge, attitude and skills and thus trigger innovation processes ranging from people-to-people spread of technology to institutional and policy change" (CPWF: 2012). At the methodology's foundation is a focus on identifying well-defined development challenges in clearly delineated areas, such as river basins like that of the Volta, in order to create and implement adaptive and contextually appropriate interventions that take into account diverse social, economic and ecological settings (CPWF: 2012).

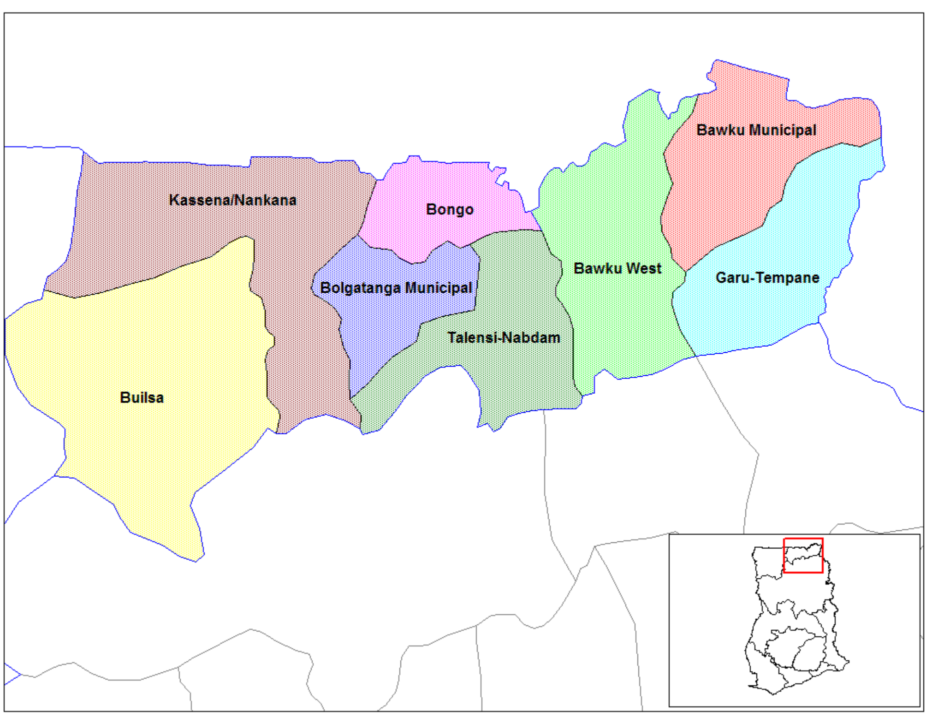
The Volta River Basin is geographically situated across Burkina Faso, Ghana, Benin, Cote d'Ivoire, Mali and Togo. In Ghana, where this particular research was conducted, the Volta River Basin system as a whole constitutes approximately 70% of the nation's available water, and therefore plays a vital role in supplying water for agriculture, industry and household use for a large majority of Ghana's population (Sarpong: 4). Currently there are more than 1,700 small reservoirs spread across northern Ghana and southern Burkina Faso (CPWF: 2012). CPWF's research explores the institutional and technical aspects of small reservoir development and maintenance embedded within a wider rainwater management system for the Volta River Basin system (CPWF: 2012). The Volta Basin Development Challenge (VBDC), CPWF's delineated name for its work in the Volta, focuses primarily on strengthening integrated management of rainwater and small reservoirs so that they can be used equitably and for multiple purposes (CPWF: 2012).

The CPWF VBDC is comprised of five smaller projects – V1, V2, V3, V4 and V5 – each with a specific focus that, when taken together, form an integrated approach to sustainable development. The Emory graduate student research team worked in conjunction with the V5: Coordination and Change Project in order to investigate the ways in which scientific knowledge is produced by V2-V4 project implementers and participants in two regions in northern Ghana, as well as how that knowledge is contributing to innovative changes in project stakeholders' knowledge, skills and livelihood activities.

PROJECT SITE AND STUDY POPULATION

This research was conducted in two regions of northern Ghana: the Upper East Region (UER) and the Upper West Region (UWR):

UPPER EAST REGION



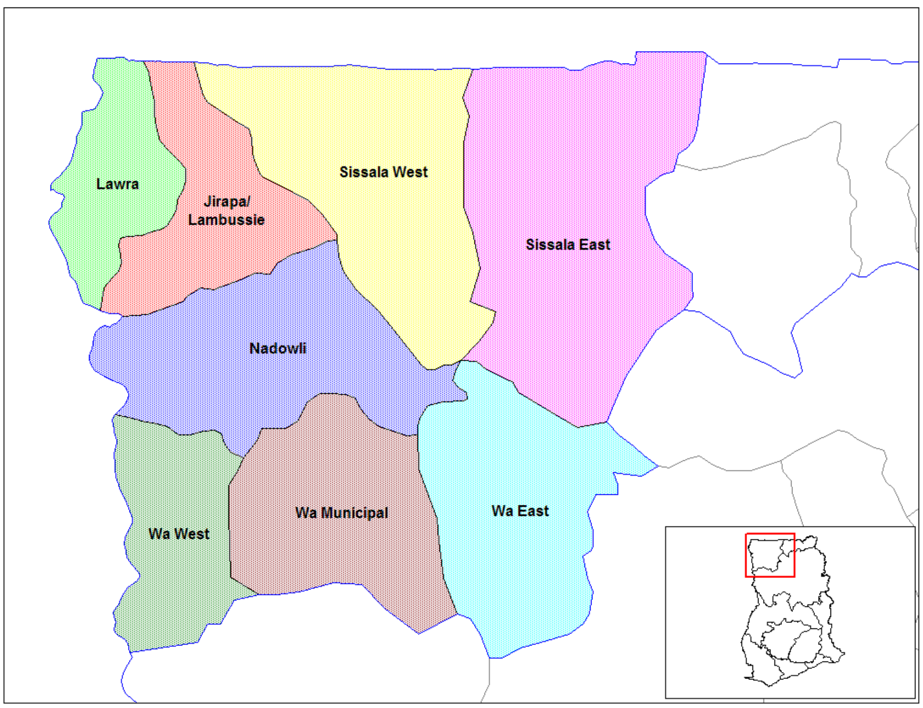
The Upper East is one of the smallest regions in Ghana and constitutes approximately 2.7% of the total land area of the country (Modern Ghana: 2012). According to a recent census, there are currently 920,089 people residing in the Upper East, which is equivalent to less than 5% of the national population (Modern Ghana: 2012). The population of the UER resides primarily in rural areas (84%), making it the least urbanized region in the country (Modern Ghana: 2012). The primary economic activities of those located in the Upper East include agriculture and industry; over 80% of the population is engaged in agricultural activities as their primary means of subsistence (Modern Ghana: 2012). Major agricultural outputs for both the UER and the UWR include maize, sorghum, millet and rice during the rainy season, and garden vegetables such as okra, pepper, tomatoes and onions during the dry season. The rainy season lasts from approximately May/June to September/October, and the dry season from November to mid-February.

The UER, bordered by Burkina Faso to the north and Togo to the east, is divided into ten administrative districts, including Bawku West District. Binaba, where this research was conducted, is a large market town in Bawku West that lies between two reservoirs; the largest of the two reservoirs - Binaba Dam - lies on the northeast edge of town and is part of both the V3: Management of Small Reservoirs Project, and the V4: Governance of Rainwater and Small Reservoirs Project.

The V4 Project, led by the International Water Management Institute (IWMI) in partnership with CIRAD and the Water Resources Commission (WRC), focuses on the sub-basin/watershed level which spans multiple districts within the Upper East. V4 partners facilitate Multistakeholder Platforms comprised of representatives from the community, including farmers and local leaders (chiefs), as well as district and regional-level government officials. The purpose of the MSP is to bring together a diverse set of stakeholders to discuss and identify innovative and socially acceptable district and regional-level policies related to land and water governance.

The V3 Project, on the other hand, focuses on the smaller reservoir level. The objective of V3 is to develop integrated reservoir management strategies, including conducting seed production trials in irrigated fields downstream of the dam where project participants grow rice in the rainy season and cultivate gardens (primarily onions) during the dry season. Led by CIRAD in partnership with the Ghanaian Savannah Agricultural Research Institute (SARI) and the Ministry of Farming and Agriculture (MOFA), project participants cultivate new and improved varieties of rice and onion seeds that are more appropriate for Binaba's soil and climate, produce higher yields for sale and consumption, and have better qualities such as taste, size, etc. V3 is the only project that does not host either an MSP or IP (at least it is not identified as such by project implementers) but instead hosts "meetings" at the Binaba Dam. Unfortunately, we were not able to ascertain whether these meetings are supposed to represent an innovation configuration similar to MSPs and/or IPs, or the more traditional "on-farm trial" common in agricultural development.

UPPER WEST REGION



The Upper West Region is larger than the Upper East in terms of land size, but has a smaller population, a lower population density, and fewer District Assemblies than its Eastern counterpart (Modern Ghana: 2012). 17.5% of the region's total population lives in urban localities, making it the second least urbanized region after the Upper East (Modern Ghana: 2012). The primary economic activity of those residing in the Upper West is peasant farming; 72% of the population is engaged in agricultural activities, including rearing livestock (Modern Ghana: 2012). The UWR is likewise divided into districts, including Lawra District in the north-westernmost corner of the country. Orbilli and Nabrunye are two villages in Lawra District involved in the V2: Integrated Management of Rainwater for Crop-Livestock Integration Agroecosystems Project.

The V2 Project focuses on increasing crop and livestock productivity at the household level in order to enhance participant livelihoods. The Project works to strengthen institutional capacities and improve equitable and gender-sensitive performance of crop and livestock value chains. Specifically, the International Livestock Research Institute (ILRI), in partnership with the Ghanaian Animal Research Institute (ARI), works with farmers to test new ways of cultivating crops, including using two different rainwater harvesting techniques and intercropping maize and soybeans. V2 also works to integrate livestock rearing and cultivation, which includes housing the animals, using collected manure on fields for fertilizer, and storing crop residues for livestock fodder. The V2 farmers are also involved in Innovation Platforms (IPs). These IPs are multistakeholder dialogues that concentrate on bringing together the various actors involved in local value chains for specific agricultural commodities such as maize (producers, processors, traders, sellers, etc.) in order to identify innovative ways of enhancing the performance of said value chains.

RESEARCH

OBJECTIVE:

The primary objective of this research, therefore, is to determine how the aforementioned interventions of the V2, V3 and V4 Projects have changed the knowledge, skills and livelihood practices of local stakeholders. This research will assess not only the changes that have occurred among project participants, but will also investigate if/how the same new skills and practices have been adopted by non-participants in order to determine potential knowledge spread.

This particular research is part of a broader Innovation Research Project for V5 that aims to identify the concurrent changes that have also taken place among V2, V3 and V4 project implementers. Specifically, the broader research will identify project researchers' and technicians' definitions of innovation i.e. what they consider innovations as a result of their interactions with project participants. As previously mentioned, agricultural innovation is a systemic process that involves change not only at the community level but at the organizational and institutional levels as well. Understanding the motivations and justifications of implementing partners is therefore integral to assessing if and how agricultural innovation has occurred.

Since this particular report is focused solely on the community level, it is difficult to ascertain the extent to which new practices and skills exhibited by community members are truly products of agricultural innovation systems. For the purposes of this report, therefore, innovation is defined as *any* adoption of techniques and/or products of project interventions (i.e. "technologies") that have led to changes in villagers' knowledge, skills and practices. The analysis of project participants presented in this report will consequently be limited to determinant factors affecting said adoption. This analysis, coupled with the separate V5 analysis of project implementers' experiences, will shed light on how agricultural innovations emerge across people, place and time, and how those innovations can potentially contribute to sustainable natural resources management and equitable agricultural development.

RESEARCH QUESTIONS:

There are two overarching questions that this research will address:

1. What changes in knowledge, skills and practices do project participants and their neighbors report as a result of participating in the Volta Basin Development Challenge?
2. Can we typify or characterize an "innovator" based on farmers' adoptions and/or adaptations of new technologies?

METHODS:

This research was conducted over a seven-week period between May and July of 2013. The Emory graduate student research team conducted semi-structured surveys of project participants and nonparticipants in the two project sites: 10 participants (3 female, 7 male) and 9 nonparticipants (6 female, 3 male) in the Upper East, and 20 participants (8 female, 12 male) and 5 nonparticipants (3 female, 2 male) in the Upper West, for a total of 44 surveys. A snowball sampling methodology was used which consisted of identifying key project participants who were able to provide us with the contact information for the remaining project participants in each project site. During each of these project participant interviews, we probed to identify other information rich neighbors, kin, and/or value-chains members (traders, processes, etc.) relevant to the objective and scope of the research.

DATA ANLYSIS and RESULTS

REPORTED CHANGES:

Participants listed a variety of ways that project interventions had resulted in changes in their livelihoods. A comprehensive list is included in Appendix 1. Below we outline the major change that each V Project has affected:

V2: tied ridges

V3: onion and rice seed trials

V4: prohibition of riverbank cultivation and bush burning

In the section below, we refer to the changes that each project has promoted as "technologies" for lack of a better word. By this, we mean the activities, innovations and new practices outlined above that the projects have promoted while simultaneously carrying out their research.

THE PROFILE OF AN INNOVATOR:

Overwhelmingly, project participants discuss innovation more in terms of linear adoption than as a system of processes. This does not mean that the AIS approach is not relevant, only that villagers do not conceptualize innovation in this manner. Villagers assess innovation as dichotomous - they either did adopt a practice, or they did not. The factors underlying their decision and ability to adopt a new technology takes into account the processes, actors, and alternative ways of organizing that are typical of the AIS approach.

The most determinant factor in terms of technology adoption is whether individuals were project participants. What it means to be a project participant varies from project to project and site to site, but vaguely it means that they attend MSPs, IPs or other meetings with their peers and experts who may be agricultural extension agents, researchers or local NGO employees, and they participate in the activities that these meetings are promoting. Overwhelmingly, participants report a much higher adoption rate than nonparticipants. They have access to the necessary information and inputs, and there is very little occurrence of resisting project initiatives, possibly because of the benefits that have been associated with being model participants in the past (increased social capital, food aid, and inputs like fertilizer and seeds). People generally do what they are told to do. Access to the project itself is the most determinant factor – there is limited spread of practices into the wider community. Our analysis outlines four other factors that determine adoption in an attempt to explain why being a project participant makes adoption more likely. We divide these factors into four categories: (1) access to inputs (2) access to information (3) ability to sell products that result from technologies, and (4) risk mediation. We would also like to note here that it is much too early to expect to see a great deal of nonparticipant adoption, but that the spread of project interventions should be expected in the future. This analysis should offer insight into the profile of a typical adopter and as a result should contribute to predicting the future impact of the VBDC.

1. Access to Inputs

The most important input in determining adoption is whether individuals have access to appropriate land. In V3, participating in rice and onion trials necessitates owning or having access to land that is irrigated by the Binaba Reservoir. At the site where our research was conducted, land was distributed to people who provided labor for the reservoir's construction in the 1970s. Land is then transferable to kin when the original owner dies, and there are instances of the land being rented or loaned out to other people. However, this land tenure system obviously varies from community to community. Furthermore, there is confusion among non-owners about how exactly people came to occupy the land – some reported that people owned land simply because their family compounds were located near the area. Because our research was not a quantitative study using statistical sampling techniques we cannot be certain, but it seemed that the people who had access to land irrigated by the reservoir were relatively wealthier and had a higher degree of social connectivity than those who did not. Importantly, having access to this land was a prerequisite for becoming a project participant. If this last statement is true, then the project selected against people who were poorer and less socially connected. It is unclear whether this was done by local implementing partners intentionally or not, but the implications of this type of selection are extremely important and were hopefully considered in the design.

Other inputs that facilitate adoption include fertilizer, pesticides, seeds, livestock such as ducks and geese and free livestock vaccinations. The project also facilitates the pooling of labor when necessary. In part, participants join projects because they expect that they will be given access to these inputs, whether through loans, outright giving (including food for work), or facilitation. Non-participants do not adopt project interventions because they often do not have the same type of access. Improved seed varieties were unavailable in the markets of the towns where trials were being conducted. In one case this was because the implementing partners had specifically told participants to retain the seeds. Participants did not fully understand why this was necessary. Again, in theory the seeds will be available in the future as participants sell excess in the markets. Aside from availability, however, community members reported that they would not be able to afford to buy these inputs without the project's help. Participants and non-participants alike reported that these inputs were vital in adopting new techniques, and without them they would not adopt.

There were also inputs that the project did not provide that would help encourage adoption. In multiple sites, participants reported that they needed fencing to deter livestock from destroying crops. There were also non-participants who reported that they did not have oxen or plows and therefore could not adopt project interventions like improved seed varieties. Community members also reported that time was an important input that affected adoption. People who have alternative activities to do in the dry season often choose these activities over project intervention activities without knowing which is more profitable. In some cases they give the land to other household members to use. For example, fishermen in Binaba give their land out to female family members to grow onions during the dry season while they fish. Fishing rights are regulated by a set of community agreements, including a 5 cedi (about $2.50) fee to be able to fish in the reservoir.

Lastly, most project interventions are dependent on the availability of water and irrigation from small reservoirs. It is necessary to have systems in place to repair reservoirs when they malfunction. At the Binaba dam, an association of onion growers joins together to repair the dam, and the fishermen's association contributes financially. These types of inter-community relationships determine whether adoption is even possible and may not be feasible in communities where there is a high level of conflict or tension.

2. Access to Information

Access to information also plays a significant role in determining adoption. Interviewees frequently cited education as a reason why individuals adopt the “new methods of farming.” The research does not support this explanation. While project leaders were more likely to have completed some secondary school, project participants and nonparticipants had various levels of education. The same is true of age - interviewees thought that younger people were more likely to adopt new methods, but there were many older project participants who adopted interventions, and many younger nonparticipants who did not adopt interventions.

Prior research has taken gender into account when assessing access to information. The relationship between gender and adoption in these communities is not direct; projects intentionally chose females to participate in order to meet a sort of quota. Female participants stated that they did not know why they were chosen, other than that they were women and having women in the group was a requirement; "they just chose me. They needed a female to be a part of the group." A separate paper could perform a gender analysis on how gender and adoption are related, which would be very informative and useful to the wider R4D Community. There were differences in types and extents of participation between women and men as well as differences in decision-making power and methods of information dispersion. Here, we will simply note that there were no blatantly obvious barriers to adoption that women experienced precisely because the projects were so inclusive of women.

The degree to which other organizations and people are spreading information about the same technologies also positively influences adoption. Traditional leaders (chiefs), NGOs, other research organizations and agricultural extension agents all fill this role. Community members do not differentiate between projects or organizations. They may know the individuals who lead meetings by name, but they generally do not know which organization they are affiliated with, with the exception of their assigned extension agent. This may serve to reinforce ideas, but also implies that projects should be working together to reduce duplication and ensure that messaging is clear.

Equally important is having a "community champion" to represent the project. Precisely because projects are viewed as transitory and impermanent, we expect adoption rates to be higher in communities where there is a leader who is dedicated to the project and enjoys a high standing within the community. Of course, being selected to be a group leader in and of itself contributes to an individual's social capital. In one of the communities, the farmers' leader seemed to be more active in promoting information dissemination and encouraging participants. Having completed secondary school and training as an auto-mechanic, he was very well educated which may have given him an advantage in terms of understanding meeting proceedings conducted in English. He held meetings not only with project participants, but also taught non-participants individually and held meetings for the entire community. Nonparticipants in this area generally knew about the project's activities and the "new method of farming."

Similarly, if not an actual project participant, individuals with a close relative or friend knew more about new technologies than did those without. Information about technologies is dispersed in a variety of ways, including at local drinking spots where beer and pito are consumed, in visiting other communities to make marriage arrangements, in farmers' associations, and in formal meetings, often held before church or other major community events. Notably, most of this space is male-dominated, implying that women probably have alternative channels for consuming information. The project must take these channels into account if women and men are to adopt at similar rates. Women's savings and loans groups are prevalent, and this may be one source of entrée.

Individuals who have some kind of motivation to need cash are also more likely to adopt. Examples we saw include needing to pay children's school fees, wanting to move out of the extended family compound and needing money to construct a house, and not having to migrate south for labor, enabling men to stay at home and look after livestock.

3. Ability to Sell Products

Participants and nonparticipants alike stressed that they needed demand for the products of technologies in order to adopt. In the case of the onion trials, there was concern that the market would be flooded, a legitimate concern especially if nonparticipants began adopting the new higher-yielding variety of onions as well. Physical market access was generally not a concern – the communities where we worked were within geographic proximity to a market. At these local markets, women generally sell to a wholesaler, or a middle-man comes to their own farm and buys produce in bulk to sell to a wholesaler who then takes the product to Tamale or Kumasi. The problem, however, was ensuring that demand was high enough for the new variety.

The ability to store products while waiting to sell at a high-enough price is dependent on storage facilities. While another project was operating in one of the communities to build storage houses for farmers, wholesalers also need to be able to store onions to avoid rotting.

4. Risk Mitigation

In some cases, individuals did not adopt technologies because they perceived them as too risky. To mediate this risk, people would perform experiments, such as sowing new seed varieties on half of the land and traditional varieties on the other half and then comparing yields. Record keeping may help mitigate this problem by showing evidence of how much money was spent to adopt the technology versus how much was gained as a result of selling the products. Record keeping is not currently a prevalent practice.

Aside from education, participants do not actually list any of these practices as determinants of adoption. They instead explain non-adoption as laziness - lazy farmers are not chosen to be participants in the project. As one farmer explained, “for a project that comes to do farming work, MOFA (the agricultural extension agents) know all the farmers in the community. They will not select lazy farmers who will do the work up to a point and then stop. MOFA knows the serious farmers who they can push, and those are the ones who represent the district.”

As a caveat, it is important to note that most of the above observations are true only of V2 and V3. It is difficult to assess adoption or innovation as a result of V4 activities because the project participants were not the intended users of information. V4 was attempting to develop innovative ways to reduce bush burning and riverbank cultivation as representative of other farming practices, but the participants in the project did not actually practice bush burning or riverbank cultivation. While information may spread from participants to the intended users in the future, it is not currently possible to assess the impact.

CONCLUSION

In summary, the most critical factor affecting technology adoption was whether or not a community member was a project participant. While this may seem like an obvious conclusion, the implications for agricultural innovation systems are important. As previously defined, project participants are those villagers who attend MSPs, IPs, or other types of meetings with their peers, hosted by “experts” i.e. agricultural extension agents, researchers and/or local NGO employees. These meetings - whether explicitly labeled as MSPs/IPs like in the V2 and V4 project sites, or simply labeled as “meetings” like in the V3 project site - become spaces through which agricultural innovation can occur. However, in order for this to happen, these “innovation configurations" must be appropriately designed and function beyond the traditional role of simple knowledge creation, exchange and use. These configurations must also include an explicit and deliberate focus on creating "shared visions, well-established linkages and information flows amongst the different public and private actors, conducive incentives that enhance cooperation, adequate market, legislative and policy environments, and well-developed human capital" [12]. In other words, innovation platforms must go beyond simple knowledge exchange - even if that knowledge exchange includes valuing and integrating indigenous knowledge - but instead exchange knowledge for the purpose of helping participants exercise agency to bring about broader institutional and policy change (Klerkx 2012:467).

While we do not have the primary data to support whether or not V2's IPs and V4's MSPs (1) were truly considered "innovation configurations" per the definition in the AIS literature, and (2) directly contributed to creating more enabling environments, and therefore contributed to technology adoption, the literature on AIS supports the assertion that when designed appropriately, innovation configurations can become integral vehicles through which to achieve agricultural innovation.

We can confidently assert based on our primary data, however, that those villagers who attended meetings, and were thus considered project participants, had an overwhelmingly higher adoption rate than nonparticipants. The four other factors that shed light onto why being a project participant makes adoption more likely - access to inputs, access to information, ability to sell products that result from technologies, and risk mitigation - highlight an important tension in project design and implementation; the probability versus ability of community members to adopt project interventions.

The dissemination of knowledge from project implementers to project participants is only one factor that enabled participants to adopt and use project technologies. Without the additional four factors, however, it is unlikely that project participants would have been able to do so. Addressing socioeconomic and political factors like land ownership, social capital and market demand are part and parcel of identifying and creating the enabling environments that are necessary for agricultural innovation to occur. Project participants were more successful at technology adoption not just because they received new knowledge about the technologies from project implementers, but because they were supported, either intentionally or unintentionally, with things like increased access to certain goods and services, information, etc.

Based on this analysis, while it is likely that the knowledge produced by each project will continue to be disseminated to the broader nonparticipant community, thereby increasing the *probability* of technology adoption among nonparticipants, their actual *ability* to adopt those technologies remains relatively low due to the lack of a supporting systems, goods, services, infrastructures, institutions, and policies (and most poignantly a lack of available fertile and irrigated land and access to agricultural inputs). Therefore, in order for technologies to be adopted within the broader landscape, knowledge dissemination in and of itself is not a sufficient precursor for adoption, and should be coupled with the creation of enabling institutional and policy environments - from policies such as land redistribution to increasing market demand for certain products such as onions - in order to increase both the probability and actual ability of people to adopt interventions.

The conclusions of this study can provide valuable insights to organizations like the CPWF VBDC on how to understand and integrate factors that determine technology adoption into future research and programming efforts. In addition, the study's analysis of agricultural innovation systems will hopefully engage all relevant stakeholders involved in agricultural development strategies in the Volta Basin River System on how to conceptualize, create and implement innovation configurations that not only produce, exchange and use knowledge, but do so for the purpose of enabling systemic and structural change. Without such change, achieving poverty reduction and sustainable natural resources management will remain a challenge.

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APPENDIX

Appendix 1: New Practices Described in Interviews, by Project Area

Project	Practice
V2	Tied and regular ridges that trap rainwater and prevent erosion
V2	Technique for sowing maize in lines using a rope
V2	Ventilating livestock pens, building larger pens, cleaning pens more frequently
V2	Livestock vaccinations, free for project participants
V2	Mixing manure with inorganic fertilizer
V2	Using crop residue as fodder
V2	Composting (only new in some cases)
V2	Intercropping maize and soybeans
V2	Water pits to collect water for livestock
V2	Recording expenditures and budgeting
V2	Linking with market women (only the farmers' group leader mentioned this)
V3	Onion storage houses with raised racks
V3	Transplanting technique for rice
V3	Composting
V3	Improved varieties of rice and onions
V3	Technique for planting maize in rows and sowing only one seed per hole
V3	Waiting until market is high to sell
V3	Unity and conflict mediation
V4	Eliminating riverbank cultivation
V4	Eliminating bush burning