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Smallholder Irrigation Technology Diffusion in Ghana
Insights from Stakeholder Mapping

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Abstract

Irrigated agriculture can support food and nutrition security, increase rural employment and incomes and can act as a buffer against growing climate variability and change. However, irrigation development has been slow in Africa south of the Sahara and Ghana is no exception. Out of a total potential irrigated area of close to 2 million ha, less than 20,000 ha large-scale irrigation and less than 200,000 ha of small-scale irrigation have been developed; but the latter is only an estimate. To identify entry points for accelerating small-scale irrigation development in Ghana, a national and a regional stakeholder Net-Map workshop were held in Accra and Tamale, respectively. The workshops suggest that a wide variety of actors from government, the private sector, international organizations and funders, research organizations and NGOs are involved in the diffusion of small-scale irrigation technologies. However, there are important differences between actors perceived to be key at the national and at the regional levels in northern Ghana. At the national level, diffusion of small-scale irrigation technologies is considered to be largely influenced by the Ghana Irrigation Development Authority together with a series of private sector actors focused on importation, distribution and financing of technologies. Farmers are considered to have no influence over the diffusion of small-scale irrigation, suggesting that small-scale irrigation is largely considered a supply-driven process. In northern Ghana, on the other hand, farmers are considered to be key influencers, although participants noted that much of this was potential influence, together with a larger and more diversified set of government stakeholders that are seen as regulators and possibly gatekeepers. For irrigation diffusion to successfully move from importation to distribution to benefiting smallholder farmers, all of these actors have to come together to better understand farmers' needs and challenges. A multi-stakeholder platform could help to increase communication between farmers as the ultimate beneficiaries of small-scale irrigation technologies and the many other actors interested in supporting this process.

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Abbreviations and Acronyms

ACDEP	Association of Church-based Development NGOs
AfDB	African Development Bank
AGRI_BUSINESSES	Agribusiness
CAREINT	Care International
CEPS	Customs Excise and Preventive Service
CGIAR	Consultative Group for International Agricultural Research
CIAT	International Center for Tropical Agriculture
CIKOD	Centre for Indigenous Knowledge and Organizational Development
CIP	International Potato Center
CWSA	Community Water and Sanitation Agency
DANIDA	Danish International Development Agency
DFID	Department for International Development
DEV_FIN_CORP	US Government International Development Finance Corporation
ECG	Electricity Company of Ghana
ENERGY_COMM	Energy Commission
EPA	Environmental Protection Agency
EU	European Commission
FAO	Food and Agriculture Organization of the United Nations
GCAP	Ghana Commercial Agriculture Project
GHANAREVAUTH	Ghana Revenue Authority
GHANASTANDAATH	Ghana Standard Authority
GIDA	Ghana Irrigation Development Authority
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GOG	Government of Ghana
iDE	International Development Enterprises
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILSSI	Innovation Laboratory for Small-Scale Irrigation
IRRIGSUPPLIERS	Irrigation suppliers
IWAD	Integrated Water & Agricultural Development
IWMI	International Water Management Institute
MADE	Market Development Programme for Northern Ghana
MESTI	Ministry of Environment, Science and Technology
MoENERGY	Ministry of Energy,
MoFA	Ministry of Food and Agriculture
MoWATER	Ministry of Water
NEDCO	Northern Electricity Distribution Company
NGOs	Non-governmental organizations
NDA	Northern Development Authority
ORGS	Organizations
PAOP	Power Africa Off-Grid Project
PFJ	Planting for Food and Jobs

PUBLIC_UTI_REG	Public Utility Regulatory
RCC	Regional Coordinating Council
RURALDEVELOPFUND	Rural Development Fund
SADA	Savanna Agricultural Development Authority
SAPIP	Sustainable Agriculture Productivity Improvement Project
SARI	Savanna Agricultural Research Institute
SSI	Small-scale irrigation
SSIT	Small-scale irrigation technologies
Tradleaders	Traditional leaders
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
US	United States
WASH	Water, Sanitation and Hygiene
WRC	Water Resources Commission

Introduction

The contribution of irrigation to food security has been essential, generating 40 percent of global food production on just under a third of the world's harvested land. The role of irrigation will likely increase as a result of growing climate variability and climate change, which renders rainfed food production increasingly risky (Rosegrant et al. 2009; Ringler 2017). Irrigated agriculture supports food production in dry seasons and in areas that receive too little rainfall to grow food and increasingly supplements rainfall in areas with growing uncertainty of rainfall events. In addition, it also supports employment, incomes and nutrition security (Mendes et al. 2014). Compared to other regions in the world, irrigation development has been slow in Africa south of the Sahara, which accounted for only 2.6 percent of global irrigated harvested area in 2010 (Ringler 2017).

During the 1960s to 1990s, most irrigation development was through large, publicly funded systems, often linked to reservoir development. Much of this development was concentrated in Asia where rice (and sometimes wheat) are the main staple crops. Very little investment went into large-scale irrigation in Africa south of the Sahara, in line with low overall investment in agriculture in the region, larger land frontiers and a focus on less water-intensive staple crops.

However, as a result of technological innovation, including the availability of affordable, individual pump sets and cheaper well-drilling technology since the 1980s, the number of individual smallholder irrigators quickly increased. Small-scale irrigation, developed by individual farmers or small groups of farmers took off particularly in Asia, where landholdings are small and some countries provide subsidized or free electricity to agriculture (Shah 2015). The sustainable potential for small-scale irrigation is also considerable in Africa south of the Sahara: Xie et al. (2014) estimate a total potential of 30 million hectares using motor pumps directly purchased and operated by individual farmers. To date, only a small share of potential irrigated area has been developed.

The literature on irrigation in Ghana describes a series of challenges faced by farmers who want to take up irrigation as well as by technology suppliers. Challenges for accessing and using small-scale irrigation technologies include a lack of financial services for the purchase of irrigation technologies and the continued high cost of many irrigation technologies. Other challenges include a lack of accessible water resources, complex land rights systems, a lack of input and output markets, weak farmer organizations, and a lack of extension on irrigation technologies (Namara et al. 2011; FAO and IFC 2014). The majority of small-scale irrigators belong to the richest income quintile of the farming population (Namara et al. 2014). Challenges on the supply side include lack of a suitable technology distribution network, lack of repair services and high levels of bureaucracy associated with technology imports. Other barriers include insufficient demand for the technology, and lack of offers combining technology sales with financing models, such as pay-as-you-go services, making it challenging for farmers to acquire motor pumps and other advanced technologies (FAO and IFC 2014).

Moreover, both farmers and technology suppliers are affected by a weak enabling environment. Ghana's land tenure system is highly complex, and lack of secure tenure reduces farmers' incentives to invest in costly technologies, that take more than a single season to recuperate (Ayamga et al. 2016). Similarly, Ghana does not have a strong system for accessing credit in rural areas. Finally, government plans—while acknowledging small-scale irrigation—continue to focus on large-scale, public irrigation investment in national strategies (Namara et al. 2011).

Xie et al. (2014) estimates a total potential of 1 million hectares of small-scale irrigation in Ghana, generating US\$0.9 billion a year and benefitting 5 million rural people. FAO AQUASTAT estimates a total irrigation potential of 1.9 million hectares for the country, but only 34,000 hectares of this area had been developed (FAO and IFC 2014). Other studies suggest that small-scale irrigation already covers a larger area. Namara et al. (2013) suggest that small-scale irrigated area in Ghana covers already 186,000 ha benefitting 0.5 million people compared to large-scale irrigated area of 13,000 ha benefitting just 11,000 farmers. Finally, Namara et al. (2014) note that more than 65,000 pumps valued at US\$ 8 million had been imported into Ghana during 2003-2010.

To better understand how smallholder irrigation use can be strengthened in Ghana, two stakeholder workshops were carried out by the International Food Policy Research Institute (IFPRI) and the International Water Management Institute (IWMI) under the Innovation Laboratory for Small-Scale Irrigation (ILSSI) supported by USAID, applying the Net-Map method.

This paper analyzed the outcomes of those workshops to identify entry points to strengthen scaling and diffusion of smallholder irrigation technologies. Two group interviews/workshops were undertaken: one at the national level with a focus on national policy and networks, and one at the regional level focusing on the same in the Northern Region of Ghana. The following sections describe the Net-Map process, followed by results broken into two parts: first national-level results and second regional-level results. The paper concludes with insights on how to strengthen diffusion of small-scale irrigation in Ghana at the national and regional levels.

Methodology

To understand diffusion of small-scale irrigation technologies, the paper applied the Net-Map method (Schiffer, 2007; Schiffer & Waale, 2008). Net-Map combines stakeholder mapping, power and influence mapping and social network analysis (Schiffer, 2007; Schiffer & Waale, 2008). For this activity, it helped stakeholders to identify actors, discuss their involvement, visualize how actors are connected to each other, and consider the influence the actors have in relation to the diffusion of small-scale irrigation technologies in Ghana.

Net-Map permits stakeholders to understand not only formal but also informal interactions and helps to identify linkages that could be strengthened. It was applied in a group setting, which allowed stakeholders to exchange ideas and share information, facilitating a consensus view of the network and potentially supporting future coordination among participants. Visualization of networks during the workshop allows for a participatory rather than extractive process, wherein the complexity of the network can be viewed and analyzed by participants.

This paper presents the results from two stakeholder workshops, focused on: 1) identifying the actors who are involved in the diffusion of small-scale irrigation technologies (SSIT) in Ghana; 2) how these stakeholders interact with each other; and 3) the power/influence actors are perceived to have in the diffusion of SSIT. The first workshop was conducted in Accra on March 9, 2020, and the second, regional-level event, in Tamale on March 10, 2020.

Participant selection

Project partners from the first phase of the ILSSI project were asked to suggest key stakeholders at the national and regional levels who are involved in and knowledgeable about SSIT policy and programs, with a focus on representing diverse roles and perspectives, that is considering government, donors, private sector, NGOs, and research organizations related to small-scale irrigation in Ghana. A list of participants covering these categories was identified and contacted. Attempts were made to invite participants from all five categories of stakeholders. At the national level, eight stakeholder institution representatives participated in the workshop while fifteen regional stakeholder representatives related to SSIT programs and projects participated in the regional event. Details of participants are listed in appendix 2. Unfortunately, no private sector representative was available to participate, although other participants were able to provide insights related to private sector activities.

Net-Map process

The Net-Map approach involved guiding the participants through a set of questions about the network and documenting their responses on a large piece of paper. Participants were first presented with the guiding question for the Net-Map workshop: *“Who influences the diffusion of improved small-scale irrigation technologies at the national [regional] levels?”* Then they were asked to list the actor categories and associated actors that are relevant to the guiding question. Actor categories listed were: government, international organizations, non-governmental organizations, private sector, and research. Thereafter, participants were asked to *identify how these actors were linked*. Participants identified key interactions in the network—formal authority or oversight, funding or financing, technical advice, and advocacy—and drew color-coded arrows between actors to specify links between actors.

In the third stage, participants were asked how influential each of the listed actors were in the diffusion of SSIT. In response to this question, participants assigned influence scores to the listed actors in the network by stacking checkers. The scores ranged from 0 -no influence, to 5 -very high influence. The scores represented the perceived ability of actors to influence the diffusion of improved SSIT.

Finally, participants shared their knowledge on challenges and opportunities for enhancing the diffusion of SSIT. Details of the interview guide can be found in appendix 1.

The analysis was completed using the social network analysis software VisuaLyzer version 2.2 (Medical Decision Logic Inc, 2014). The network structures from the national and regional meetings were examined to determine the extent of centralization—or a tendency for most actors to be linked to only a single or small number of actors. Other network characteristics were examined, including identification of clusters (groups of actors that are linked to each other), brokers (actors who, if removed, will lead to a disconnect in the network), network diameter (longest distance between the two most distant actors), and core-periphery actors (defining a combination of a limited number of highly centralized actors and a series of loosely connected actors at the periphery). Actor centrality measures were also examined, including degree centrality (the number of ties an actor has), closeness centrality (the steps an actor must take to reach all other actors in the network), and betweenness centrality (a measurement of how often an actor appears on the shortest paths between other actors in the network). The influence of the different types of actors was also examined based on the perception of participants.

National-level stakeholder network results

Figure 1 depicts key national-level actors in the diffusion of SSIT. The national network has 28 actors or groups of actors and 51 links for formal authority, advice, technical information and advocacy. The national network mediating the diffusion of SSIT suggests a high level of centralization (with a centralization degree of 93 percent) around four types of core actors: the Ministry of Food and Agriculture's Ghana Irrigation Development Authority (MoFA_GIDA), the agri-business sector, importers and distributors, and farmers. These four core actors or group of actors are loosely linked to a series of peripheral actors. The national-level network suggests that the public and private sector are closely interacting with both being key central players.

Table 1 provides a complete list of the actors included in the network, the actor category, and their full name or names (when an actor is an aggregate of multiple actors).

The network diameter, describing the largest distance between two actors is 7, and the average distance is 3.18. The network density, which describes the proportion of actual links or connections in a network, is calculated at 0.11. If all actors were connected, the density would have been 1. The low value for network density suggests sparse connections across actors in the national network.

Actor influence over SSIT dissemination

Actors in Figure 1 are sized by their influence over the diffusion of SSIT based on the perceptions of the participants in the net-map workshop. Actors are listed by influence score in Table 2. The Ministry of Food and Agriculture (MOFA), and particularly its Irrigation Development Authority (GIDA) was identified as having the highest influence score—and was the only actor with a score of 5. While the influence of GIDA was considered to be highest, workshop participants noted that this was in part, potential influence in that MOFA_GIDA currently provides technical advice but was known to have the intention to broaden its oversight role over a broader range of irrigation actors. Irrespective of the breadth of GIDA's role, MoFA plays a critical role in policy development with the power to support or constrain irrigation activities.

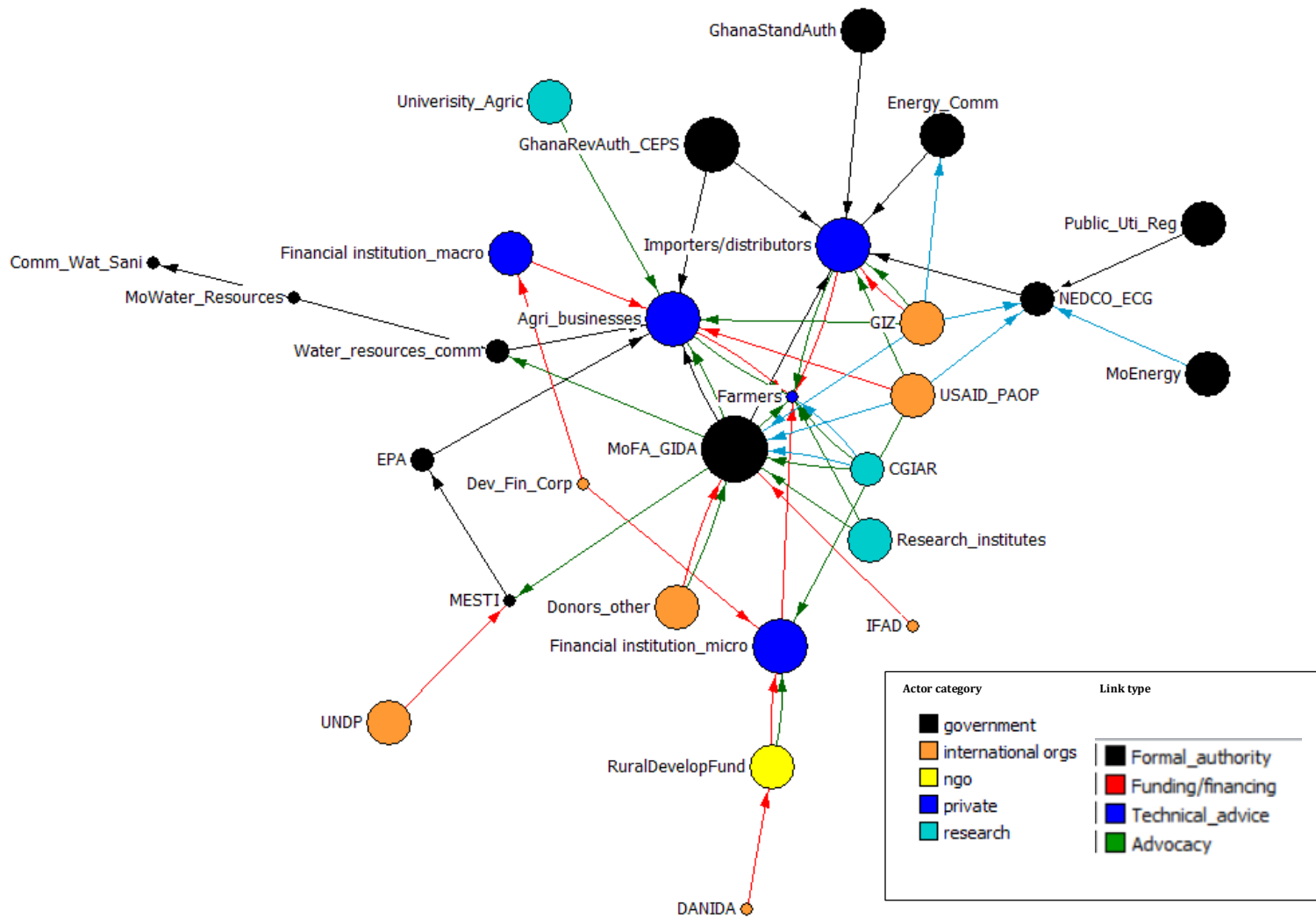


Figure 1: Complete national network, actors sized by influence level (actor full names found in Table 1)

Table 1: National actor key, category and full names

	Actor	Category	Full name(s)
1	Agri_businesses	Private	Irrigation focused agribusinesses: IWAD, RMG, ECOM Trading & Agro-Input dealers
2	CGIAR	Research	Consultative Group for International Agricultural Research: IWMI, IITA, IFPRI
3	Comm_Wat_Sani	Government	Community Water and Sanitation Agency
4	DANIDA	International orgs	Danish International Development Agency
5	Dev_Fin_Corp	International orgs	US Government Development Finance Corporation
6	Donors_other	International orgs	Japan International Cooperation Agency, Korea International Cooperation Agency, & Food and Agriculture Organization
7	Energy_Comm	Government	Energy Commission
8	EPA	Government	Environmental Protection Agency
9	Farmers	Private	Farmers
10	Financial institution_macro	Private	Large-scale financial institutions
11	Financial institution_micro	Private	Organizations supporting microcredit, agricultural development banks, village savings and loans, etc.
12	GhanaRevAuth_CEPS	Government	Ghana Revenue Authority, Customs Excise and Preventive Service
13	GhanaStandAuth	Government	Ghana Standard Authority
14	GIZ	International orgs	Deutsche Gesellschaft für Internationale Zusammenarbeit
15	IFAD	International orgs	International Fund for Agricultural Development
16	Importers/distributors	Private	Importers, distributors & key irrigation suppliers: Dizengoff, Agritop, AGRO_Africa, Tech shelters, Interplast, solar pump installers and suppliers, energy-focused retailer
17	MESTI	Government	Ministry of Environment, Science and Technology
18	MoEnergy	Government	Ministry of Energy, Renewable Energy Directorate
19	MoFA_GIDA	Government	Ministry of Food and Agriculture, Ghana Irrigation Development Authority
20	MoWater_Resources	Government	Ministry of Water Resources
21	NEDCO_ECG	Government	Northern Electricity Distribution Company & Electricity Company of Ghana
22	Public_Uti_Reg	Government	Public Utility Regulatory Commission
23	Research_institutes	Research	Water Research Institute, Crops Research Institute, SARI
24	RuralDevelopFund	NGO	Rural Development Fund
25	UNDP	International orgs	United Nations Development Programme
26	University_Agric	Research	Agricultural universities and colleges
27	USAID_PAOP	International orgs	United States Agency for International Development, Power Africa Off-Grid Project
28	Water_Resources_Comm	Government	Water Resources Commission (WRC)

Other influential government bodies include the Ghana Revenue Authority and the Customs Excise and Preventive Service (GhanaRevAuth_CEPS), with a score of 4. The GhanaRevAuth_CEPS, which is an agency under the Ministry of Finance, determines the duties paid for irrigation equipment—the vast majority of which is imported. While agricultural materials are supposed to be duty-free, new technologies, such as solar panels, are often excluded from exemption. This constitutes a major barrier for the importation of irrigation equipment and directly reduces affordability of SSIT for poorer farmers.

The Ghana Standards Authority (GhanaStandAuth), which determines the standards for equipment to be certified in Ghana received a power influence ranking of 3. According to workshop participants, the agency can influence the quality of equipment utilized in Ghana, but the agency was not seen as strong in enforcing standards. A further agency, the Energy Commission (Energy_Comm) of Ghana, approves the importation of solar equipment, including solar panels for irrigation, and thus, is considered to have a score of 3. The Ministry of Energy (MoEnergy) also has a score of 3 because the Ministry's Renewable Energy Directorate plays an important role in policy and advocacy for solar irrigation, and is working on this with Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the World Bank (which was not considered among the key SSIT actors and thus, does not feature in the network).

There are numerous private sector actors in this space and workshop participants created different groupings to represent the main activities and characteristics of these actors. Agri-businesses and importers/distributors of irrigation equipment were the two key groupings but they sometimes overlap. Both actor groups were given an influence score of 4. The workshop participants noted that many agribusinesses are working in the SSIT space. They interact with farmers directly through local offices and provide credit and extension on the irrigation technologies that they sell directly to farmers. For example, some private sector actors provide solar irrigation systems to farmers, with the costs of the solar irrigation technology to be paid back with farmers' harvests. Some distributors and importers are also connected with international organizations and donors to support their operations. Importing, distributing, and retailing are often undertaken by the same company. For instance, *Interplast* imports and retails pipes, tubes and sprinkler systems, while HTC & Co. imports and sells pumps. These private sector actors also determine the cost of SSIT and thus directly affect affordability of technologies by farmers.

Financial institutions were also identified as important actors by the national workshop participants as they play a key role in determining access to funding. Workshop participants proposed to divide them into large-scale funders and commercial banks, and small-scale or agriculture-focused financial institutions. Small-scale lenders (Financial institution_micro) were given a score of 4 and large-scale (Financial institution_macro) a lower score of 3, as the latter generally do not directly work with individual farmers on SSIT. Despite their perceived influence, workshop participants noted that financing of SSIT required subsidies from donors or governments for SSIT to take off through more favorable interest rates for farmers.

National and regional research institutes were considered to be relatively influential, with a score of 3. They collectively research whole packages of small-scale irrigation technologies including regionally appropriate crops, inputs, and practices. This information is used by MOFA_GIDA and other actors to determine which production practices can be promoted under small-scale irrigation. Agricultural training universities and colleges were also identified as influential by workshop participants with a score of 3 because they are supposed to train extension agents in small-scale irrigation practices. CGIAR research centers, namely the International Water Management Institute (IWMI), the Institute for International

Tropical Agriculture (IITA), and the International Food Policy Research Institute (IFPRI), were identified by the workshop participants as contributing evidence on SSIT but were slightly less influential, with a score of 2.

The Public Utility Regulatory Commission (Public_Uti_Reg) sets the price of electricity, influencing any irrigation projects connected to the public power grid, and were given a score of 3. The major power companies, Northern Electricity Distribution Company and Electricity Company of Ghana, (NEDCO/ECG) are also important because they would be involved in any negotiation for reduced electricity tariffs for small-scale irrigators. NEDCO/ECG was given a score of 2.

In general, donors and most international organizations were given scores of 3, although they were described as playing different roles. The Japan International Cooperation Agency (JICA), Korea International Cooperation Agency (KOICA), and the Food and Agriculture Organization (FAO) of the United Nations were included in the aggregate actor "other_donors". JICA provides both technical and financial support to GIDA on the formation of water user association, including by-laws and regulations. KOICA has supported MOFA_GIDA in the operation of some larger irrigated rice fields while the FAO supported some drip irrigation systems.

A series of other donors were kept separate. They include GIZ, which was considered a particularly important influencer of the policy dialogue around SSIT in Ghana, in addition to directly supporting several smaller regional projects. UNDP was also identified as an independent donor actor as the agency undertook a lot of work on irrigation through financial support of the Ministry of Environment, Science and Technology (MESTI). Finally, USAID, especially through the Power Africa Off-GRID Project (PAOP), provides technical support to solar companies and energy focused retailers. Technical advice is also provided by PAOP to micro-finance institutions to help them mobilize capital for SSIT.

It is also noteworthy to name some of the actors that are not considered to have any influence in the SSIT process. Key among these actors are farmers themselves. While farmers are the actor group with the largest number of links reaching them among the non-influential actors, they are not considered as influencing any of the actors that are aimed to support them. The lack of influence of farmers themselves in the SSIT process might well result in mal-investment and the roll out of solutions that are not in line with farmers' needs and desires (Sterk et al. 2013).

Workshop participants identified the Community Water and Sanitation Agency (CWSA) as a further actor with nil influence on the diffusion of SSIT. This might well be a missed opportunity given the agency's function to support safe drinking water and sanitation in rural communities and small towns according to the CWSA website. If suppliers of Water, Sanitation and Hygiene (WASH) and irrigation services do not cooperate, then important synergies might be missed and costs of tradeoffs, such as from water scarcity or water pollution could be increased (Ringler et al. 2018; UNSCN 2020). The lack of influence of the Ministry of Water Resources over the diffusion of SSIT is similarly concerning, as extensive development of small-scale irrigation can affect the sustainability of water resources for both irrigation and other uses, and sustainable use of resources effectively constraints expansion potential (Xie et al. 2014).

Table 2: Actor influence and degree centrality scores

Actor	Influence	Degree	In-degree ^a	Out-degree ^b
MoFA_GIDA	5	11	6	5
Agri_business	4	9	8	1
Financial institution_micro	4	4	3	1
GhanaRevAuth_CEPS	4	2	0	2
Importers/distributors	4	8	7	1
Donors_other	3	1	0	1
Energy_Comm	3	2	1	1
Financial institution_macro	3	2	1	1
GhanaStandAuth	3	1	0	1
GIZ	3	5	0	5
MoEnergy	3	1	0	1
Public_Uti_Reg	3	1	0	1
Research_institutes	3	2	0	2
RuralDevelopFund	3	2	1	1
UNDP	3	1	0	1
Univerisity_Agric	3	1	0	1
USAID_PAOP	3	5	0	5
CGIAR	2	2	0	2
NEDCO_ECG	2	5	4	1
EPA	1	2	1	1
Water_resources_comm	1	3	2	1
Comm_Wat_Sani	0	1	1	0
DANIDA	0	1	0	1
Dev_Fin_Corp	0	2	0	2
Farmers	0	6	6	0
IFAD	0	1	0	1
MESTI	0	3	2	1
MoWater_Resources	0	2	0	2

Notes: ^a/In-degree: in-coming connections --a measure suggesting prestige as many others try to influence them
^b/Out-degree: out-going connections—an indication of being an influencer.

Actor centrality

Complete network

An important network measure is the degree centrality. Degree centrality is defined as the number of links associated with a single node or actor incident upon a node (i.e., the sum of actors one actor is connected to). Degree centrality can be further broken down by the number of in-coming connections (In-degree)—a measure suggesting prestige as many others try to influence them—and out-going connections (Out-degree)—an indication of being an influencer. NEDCO_ECG has a degree centrality score of 5. Most (4) connections are in-coming, including links from regulators and international organization

seeking to influence their arrangements with farmers. Besides, NEDCO_ECG has an out-going link reflecting the requirement that it provides permits to irrigation schemes that are distributing power to a large number of farmers.

The actor with the highest degree centrality in the complete network is MoFA_GIDA. MoFA_GIDA has 11 links, with an almost equal number of incoming and outgoing links, reflecting its role as a policymaker as well as its central role on technical advice. Key policy and technical advice documents that are likely reflected in this high degree of centrality include the 2011 MOFA_GIDA National Irrigation Policy (MOFA/GIDA 2011) with the four main foci of 1) performance and growth of irrigation, 2) improved socio-economic inclusion, 3) responsible production and 4) enhanced services. The strategy considers smallholder irrigators, with a focus on improving the enabling environment for smallholders and to develop alternatives toward formal irrigation for smallholders. However, no specific interventions toward these pathways are prescribed in the policy document.

Agribusinesses and importers/distributors have degree centrality score of 9 and 8, respectively. These links are all in-coming, except for out-going links to farmers. Farmers, on the other hand, only receive links; all of their six links are in-coming. This suggests that national actors do not consider farmers to be a source of driving innovation, and not even as a source of information on how SSIT roll-out should be accelerated. There are also no mediating organizations, such as farmer associations that seem to play a role in SSIT diffusion. There are no local NGOs either. In fact, only a single NGO was identified as playing a substantial role in SSIT diffusion, Rural Development, which was co-founded by the governments of Denmark and Ghana.

Most international organizations and research institutes have only out-going links, reflecting their role as funders or advisors of policies and programs. USAID PAOP and GIZ have the most out-degree centrality scores of 5. Research institutes and CGIAR institutes both have scores of 2. All other international organizations and agricultural universities and colleges (University_Agric) have an out-degree score of 1.

Information network

Isolating the links that demonstrate flows of information—technical advice and advocacy—provides additional information about the particular roles of some of the actors (Figure 2). For instance, the USAID Power Africa Off-Grid Project (POAP) focuses on technical advice and the provision of grants to accelerate the development of off-grid solutions in rural areas (Power Africa n.d.) with a focus on both government agencies, such as the Ministry of Food and Agriculture as well as groups of private sector intermediaries, such as importers and distributors and finance organizations. GIZ plays a similar role, advocating for SSIT and advising private sector actors as well as government bodies, but focusing more on agribusinesses and not finance organizations. The information network also highlights which actors are providing information directly to farmers. They include private sector actors, research institutes, and MoFA_GIDA. Workshop participants acknowledged that MoFA_GIDA advice may not be accessible to typical smallholder farmers, however, as the organization only has officers at the regional level.

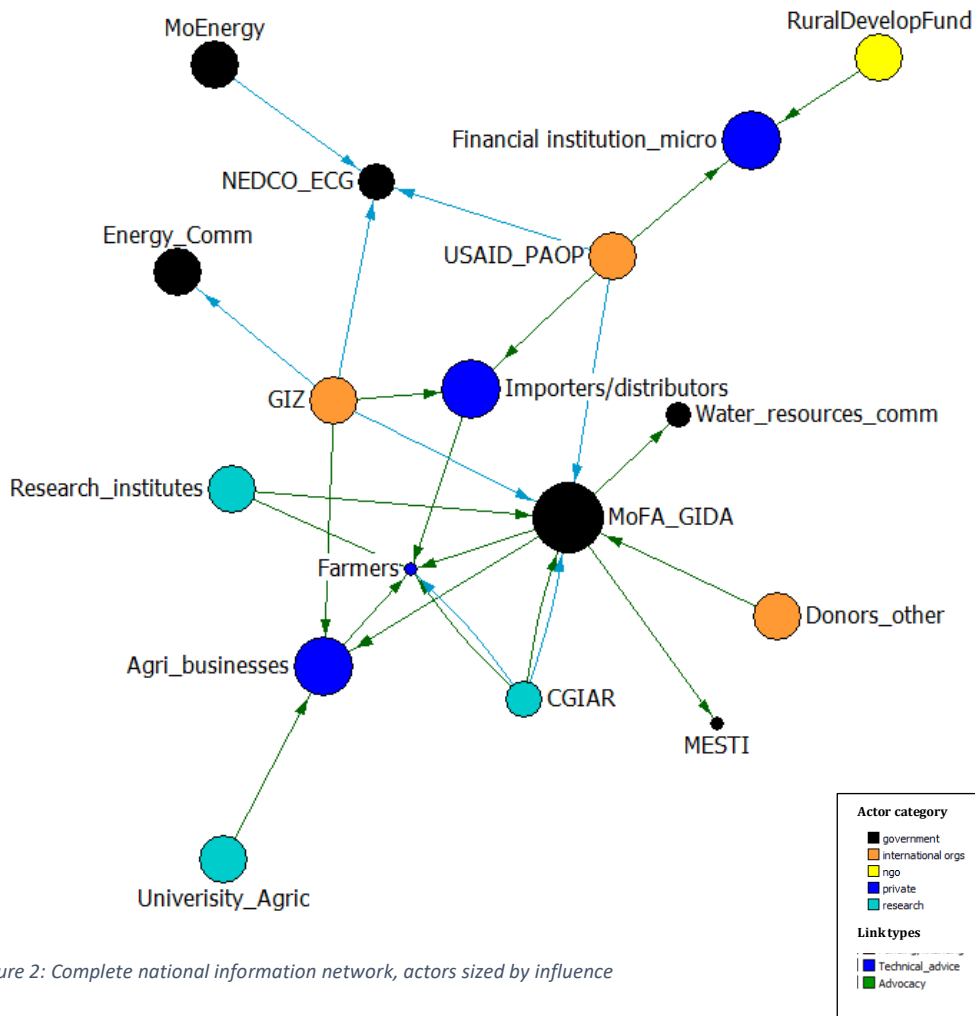


Figure 2: Complete national information network, actors sized by influence

Funding network

The funding network shown in Figure 3 highlights the paucity of actors involved in providing funding or financing directly to farmers. Only private sector actors—agribusinesses, importers/distributors, and micro-finance institutions—are seen as providing funding for SSIT to farmers, and given the private-sector focus of funding, most of these funds are likely provided on conditional terms requiring repayment following harvests, or with specific interest rates. Some of the private actors are likely also channeling funds from donors to farmers, such as the chain from DANIDA to Rural Development Fund, which in turn provides funding to the micro-finance sector; similarly the US Government International Development Finance Corporation provides funding to both larger financial institutions as well as to the micro-finance sector. The USAID Power Africa Off-Grid Project and GIZ have similar arrangements. There are also disconnected linkages between IFAD as well as other donors that support GIDA and MOFA without funding necessarily reaching farmers, and between UNDP and the Ministry of Environment, Science and Technology, which is itself a government actor with no identified influence over SSIT.

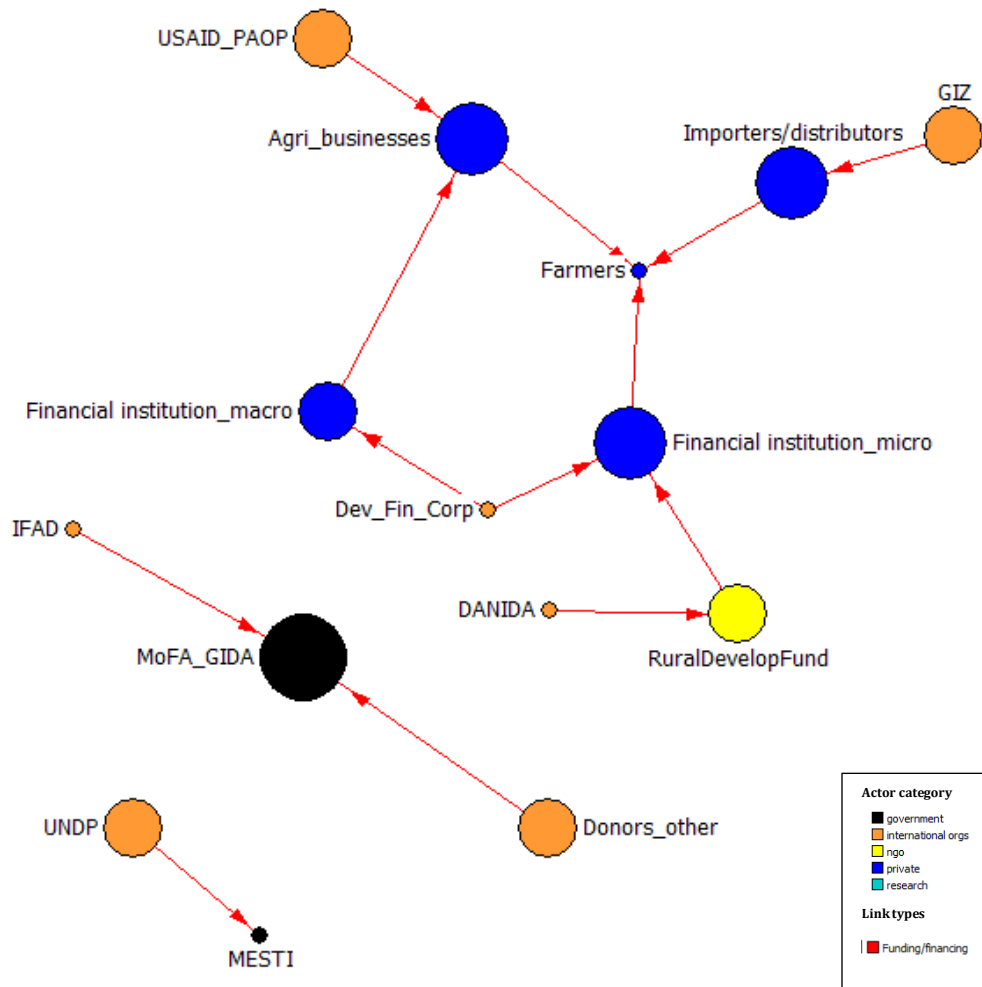


Figure 3: National funding network, actors sized by influence

Challenges and solutions

The national-level meeting participants highlighted a few challenges to improved dissemination of SSIT. The cost of irrigation technology packages was considered a significant barrier. Paraphrasing the comments of one participant in the workshop, “the challenge is to enable poor farmers to purchase something expensive and ensure it is a worthwhile investment”. This includes an evaluation of the cost of pumps and other equipment in the context of the crop under production as well as expected yields.

Importantly, SSIT is a package that goes far beyond the purchase of the irrigation technology and includes also higher value crops, modern inputs, such as fertilizers and pesticides, and advanced agricultural management practices that must all be appropriately applied to help farmers recoup the cost of the investment in irrigation technologies.

Relatedly, low access to credit and high credit risk, poor business and bookkeeping skills, and challenges of ensuring and maintaining a market for produce can all exacerbate challenges in recouping the cost of SSIT.

Workshop participants also noted that training farmers in financial models and holistic production packages was critical. Out-grower models were described as successful, wherein a nucleus farm provides extension and access to inputs as well as irrigation technology.

Finally, workshop participants stated that expansion of small-scale irrigation in Ghana is limited by water availability and land tenure issues. Water availability determined whether or not irrigation is feasible and what irrigation technologies are required. Participants suggested to develop an irrigation suitability map to help guide donors and investors about what is feasible where. Furthermore, technologies that are promoted to farmers must be vetted to be effective and appropriate for the context. In terms of land tenure, traditional leaders are often in charge of granting lands for irrigation use. Therefore, it is important to engage leaders early on in the SSIT diffusion process.

Agribusinesses can play a major role in addressing some of the constraints, according to participants. They can work directly with farmers, providing credit, strengthening capacity and supporting market linkages. Workshop participants also suggested that national and international research institutes should support the evidence base for policies related to SSIT, liaising in particular with MoFA_GIDA—which participants incidentally identified as the key government actor for SSIT—as well as other key policy actors. GIDA plans to play a more regulatory role, and to centralize management of irrigation in one place. As part of this effort, there is a plan to develop an irrigation master plan. However, budget constraints in the directorate have impeded progress.

Regional-level stakeholder network results

Figure 4 presents the regional (i.e. sub-national) network for SSIT diffusion for northern Ghana developed by regional Net-Map workshop participants. The regional network includes 29 actors and 99 links, which reflects a similar number of actors but a larger set of links when compared to the national map of SSIT diffusion. Thirty-eight percent of the actors were from international organizations, a little over a quarter from government institutions (28 percent) and less than a quarter from the private sector (21 percent). This contrasts with the national-level network where government actors dominated (43 percent), followed by international organizations (25 percent), the private sector (18 percent), and research organizations (11 percent). International organizations appear to play a strong role in sub-national diffusion of SSIT, as evidenced by their prevalence in the regional network. Moreover, the regional network shows a slightly larger set of NGOs involved in SSIT diffusion without any overlap with the national map. Moreover, several additional international organizations and donors are shown in the regional map, such as the World Bank, the FAO, Global Affairs Canada, and the Government of the Netherlands.

Table 3 provides a list of key actors, their full names, actor categories and influence scores. Some of the actors are aggregates of similar actors, when multiple actors play a similar role in the network.

The network diameter, describing the largest distance between two actors is 6, and the average distance is 2.34. The network density, which describes the proportion of actual links or connections in a network, is calculated at 0.24. If all actors were connected, the density would have been 1. The low density value suggests sparse connections across actors in the regional network.

The regional network is centralized with a degree of centralization of 81 percent, which is below the centralization level of the national network of 93 percent. The regional network clusters around six core

actors, compared to four core actors in the national network. These include CGIAR (which regional workshop participants identified as an international organization rather than a research partner), farmers, irrigation suppliers, the Regional Coordination Council (RCC), regulators, and research institutes. The relatively high centralization draws attention to the number of isolates—occurrences where single actors are connected to other single actors—in the network.

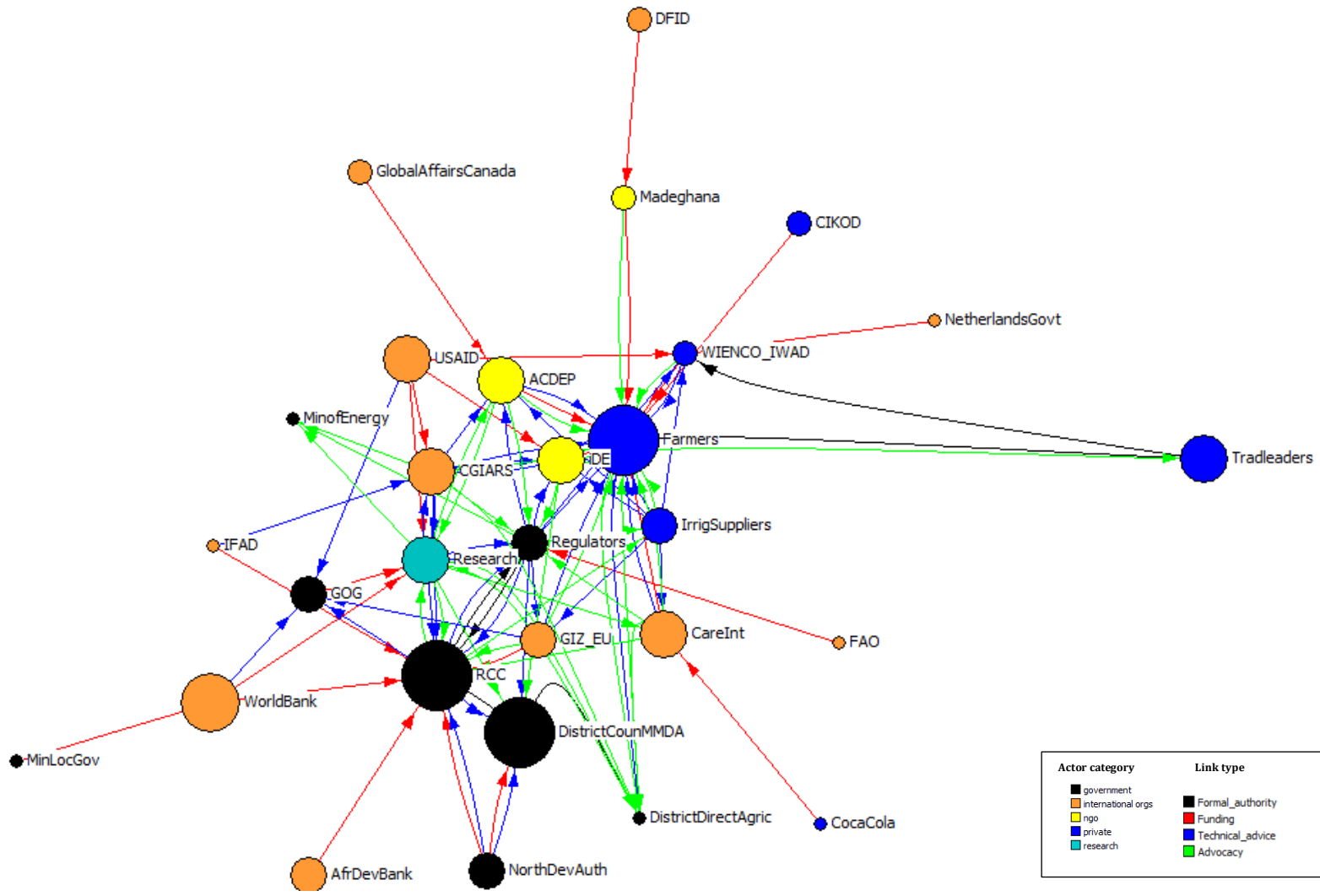


Figure 4: Complete regional network, actors sized by influence level (actor full names found in Table 3)

Table 3: Regional actor key, category and full names

	Actor	Influence score	Category	Full name(s)
1	Farmers	5	Private	Farmers
2	RCC	5	Government	Regional Coordinating Council- Northern Ghana Agric working group, Dept. of Agric (projects- SAPIP- Savannah Zone Agriculture Productivity Improvement Project, GCAP- Ghana Commercial Agriculture Project)
3	DistrictCounMMDA	5	Government	District Council/Municipal Assemblies
4	DistrictDirectAgric	5	Government	Directorate of Agric
5	WorldBank	4	International orgs	World Bank
6	Research	3	Research	Water Research Institute, University for Development Studies, SARI
7	CGIAR	3	International orgs	CIP, IWMI, IITA, CIAT, World Vegetable Centre
8	Tradleaders	3	Private	Traditional leaders (chiefs)
9	USAID	3	International orgs	United States Agency for International Development
10	ACDEP	3	NGO	Association of Church-based Development NGOs
11	iDE	3	NGO	International Development Enterprises
12	CareInt	3	International orgs	Care International
13	IrrigSuppliers	2	Private	All irrigation suppliers- irrigation, agro-dealers- seeds, fertilizer, hydro farms, Kickstart, Hartum, Dizengoff, Interplast, Pump Tech
14	Regulators	2	Government	EPA-Environmental Protection Agency, GIDA- Ghana Irrigation Development Authority, WRC - Water Resources Commission
15	NorthDevAuth	2	Government	Northern Development Authority (NDA)
16	GIZ_EU	2	International orgs	GIZ_EU
17	AfrDevBank	2	International orgs	African Development Bank (AfDB)
18	GOG	2	Government	Government of Ghana
19	Madeghana	1	NGO	MADE (Market Development Programme for Northern Ghana)
20	CIKOD	1	Private	Centre for Indigenous Knowledge and Organizational Development

	Actor	Influence score	Category	Full name(s)
21	DFID	1	International orgs	Department for International Development
22	WIENCO_IWAD	1	Private	Wienco Ghana Limited_Integrated Water & Agricultural Development Ghana
23	GlobalAffairsCanada	1	International orgs	Global Affairs Canada
24	NetherlandsGovt	0	International orgs	Netherlands government
25	FAO	0	International orgs	Food and Agriculture Organization
26	IFAD	0	International orgs	International Fund for Agricultural Development
27	CocaCola	0	Private	Coca Cola
28	MinLocGov	0	Government	Ministry of Local Government- Ghana Production Safety Net Project
29	MinofEnergy	0	Government	Ministry of Energy

Several actors have a limited number of connections. Figure 4 shows the isolates: DFID is only connected to MADE, which is an NGO operating in northern Ghana focused on the development of market systems and building supply capacity for agricultural inputs. Similarly, the Centre for Indigenous Knowledge and Organisational Development (CIKOD) is a Ghanaian NGO, which based on their website, focuses on strengthening traditional authorities and civil society organizations to facilitate sustainable grassroots organizational development with a particular interest in forest policy, is only connected to farmers. Global Affairs Canada is only connected to the Association of Church-based Development NGOs (ACDEP), which according to their website is a network of more than 40, largely church sponsored development NGOs in northern Ghana. ACDEP focuses on agricultural development, micro-finance, health care and WASH, among others. Finally, Government of the Netherlands is only connected to Wienco Ghana and IWAD Ghana. Wienco (Ghana) Limited is a private agricultural company jointly owned by Dutch and Ghanaian shareholders, which specializes in the importation and distribution of agro-inputs. Integrated Water and Agricultural Development (IWAD) Ghana, according to its website, is a private-sector company focused on expanding commercial irrigation in the Sisili – Kulpawn Basin in northern Ghana. Coca Cola only supports Care International. Finally, the African Development Bank is only connected to the Northern Regional Coordination Council (RCC) and its projects, one of ten regional administrative bodies of Ghana.

Actor influence over SSIT dissemination

The actors in Figure 4 are sized by their influence over the diffusion of SSIT based on the perception of workshop participants at the regional level. Table 4 presents the actors by influence score. The highest influence of 5 was attributed to four actors: the Regional Coordinating Council, the District and Municipal Assemblies (DistrictCounMMDA), the District Directorate of Agriculture (DistrictDirectAgric) and farmers. These actors were perceived to wield power to increase the use of improved SSIT at the regional level. Participants said farmers have the potential to diffuse knowledge about SSIT to others and thus, could serve as a major driver. This is contrary to the national network where farmers were perceived to have no influence over the diffusion of SSIT. However, participants in the regional workshop confirmed that they referred to potential influence, that is, there was scope for using latent influence. The RCC and the District and Municipal Assemblies and the District Directorate of Agriculture were identified as having power and influence because they are the main gatekeepers for activities in the region, approving implementers, distributors, and other actors of relevance to SSIT. They may also play a coordination role through these engagements, referring actors to others.

The World Bank was assigned an influence score of 4 because it provides funds to smallholders through the Ghana Commercial Agriculture Project (GCAP) project, which based on its website aims to increase “access to land, private sector finance, input and output markets by smallholder farms from private public partnerships in commercial agriculture in Accra Plains and Savannah Accelerated Development Authority (SADA) zone” (WB. nd.). The activities of this project include public-private partnerships for irrigation development. Workshop participants noted that the World Bank also strengthens the capacity of students in research institutes through organizing of conferences to scale up small-scale irrigation at the regional level.

A mix of international organizations, NGOs, research organizations and private sector actors, specifically traditional leaders, received a score of 3. The USAID provides funding for SSIT through the supply of inputs, such as solar panels and pumps to farmers and financial support to other NGOs to scale up SSI at the regional

level. Several local NGOs¹ provide resources for SSIT at the regional level based on the financial support they receive. They collaborate closely with the District and Municipal Assemblies in the implementation and scale-up of SSI. Participants noted that the funding moved by these NGOs was not large but was sufficient for impetus to SSIT at the regional level. The research institutions also play an important role by providing knowledge on SSIT at the regional level through capacity building of students, and regional and district staff in SSI. Traditional leaders also have substantial power since they are custodians of the land. They facilitate or cease the release of lands for SSIT activities at the sub-national level.

Actors labeled with a power and influence score of 2 included the Government of Ghana, the Northern Development Authority, regulators, such as GIDA, the Water Resources Commission (WRC) and the Environmental Protection Agency (EPA). Others were agricultural input and irrigation technology suppliers, such as Kickstart, Hartum, Dizengoff, and Interplast, as well as the African Development Bank, GIZ and the EU. Of note, GIDA under MOFA had been ranked as the most influential player at national level, but received only a relatively low ranking in the regional network. The NDA was established in 2017 to provide a framework for the accelerated economic and social development of the Northern Development Zone of Ghana. The Government of Ghana is listed at a level 2 power influence due to its role in negotiating funding for SSIT from a range of donors. The position of the AfDB relates to its role in supporting the Savannah Zone Agricultural Productivity Improvement Project (SAPIP) as well as other projects related to SSIT.

Global Affairs Canada, CIKOD, Department for International Development (DFID), and WIENCO_IWAD were ranked with a score of 1 related to their small funding and activity role around SSIT at the regional level. For example, DFID provides small support to MADE for the provision of drip irrigation equipment to farmers and Global Affairs Canada provides small support for ACDEP.

A few other actors were ranked by workshop participants as zero power influence or were not rated at all because they were only connected to a single other actor in the network, either providing funds, technical advice or playing the role of advocates. Others were ranked as zero influence or not rated at all because workshop participants said they work only in a small section of a district or provide funds to a local NGO working in a relatively small area of the district. These include the Government of the Netherlands, FAO, IFAD, Coca Cola, the Ministry for Local Government, and the Ministry of Energy.

¹ While identified as a local NGO by workshop participants, IDE is actually an international NGO and as such falls under the grouping of international organizations but for the purposes of this paper, the assessment of workshop participants prevails for the classification.

Table4: Regional actor degree centrality scores

Actor	Degree	In-degree ^a	Out-degree ^b
Regulators	17	7	10
Research	16	8	8
RCC	14	9	5
Farmers	13	12	1
CGIAR	12	4	8
iDE	9	4	5
ACDEP	8	5	3
IrrigSuppliers	8	2	6
DistrictDirectAgric	7	5	2
CareInt	7	3	4
WIENCO_IWAD	6	5	1
DistrictCounMMDA	6	5	1
USAID	5	0	5
GIZ_EU	5	2	3
GOG	5	4	1
WorldBank	4	0	4
Tradleaders	3	1	2
MinofEnergy	3	3	0
Madeghana	2	1	1
NorthDevAuth	2	0	2
IFAD	2	0	2
CIKOD	1	0	1
DFID	1	0	1
NetherlandsGovt	1	0	1
GlobalAffairsCanada	1	0	1
FAO	1	0	1
AfrDevBank	1	0	1
MinLocGov	1	1	0
CocaCola	1	0	1

Notes: ^a/In-degree: in-coming connections --a measure suggesting prestige as many others try to influence them

^b/Out-degree: out-going connections—an indication of being an influencer.

Actor centrality

Complete network

The government regulating authorities, such as GIDA, EPA and WRC have the highest degree of centrality with a value of 17 (Table 4), suggesting that they are very well connected to many other actors affecting SSIT diffusion, even though their regional influence score is somewhat low at 2. The three regulating agencies are grouped together because they provide oversight of the environment (land and water use) and approval for irrigation activities at the regional level. Most of the connections (10) are out-going indicating that the regulating agencies provide technical advice, such as approval of irrigation development plans to other actors in the SSIT diffusion chain. The in-coming link (7) shows that other actors are trying to influence the activities of the regulating agencies, with links coming in from both international organizations and NGOs.

Researchers have the second-highest degree centrality of 16 with equal in-coming and out-going links suggesting they influence actors through technical advice and capacity building and other actors also influence them by providing financial and technical support. The RCC has a degree centrality of 14 and is more often a recipient of advice and funds—with 9 in-coming and 5 out-going links. This reflects RCCs receipt of technical advice and funds to coordinate SSIT related activities at the regional level. Farmers have 13 links; all but one of these links are incoming, suggesting that other actors are trying to influence or support farmers. The only link from farmers to other actors is 1 (Traditional leaders). This picture is somewhat similar to the national network where farmers had no outgoing links, but differs in that farmers are considered to have considerable influence at the regional level.

The CGIAR research centers, including CIAT, CIP, IITA, IWMI and World Vegetable Center had a score of 12 with more outgoing (8) than incoming links, suggesting they influence actors by providing technical support and advocacy. Most development partners like the World Bank, USAID, Care International, GIZ_EU, IFAD, CIKOD, DFID and Coca Cola, have only outgoing links, suggesting they influence actors by providing support (technical and financial) to actors but do not receive or seek any advice. The Northern Development Authority (NDA) has only outgoing links indicating they influence other actors in the network. Similarly, traditional leaders, irrigation suppliers, and some local NGOs, such as iDE, have more outgoing links than incoming links reflecting, according to the workshop participants, their role as advocates or advisors on input supplies.

Formal authority network

Isolating the types of links, the formal authority network highlights the actors that are the key providers of authority in the complete network. Figure 5 delineates two distinct components with six actors, with government actors making up the first set of formal authority and private sector actors the second set (Figure 5). The network diameter is 2 with an average distance of 1.33. The RCC provides oversight over the District and Municipal Assemblies while they, in turn, provide oversight over the District Directorates of Agriculture. A second set of formal authority was identified by workshop participants as linking traditional leaders to both farmers and Wienco and IWAD. This relates to the important role that traditional leaders have in supporting or removing support from irrigation and other agricultural development projects that require access to land resources.

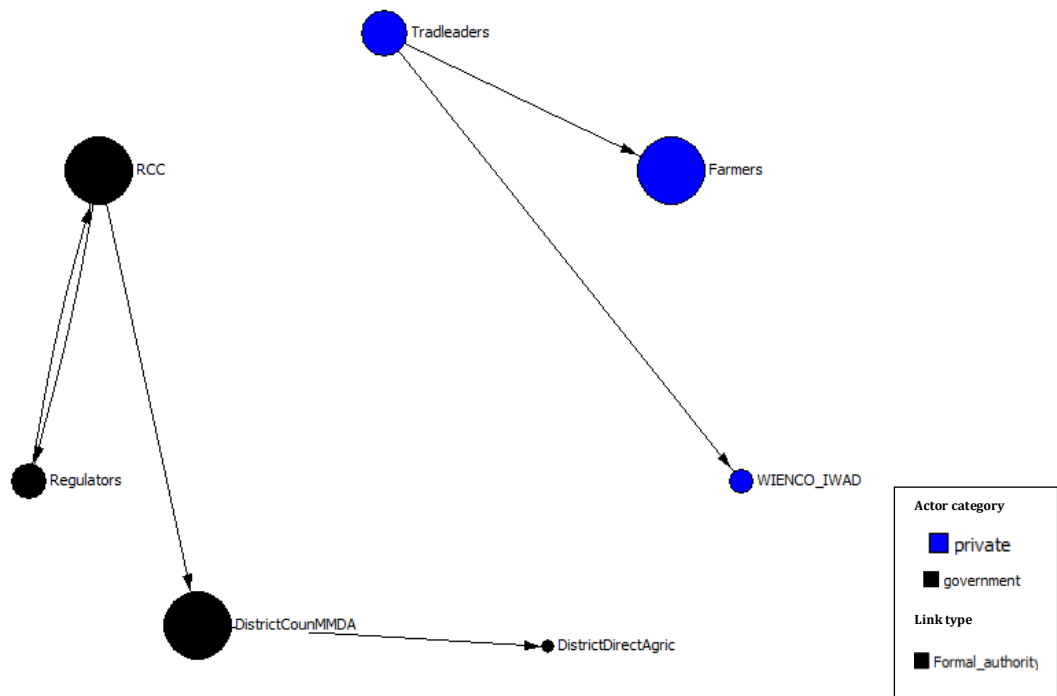


Figure 5: Regional formal authority network, actors sized by influence

Information network

The regional sub-network focusing on information linkages includes both links for advocacy and technical advice. This sub-network has 29 actors and 71 links. The information network has 4 core actors, including regulating agencies, farmers, RCC and CGIAR centers. The network diameter is 5 with an average distance of 2.17. The core regulating agencies GIDA, WRC and EPA have the highest degree centrality with more outgoing than incoming links suggesting they provide advocacy and technical advice to a range of other actors.

Research institutions have the second-highest degree centrality, also with more outgoing links reflecting their technical advice and advocacy role. Similarly, CGIAR and irrigation suppliers have more outgoing links suggesting the technical advice and advocacy roles they play. On the other hand, farmers and RCC have more incoming links reflecting their role as recipients of advocacy and technical advice. ACDEP, the District Directorates of Agriculture and the District Councils and Municipal Assemblies are recipients of advocacy and technical advice as reflected in their incoming links. The RCC has the highest betweenness centrality, which is defined by the number of times an actor lies on the shortest path between other actors in a network. Thus, it plays the role of a liaison between actors in the network suggesting it is connected to the largest number of actors.

Some of the NGOs are fairly well networked, such as IDE and ACDEP while others have only a singular linkage in the network, such as MADE, possibly due to their limited role in SSIT. Similarly, some international organizations focus only on a single national actor, like the World Bank, USAID and IFAD, while others have a broader set of linkages, such as Care International, CGIAR, GIZ and the EU.

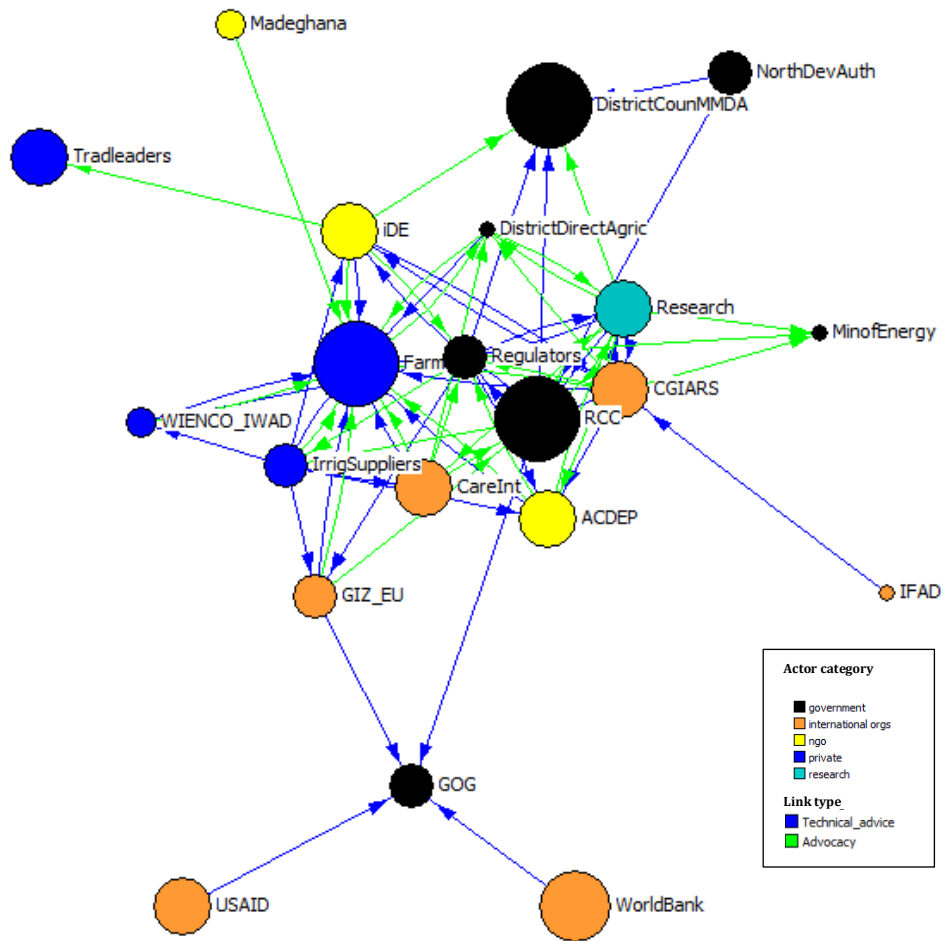


Figure 6: Regional information network, actors sized by influence

Funding network

The funding sub-network includes 29 actors and 24 funding links with 2 distinct components. The network diameter is quite wide and measured at 9 with an average distance of 4, suggesting that funding flows are widely dispersed and directed by single actors to other single actors. The key funding actors are international organizations (11), government actors (8), private sector (6), NGOs (3) and research (1).

USAID plays a distinct role in the funding network. It is the only actor funding research, the private sector, and NGOs. This role is supported by its high betweenness centrality, which reflects the extent to which USAID is in-between other actors. The World Bank funds research institutes and government. Other funders focus on single actors, such as IFAD, GIZ and EU and African Development Bank, which support the RCC whereas Global Affairs Canada, DFID, Coca Cola and the Government of the Netherlands support NGOs, international organizations and the private sector, respectively.

Farmers have the highest number of incoming links, receiving funding from many sources and is the only core actor in this network. There are no funding links between government and farmers in the area of SSIT

based on workshop participants' assessment. The RCC is the second highest recipient of support, followed by research institutes.

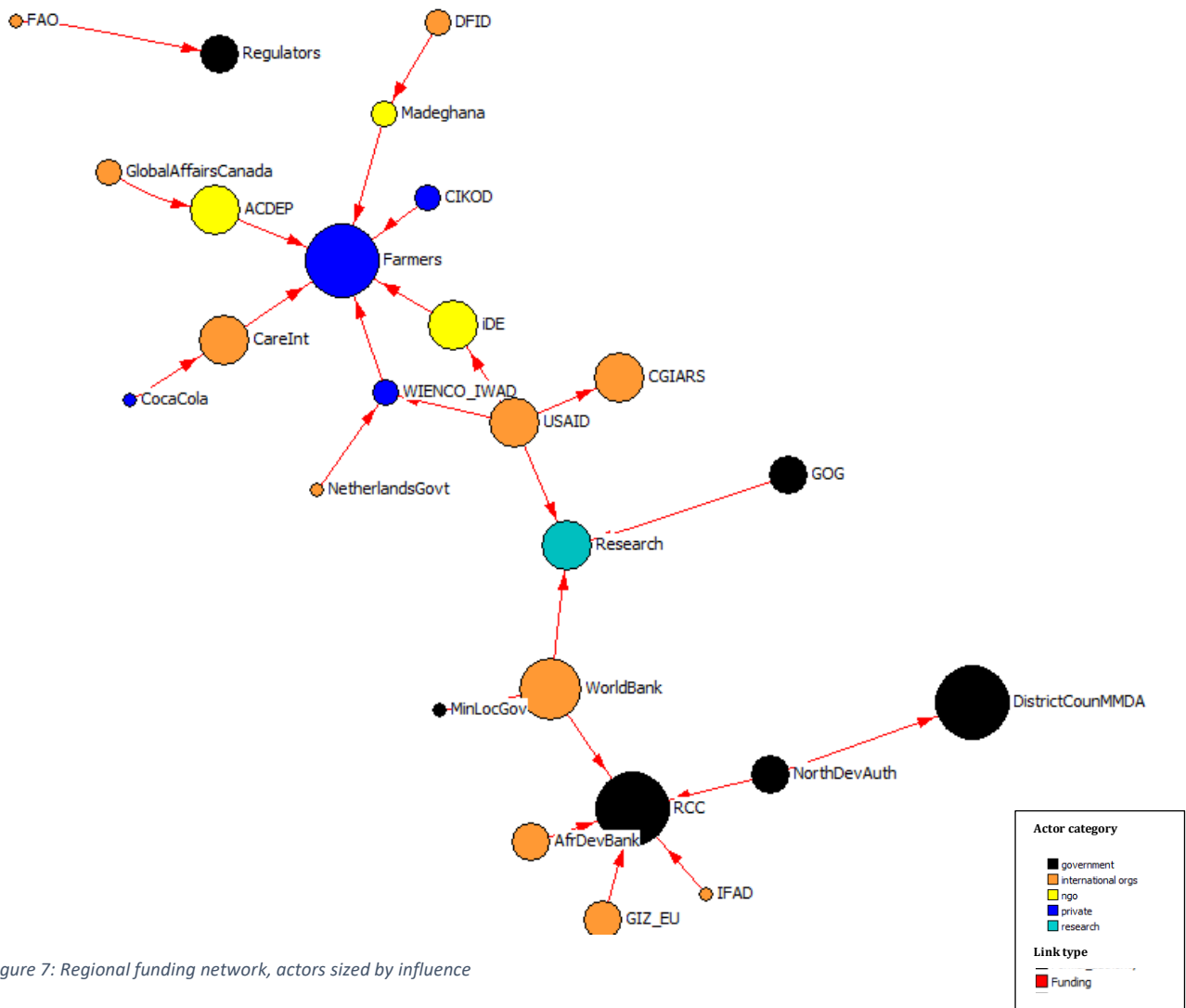


Figure 7: Regional funding network, actors sized by influence

Challenges and solutions

The regional-level meeting participants highlighted a series of challenges to the improved dissemination of SSIT in northern Ghana. Inadequate funding for research into the development of new and improved irrigation technologies and infrastructure, such as small reservoirs that can support small-scale irrigation (see, for example, Acheampong et al. 2018), as well as the lack of capacity was a major challenge identified by participants. Participants also noted that the Government of Ghana has constructed many dams in the three northern regions but has not invested in the training of agriculture extension officers to support farmers utilize the water sources. The solution they propose is to set-up a comprehensive funding package for irrigation development for research institutions and farmers for efficient use of dams by the government.

Limited prioritization of SSI policy was a second barrier identified by workshop participants. Most programs and projects in agriculture, such as e.g. the Savannah Zone Agriculture Productivity Improvement Project, are geared towards the promotion of staple crops (e.g. maize, rice and soya), rather than horticultural crops suitable for small-scale irrigation. Participants noted that at some point SARI lacked a vegetable agronomist. Without supporting research into complementary inputs to SSI, it is challenging to accelerate SSIT diffusion.

Workshop participants noted a more general lack of curriculum and training at tertiary education institutions on irrigation development, leading to a lack of experts, including irrigation engineers, agronomists and agriculture extensionists who could support increase in demand for SSIT. Participants mentioned that an irrigation extension curriculum supported by the CGIAR Research Program on Water, Land and Ecosystems had been forwarded to parliament for approval, but has not been approved to date.

Participants additionally stated that to accelerate SSIT diffusion, diffusion needed to be aligned with prioritized government initiatives, such as the “Planting for Food and Jobs” (PFJ) program, or the “One-Village-One-Dam” initiative. To drive alignment and push SSIT diffusion ahead through teaching and practice, participants suggested to identify champions of change that need to be incentivized for strengthened support. Participants also noted that while there are various publications on SSI, there has not been sufficient dialogue with policymakers on these findings and not sufficient demand by policymakers for research results to accelerate SSIT diffusion.

A final barrier noted for the long-term diffusion of SSIT is the lack of mechanisms that can support sustainability of SSI. Participants noted that sustainability mechanisms might not have been established among beneficiaries right from the project design. Beneficiaries must be involved in any development activities focused on SSIT for them to truly own the project and support sustainability. This includes effective communication on any costs that smallholder farmers bear when NGOs or other agencies provide support on SSIT. A further challenge around sustainability of SSIT diffusion relates to the fact that support to farmers usually ends as soon as the SSIT has been provided and there is no follow-up monitoring and no addressing of challenges around project sustainability. The participants suggested long-term monitoring and evaluation to ensure that investments classified as successful are also sustained.

Workshop participants also noted that women are often disadvantaged in the usage of SSI facilities due to factors such as lack of access to land. At the same time, in some communities, vegetable cultivation is perceived as an activity led by women. It is important to strengthen the gender sensitivity of SSIT to accelerate diffusion and sustainability.

Workshop participants also noted weak collaboration among institutions along the SSIT value chain as a barrier to diffusion. An example was provided in that the regulating agencies, such as EPA and WRC were not engaging each other fully about ongoing projects. Transparency about SSIT among institutions and strengthened cross-sectoral collaboration is needed among stakeholders. An additional challenge in the SSIT value chain, identified by participants, relates to input dealers whose goal is to sell, rather than to ensure that the products sold work in farmers’ fields. Input dealers do not have the role nor capacity to follow up with farmers when SSIT are not operational. Moreover, farmers are often not provided with a full package of inputs, such as improved seeds and adequate fertilizer and pesticides that can support dry-season irrigation. Without adequate complementary inputs, SSIT investments can result in crop failure and abandonment of the technology.

A final challenge that workshop participants noted is that small-scale irrigation policies and interventions were subject to politics, such as changes in government. Participants noted that policy documents and proposals about improvement in SSIT are abandoned following changes in government. An example was

the development of the research to policy action platform which was created for the region under a CGIAR Research Program on Water, Land and Ecosystems (WLE) project which the Savanna Agricultural Development Authority (now NDA) agreed to lead. Following changes at NDA due to changes in government, this activity was abandoned. Creation of a platform or coalition of stakeholders that covers the SSI value chain in the region can help synchronize data and activities on SSI across the region. This would also reduce duplication of efforts and siloes that individual actors are working in.

Conclusions

The national and regional networks for the diffusion of small-scale irrigation technologies showed that a wide variety of actors, including government, the private sector, international organizations and funders, research organizations and NGOs are involved in the diffusion process. At the national level, the Ghana Irrigation Development Authority (GIDA) is considered the most influential actor, closely followed by a series of private sector actors, including agribusiness, microfinance lenders and importers as well as regulating authorities affecting importation costs. This suggests that at the national level, there is a strong perception that the key processes of SSIT diffusion consist of a favorable enabling environment provided by the government, combined with a strong private sector focused on importation and distribution of SSIT in the rural areas of Ghana supported by adequate micro-financing. The key actors in these processes are already fairly well connected and key hurdles that need to be overcome relate to further improving the enabling environment for small-scale irrigation technologies (SSIT), improving access to complementary agricultural inputs by farmers, enhancing farmers' capacity and access to markets, and strengthening linkages between research and government actors in that direction. Among international organizations or donors, USAID and GIZ are seen as having established the largest linkages in the area of SSIT diffusion, but only one NGO was considered as a noted national actor in SSIT diffusion, with a focus on financing. National actors noted a strong linkage between actors in the energy sectors and those focused on SSIT, possibly due to a recent focus of small-scale irrigation on solar powered motors. Other actors, that might *a priori* be considered important for the diffusion of small-scale irrigation, such as the Ministry of Water Resources and farmers themselves, are considered to have zero influence over the diffusion of small-scale technologies.

Given that Ghana has seen waves of dis-adoption of small-scale irrigation technologies--Adeoti et al. (2009) note, for example, a dis-adoption of treadle pumps of 21 percent with a further 10 percent of farmers changing to other irrigation technologies in just two years--suggests that a strengthening of the role of farmers through a combination of the more top-down assessment of irrigation technology diffusion with a more bottom-up assessment could strengthen the overall sustainability of SSIT in rural Ghana.

In northern Ghana, the network of regional actors driving SSIT is somewhat less centralized and workshop participants identified a larger set of actors. Contrary to the national network, farmers are considered to be key actors, ranked at the highest influence level, but workshop participants noted that much of the strong influence they accorded to this actor was potential at this point in time, in the SSIT diffusion process. Thus, even though farmers appear to be more involved, there was a recognition by workshop participants that their voices might not be adequately reflected, suggesting a more supply-driven than demand-driven diffusion process. While the national network noted that GIDA was the most influential actor, the regional network identifies the Regional Coordinating Council together with a series of working groups and Projects, specifically, the Northern Ghana Agriculture Working Group, the Department of Agriculture and associated projects, such as the Ghana Commercial Agriculture Project as key influencers in the diffusion of SSIT. Additionally, District Council/Municipal Assemblies and the Directorate of Agriculture are considered key for the diffusion process. This contrasts with the perceived importance of private sector actors identified as important in the national network.

The strong influence of a large number of government actors in the northern region, rather than the agribusiness and microfinance actors identified at the national level, suggests that at the regional level a large, somewhat dispersed set of government actors might be gatekeepers for SSIT diffusion. As an example, GIDA, which is perceived to play the role of a connector and enabler at the national level, is perceived as a regulator in the regional workshop, together with the Environmental Protection Action and the Water Resources Commission, with specific roles of oversight over water and land use and the environment. These three agencies are seen as highly connected, but with limited influence in the actual SSIT diffusion process. The regional network has a higher number of NGOs and a series of research organizations supporting SSIT diffusion, but workshop participants suggested that more is needed for research results to affect policy and capacity building for future engineers and other experts in small-scale irrigation.

Finally, contrary to the national network, micro and macro lenders and agents focused on energy supply were not identified in the regional network as important in affecting the SSIT diffusion process. Much has been written of the paucity of access to affordable finance in Ghana (Alhassan et al. 2020; FAO and IFC, 2014; Quartey et al. 2012), which might be reflected in the perceived importance of this sector at the national level, as well as the lack of influence of this sector in driving current diffusion processes on the ground, given its continued absence in northern Ghana.

The funders supporting the SSIT process differ somewhat between the national and regional network but are highly dispersed in both cases, with most funders supporting a single actor or single project with the exception of USAID at the regional level and national level, GIZ at national and the World Bank at regional levels. The large number of different government actors that affect the SSIT process in the regional network, the limited number of linkages across donors in the SSIT area and the small number of NGOs with a substantial role in the SSIT process suggests that the proposal of a multi-stakeholder platform as suggested by the regional workshop participants could increase synergies and help address some of the key bottlenecks identified by both national and regional workshop participants. This should also help strengthen support and reduce failure of network components when a single actor, either funder or NGO leaves the system.

Regardless of these options to strengthen the network for diffusion of SSIT in Ghana at national and northern regional levels, working with the most influential actors identified by workshop participants for this paper, as well as with the most connected actors, can help strengthen the role and influence of actors with interest in the SSIT diffusion process that are currently not seen as influential or have not been able to establish strong linkages. Such linkages can be further diversified and strengthened through a multi-stakeholder platform whose role should be independent of politics and solely driven to support rural agricultural growth through sustainable expansion of SSI.

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Appendices

Appendix 1

Interview guide

ILSSI Net-Map Workshop Guide – National and Regional

Overview of the Workshop:

The International Food Policy Research Institute (IFPRI) and the International Water Management Institute (IWMI) with support from USAID under the Innovation Laboratory for Small-Scale Irrigation (ILSSI), under the leadership of Texas A&M, are contributing to the implementation phase II of the ILSSI research program centered on four areas of inquiry:

1. Strengthen information, tools, and policy and programmatic approaches to support environmentally and economically sustainable scaling of small-scale irrigation (SSI), while simultaneously reducing and mitigating risks.
2. Generate evidence on SSI technologies in the context of climate variability that can inform development investment and plan for resilience.
3. Identify approaches that improve inclusive access for women, men, and youth to technology and practices to increase productivity.

In this workshop, we will focus on identifying the actors that influence the diffusion of small-scale irrigation (SSI) technologies in Ghana and how these stakeholders interact with each other. Tomorrow we will consider the same question at the regional level in Tamale, so today we will focus on the national-level stakeholders. We will start by listing all the actors involved in the diffusion of small-scale irrigation (SSI) technologies at the national level. We will then determine how these actors are linked, examine how influential each actor is, and then discuss ways to accelerate the diffusion of SSI technologies in the country.

Net-Map is a tool to explore how things are done, not how things ‘should be’ or how they are ‘officially’ or in formal documents. This is why we need the personal knowledge and insight of people like you, who have knowledge of the stakeholders involved in SSI and how they interact.

The overall guiding question:

Who influences the diffusion of improved small-scale irrigation technologies at the national and regional level?

Step 1: Determine Actors

Which actors play a role in the diffusion of small-scale irrigation technologies at the regional level?

- Prompt the workshop participants by asking for actors within various categories
 - o Government (regional and national)
 - o International Organizations (donor or NGO)
 - o Local NGOs / Civil Society
 - o Private Sector
- Actors do not have to be highly influential, but they do have to be “involved” or influence the diffusion of SSI.

Step 2: Drawing links between actors

For each actor on the sheet, who is connected to whom by:

- Formal authority
- Money/funding
- Technical advice
- Advocacy

- One link at a time, explain the definition of the link and go through all the actors on the board asking if a link exists.
Note: Links should be very specific to avoid linking all actors to every other actor. Links should be done in different colors.

Link definitions:

- **Formal Authority:** Formal authority is any official relationship that links people based on a formal chain of command / organizational hierarchy.
- **Money/financial flows:** exchanges of money including funding/lending (such as loans or grants from a donor to an NGO or government) or as a commercial purchase or payment (as in a water user to a water provider)
- **Technical/policy advice:** professional information or advice provided by one actor to another on agricultural water-related issues (governance or policy).
- **Advocacy:** information provided or activities are undertaken to promote changes in policies or programs

Step 3: Attribute Influence Levels

How strongly can actors influence the diffusion of small-scale irrigation technologies at the regional level? (0 is no influence and 5 is top influence)

- **Define influence:**
 - Influence: the ability to make something happen even in the face of resistance.
 - We define influence as the ability to increase or reduce the level of small-scale irrigation in the country/region using SSI technologies.
 - We are interested in the current and actual state of influence, not a possible future level of influence over the issue. Focus on the ability to influence the diffusion of SSI, not the actor's overall level of influence.

Note: after setting up the influence towers, verbalize what you see, starting with the highest tower. E.g. "Actor X has the highest tower with a height of five tower pieces, followed by the actors Y and Z, both on towers of four." Encourage the interviewee to adjust anything if he or she has second thoughts. Then adjust the heights of the other towers accordingly.

- I see you have put this actor on the highest tower. Why? Where does his/her influence come from?
- You have linked this actor to so many others, but you say he doesn't have much influence, why is that so?

Step 4: Discussion

After the Net-Map is completed, lead participants in a discussion around the following questions:

- What are the major constraints to the diffusion of SSI technologies?
- Looking back at the map, how can we accelerate diffusion? (e.g. who needs to talk to who?)

Appendix 2

ILSSI Stakeholder Mapping Workshop (9th March 2020)

Participants	Organization
1. Noora-Lisa Aberman	IFPRI
2. Seth Asante	IFPRI
3. Afua Atuobi-Yeboah	UG-SPH/IFPRI
4. Zenebe Adimasu	IWMI
5. Rebecca Afful	IWMI
6. Paulina Addy	MOFA-WIAD
7. Richard Hammond	USAID-PAOP
8. Mark Newton	USAID-Economic Growth Office (Energy and Fisheries Sector)
9. Eric Samuel Edu Danquah	GIDA
10. Rosita	Farm Radio International
11. Cephas	Kosmos Energy
12. Gideon Plange	GIZ

ILSSI Stakeholder Mapping Workshop (10th March 2020)

Participants	Organization
1. Malex Alebikiya	ACDEP
2. Ariku Martin Akudugu	Ariku Farms
3. Emmanuel Sagoe	IWAD Ghana Limited
4. Afua Atuobi-Yeboah	UG-SPH/IFPRI
5. Fred Kizito	IITA/CIAT AFRICA RISING
6. Jack Ke	Hydro Farms
7. Margaret Boni	Hydro Farms
8. Seth Asante	IFPRI
9. Abdul-Salaam Alhassan	MOAP-GIZ
10. Peter Dakudzi	RAD/SAPIP
11. Langkeu Festus Aaron	SAPIP
12. Zenebe Adimassu	IWMI
13. Rebecca Afful	IWMI
14. Abdulai Eliasu	CARE
15. Ernestina Yikyio	Fallu Farms
16. Aaron Bunali Aduna	Water Resources Commission, Bolga
17. Saa Dittoh	WACWISA UDS, Tamale
18. Alhassan Rasheed	IDE Ghana
19. Felix K. Abagale	WACWISA, UDS Tamale

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